Geographic Information Science Implications for Urban and Regional Planning

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Abstract: *This paper was prepared in response to the University Consortium for Geographic Information Science (UCGIS) 1999 Summer Assembly application challenge. The purpose of that challenge was to review the achievements and implications of geographic information science relevant to urban and regional planning. The review identified five areas of geographic information science contributions: geographic information database development for planning-related analysis; integration of geospatial technologies with urban models; building of planning support systems; facilitating discourse and participation in the planning process; and evaluation of planning practice and technological impact. Those five areas were evaluated against UCGIS research and educational challenges. While the scientific progress in building tools to support planning process is impressive, there has been little effort to provide practical guidance on strategic information management, to institutionalize information and decision support tools, and to transfer the technology to planning settings. This shortcoming in diffusion of planning tools limits the utility of science to policy and decision making that is so essential for developing environmentally, socially, and economically healthy communities.*

The educational process, which is the first major step in technology transfer, has many challenges of its own, including the availability of materials suitable for training planning professionals and other participants in the planning process and the provision of the infrastructure needed for teaching and research. Therefore, further research and policy development in the following areas would enhance the application of planning support systems and tools: education and technology transfer; database building, maintenance, and access; standardization; and legislation.

Introduction: Scope and Description of the Urban and Regional Planning Application Challenge

Planning is a future-oriented activity, strongly conditioned by the past and present. It links "scientific and technical knowledge to actions in the public domain" (Friedmann 1987: 38). Ideally, it happens via public discourse between all groups and individuals interested in and/or affected by urban development and management activities pursued by the public or private sector. In practice, such comprehensive sharing of information and decision making is rarely found. At their best, urban and regional planning agencies are rich, dynamic arenas where many societal problems and solutions are explored and addressed in a direct and tangible way. Examples of such problems are: urban growth; unemployment and economic revitalization; transportation; environmental degradation and protection; neighborhood decline and redevelopment; historic preservation; conservation of land and natural resources; and provision of open space, parks, and recreational facilities.

Planning-related decisions are made daily through a complex, often politically charged process involving a plurality of interests. In too many regions of the globe, however, the planning process and planning outcomes are the domain of powerful interest groups, far removed from the façade of democratic process. The role of widely disseminated, accurate geographic information is imperative to the planning process. Moreover, the implementation of planning decisions makes a long-term imprint on the structure, functionality, and quality of life in urban environments. While most urban and regional planning occurs at the local level, national and state policies and legislation often influence the planning activities.

Planners have always sought tools to enhance their analytical, problem-solving, and decision-making capabilities (Mandelbaum 1996). Beginning in the late 1950s, planners started to develop and use computerized models, planning information systems, and decision support systems to improve performance (Brail 1987, Klosterman 1990). The adoption of a geographic information systems (GIS) and land information systems is a more recent manifestation of the same effort to incorporate new tools and technologies. Planning departments have been on the forefront of GIS use among local government agencies (French and Wiggins 1990, Juhl 1993, French and Skiles 1996, Warnecke et al. 1998). The planners' interest in GIS and other geospatial technologies derives from the spatial nature of urban phenomena and from the interdisciplinary nature of urban planning.

Planners can apply geographic information technologies in all aspects of the planning process, including data collection and storage, data analysis and presentation, planning and/or policy making, communication with the public and decision makers, and planning and/or policy implementation and administration. GIS technology is most commonly used for comprehensive planning, zoning, land use inventories, site suitability assessments, and socio-demographic analysis, and is generally used for mapping purposes (Budic 1993, 1994, Harris and Elmes 1993, Warnecke et al. 1998). The value of maps in understanding and communicating planning issues is well recognized and appreciated. The more-sophisticated analytical applications, which contribute to other aspects of the planning process, are less developed.

Research suggests that the GIS-based tools developed by vendors and/or academics are for various reasons underutilized and unsuitable for planning (Harris 1989, Harris and Batty 1993, Holmberg 1994, Klosterman 1997). In a study of parcel-based GIS for land supply and capacity monitoring, Vernez-Moudon and Hubner (2000) attribute this underutilization of GIS technology to the inadequate capacity and structure of planning institutions, which remain unsuited to the new forms and processes required for effective utilization of planning and decision support systems. This problem has persisted from the early attempts at computerization of land supply monitoring in the 1980s (Godschalk et al 1985, Bollens and Godschalk 1987). Additional reasons for underutilization of GIS in planning include, but are not limited to, the complexity of technology, the lack of trained staff, the scarce organizational resources, and the incompatibility of the mostly generic geographic information products with the tasks and functions performed by urban and regional planners. The ability to incorporate urban models and to more directly support the decision- and policy-making processes are two main deficiencies of the current geospatial technologies and tools.

The field of computing for urban and regional planning is continuously advanced through various disciplinary areas, including geographic information science (GIScience). Ultimately, GIScience as applied in the field of urban and regional planning should advance the following goals of urban and regional planning:

- better quality (livable, safe, and aesthetically pleasing) of urban environments;
- environmentally and socially sustainable communities;
- effective spatial organization of urban activities (work, residence, commerce, and recreation);
- "smart growth" of urban areas;
- efficient communication between various urban functions;
- revitalization of deteriorated areas;
- variety of housing options;
- employment opportunities and economic development; and
- democratization of the planning and policy-making process.

This paper reviews the contribution of GIScience to urban and regional planning, evaluates those contributions against the University Consortium for Geographic Information Science (UCGIS) research and educational challenges, discusses policy implications, and identifies areas for further focus and development.

Geographic Information Science Contributions and Significance to Urban and Regional Planing

To understand the role of GIScience and technology in urban and regional planning, it is useful to refer to the theoretical underpinnings of planning, which assume instrumental and communicative rationality as two key frames for planning. Instrumental (functional) rationality is based on a positivist ideal, which puts information gathering and scientific analysis at the core of planning. It assumes a direct relationship between the information available and the quality of decisions based on this information. Communicative (substantive or procedural) rationality focuses on an open and inclusive planning process, public participation, dialog, consensus building, and conflict resolution (Innes 1996). While the two theoretical stances are often viewed as competing (Mannheim 1940, Sager 1990, Yifachel 1999), the role of information is relevant to both (and not restricted to instrumental rationality, as the more traditional view would hold). Participants in the planning process rely on many types of "information," including the formal analytic reports and quantitative measures and the understandings and meanings attached to planning issues and activities (Innes 1998). Indeed, GIScience and technology have begun to contribute to the planning practice, and in some areas the developments transcend the "communicate versus calculate" dichotomy.

The following is a review of the main areas of GIScience that are potentially the most useful for urban and regional planning practice:

1. GIS database developments for planning-related analysis;
2. integration of geospatial technologies with urban models;
3. building of planning support systems;
4. facilitating discourse and participation in the planning process; and
5. evaluation of planning practice and technological impact.

GIS Database Developments for Planning-related Analysis

Data collection takes up a considerable proportion of planners' resources. In fact, the effort put into database development is sometimes so immense that little time is left for analysis and for creative activities in designing plans and/or policies (Arbeit 1993). GIS database development must be based on a clear understanding of planning problems, process, and context (le Clercq 1990). Furthermore, since planning databases are usually derived by compiling data from multiple sources and of varying quality and scales, it is necessary to apply the rules of interoperability and integration (Devogele et al. 1998). The integration of readily available data sets is one way to reduce database development and maintenance time. For example, remote sensing data acquired via satellites or airborne cameras (Mesev 1997, Tellez and Servigne 1997) have proved very useful, particularly in mapping land use change (Lo and Shipman 1990, Logsdon et al. 1996), population density (Sutton 1997), and human activities and their outcomes (Schweik and Green 1999). Finally, the incorporation of data at several points in time is often useful, but requires system designers to be familiar with building dynamic GIS (Asproth et al. 1995).

In the positivistic vein, GIS databases are most frequently used for performing planning-related analysis and scientific inquiries (Wellar et al. 1994). Webster (1993, 1994) matches the scientific input required to the various stages of the planning process:

- problem identification requires description and prediction;
- goal setting, plan generation, evaluation of alternatives, and choice of solution requires prescription;
- implementation requires description, prediction, and prescription; and
- monitoring requires description and prediction.

Webster claims that GIS technology has limited value for predictive analysis, which is crucial for understanding the consequences resulting from future planning actions. While the GIS-based tools have proved useful for understanding physical and environmental processes, the socio-economic dynamics are still hard to model or simulate. To address this shortcoming, extensions toward enabling statistical analysis within the GIS environment have been attempted (Zhang and Griffith 1997, Luc Anselin, SpaceStat Web Site).

Integration of Geospatial Technologies with Urban Models

To enable prediction of urban phenomena and processes, GIS software must allow for modeling procedures to run within its environment. This is, incidentally, one of the most frequently cited deficiencies of GIS (Harris and Batty 1993). While urban modeling has had a rich history on its own and has achieved a high level of sophistication (Batty 1994, Klosterman 1994, Wegener 1994, Klosterman 1999a), it has only been sporadically integrated with geospatial technologies and built into the spatial decision support tools. Predictive modeling is usually performed outside GIS and is loosely coupled to the system via programming procedures. Embedding of urban models within GIS has been attempted in advanced research projects (Batty and Xie 1994), but has not become part of commercial GIS software.

The California Urban Futures Models (Landis 1994, 1995 and Landis and Zhang 1998a, 1998b), the California Urban and Biodiversity Analysis (Landis et al. 1998), and the "What if?" (Klosterman 1999b) are probably the three most comprehensive attempts to date in GIS-based simulation of land use scenarios based on demographic and economic trends, environmental constraints, and urban development policies. The models by Landis and Klosterman are unique primarily because they do an excellent job of integrating GIS with urban models. Other, more comprehensive urban models are readily available but are stand-alone models. Finally, the progress in modeling land use change in particular is impressive (U.S. Environmental Protection Agency, forthcoming), but is yet to gain usability and acceptance in planning agencies at various levels of government.

Building of Planning Support Systems

Planning support systems aid in the planning process via integrated developments usually based on multiple technologies and common interface. Planning support systems are expected to facilitate data management, analysis, problem solving, design, decision making, and communication activities. For instance, Hopkins (1999: 333) conceived planning support systems to provide "views and tools for sketch planning, model building, scenario building, evaluation, lineage tracking, and plan-based action." Hopkins found that GIS mapping concepts are insufficient for building planning support systems. Despite some limitations, GIS have become a useful component and an integral part of PSS, which tend to incorporate one or more of the following features: modeling procedures (Harris 1989, Kammeier 1999), expert systems (Edamura and Tsuchida 1999, Shi and Yeh 1999), databases, decision trees, computer-aided design or CAD (Alley 1993, Schuur 1994, Ranzinger and Gleixner 1997), hypertext (George 1997), mapping (Singh 1999), user interfaces for public participation (Shiffer 1992), virtual reality, and the World Wide Web (Doyle et al. 1998, Heikkila 1998).

As identified by Klosterman (1997), planning support systems have evolved along with planning practice from applied science in the 1960s to politics in the 1970s and communication in the 1980s. Corresponding to this evolution is the information science concern with data, information, and knowledge, respectively. Intelligence and collective design are the current modus operandi of urban planning. In line with the increasingly recognized collective nature of planning analysis, design, communication, and decision making, the 1990s have witnessed the development of collaborative planning systems, planning groupware, and co-operative work systems (Jones 1998). Laurini (1998: 315) defined groupware as a "set of computer- and network-based technologies [that] allows several users, located at different sites and using different work-practices, to work together towards the same goal." Referring to a group-planning situation, Shiffer (1992, 1995) discussed group cognition, access to media, and access to computerized analysis tools as components of a holistic planning process. Shiffer built several prototype systems to integrate and test these concepts in the planning context.

The development of group support systems technology (Coleman and Khanna 1995), including group-decision support systems (DeSanctis and Gallupe 1987, Hwang and Lin 1987) as well as theoretical and empirical studies of its use (Jessup and Valacich 1993, Chun and Park 1998), have been carried out in the management and decision sciences for more than 10 years. More recently, information technologies such as GIS (Godschalk et al. 1992, Faber et al. 1994, 1995, 1996), their offspring spatial decision support systems (Densham 1991, Armstrong 1993, Heywood et al. 1995, Reitsma 1996, Jankowski et al. 1997, Nyerges et al. 1998a), and spatial understanding (and decision) support systems (Couclelis and Monmonier 1995, Jankowski and Stasik 1997) have been suggested as information technology aids to facilitate the understanding and decision making of geographical problems for groups, including those embroiled in locational conflict. Clearly, research concerning collaborative decision making for geographically oriented public policy problems continues to gain momentum (Godschalk et al. 1992, Shiffer 1992, Faber et al. 1994, 1995, 1996, Couclelis and Monmonier 1995, Densham et al. 1995, Golay and Nyerges 1995, Reitsma 1996, Reitsma et al. 1996, Jankowski et al. 1997, Nyerges and Jankowski 1997, Nyerges et al. 1998a, 1998b).

Facilitating Discourse and Participation in the Planning Process

In common with other technologies, GIS are socially constructed via negotiations between various social groups (Harvey and Chrisman 1998). In the case of planning, those groups include professional staff, decision-makers, developers, special interest groups, citizens, and other stakeholders. GIS technology promises to improve public access to information and facilitate public participation in the planning and policy-making process. Contrary to the expectation that GIS will enhance democracy and empower disadvantaged groups, Clark (1998) warns about the creation of GIS technocratic elite. In her study of Virginia planning agencies, Nedovic-Budic (1998) found little evidence regarding improvement in public access to data. Sieber (1997) reported the difficulties experienced by non-profit organizations in obtaining GIS data. Meanwhile, there is an increasing trend toward empowering communities to plan through the provision of integrated GIS software and planning databases. The new Community 2020 CD-ROM package, made available by HUD (Housing and Urban Development) to local governments on a national basis, bundles Caliper's Maptitude™ with an extensive database of geographic, demographic, and programmatic information. Seattle's Neighborhood Data Viewer, provided to its neighborhood planning groups, includes ArcView and a comprehensive database of maps on land use, crime, and other planning information. Several authors offer examples of the positive effect of GIS and other technologies on community participation in the planning process (Sawicki and Craig 1996, Craig 1998, Sarjakoski 1998, Schon et al. 1999). New developments that strive to include in the GIS-based systems subjective information on citizens' perceptions, views, and ideas promise to enhance even further the potential of geospatial technology and tools to aid public participation in the planning process (Al-Khodmany 1999, Talen 1999).

Evaluation of Planning Practice and Technological Impact

Evaluation research is pursued in two venues: one is GIS-aided evaluation of the quality of urban communities and of planning practice, and the other is the evaluation of GIS impact on the planning process, practice, and outcomes. With respect to the planning practice, Talen (1998) applied GIS to examine the equity in distribution of pubic services to various segments of the community and to search for areas that have not received adequate planning attention and have not been allocated their fair share of public resources. In an earlier study, Talen (1996) used GIS to assess the achievement of open space goals by comparing the planned and implemented projects. Knaap et al. (1998) used GIS in their evaluation of the relevance and outcomes of planning. They questioned whether planning matters, and to answer this, they modeled the land development process as interaction between local government policies and land market participants to measure the effect of planning as a change in social welfare. Finally, the Urban Institute initiated a project to explore the feasibility of creating a national system of indicators to be used for evaluating the quality of life at the neighborhood level (Sawicki and Flynn 1996).

The other research venue has to do with determining whether the employment of geographic information technologies and tools has made a difference in planning practice (Tulloch et al. 1999). Planners have always been on the forefront of GIS diffusion, but the benefits to them are not yet well documented. To understand the impact of GIS and apply that information in designing systems that will suit planning practice, Nedovic-Budic (1998, 1999) reviewed the evaluation frameworks, methods, and empirical studies. The evaluation dimensions included system quality, information quality, information use, user satisfaction, individual impact, organizational performance (i.e., efficiency and effectiveness), and societal impact. The author found that information processing is still perceived as the main GIS benefit, while the enhancement in decision-making and empowerment is yet to be achieved. Montagu (2000) examined the fit between GIS technology and the natural resource planning process in the context of Papua New Guinea's state government. He found "little impact on the planned outcomes of environmental management across the country" and argued that the "domination of the prevailing political economy of environmental management in the planning process" is the reason for inadequate utilization of well-designed and custom-developed GIS. Obviously, the experiences and insights into building successful GIS in planning organizations at various levels, different mandates, and diverse settings will provide useful information for many current and prospective users.

GIS-based research in planning spans all five contribution areas listed above and a variety of planning subfields, including urban growth management, land use planning, zoning, housing, community and economic development, transportation planning, environmental issues, provision of community parks and open space, and supply of public utilities and amenities.

UCGIS Research Challenges

The UCGIS research challenges[1] (http://www.ncgia.ucsb.edu/other/ucgis/CAGIS.html) were defined in 1996 during the Columbus, Ohio Assembly. Ten priority research challenges evolved from the areas nominated by member institutions and from an extensive discussion between 29 delegates present at the Assembly. Recognizing that the list of research challenges will evolve over time, its primary purpose was to identify the areas where most research is needed and where public funds would be most effectively utilized. The research challenges are all applicable to the field of urban and regional planning. Data collection and integration are the most time-consuming planning activities and GIS is a prominent tool to aid in data-related activities. The data-related understanding between planners and engineers is probably the area where improvement is needed the most. A two-way exchange, with planners appreciating and taking advantage of engineering precision and accuracy and with the engineers' ability to utilize more uncertain and generalized planning data, is still a challenge to overcome. If the traditional planners' connectivity to engineering and many other public and private organizations is to be realized by computer-based networking, then distributed computing, interoperability, and scale issues are essential for enabling the exchange of data between specialized local agencies. Planners need to understand the quality of data and analyses they rely upon for planning and policy making. Improved analytical capabilities embedded in GIS software would also be a useful extension of existing tools.

Advances in the National Spatial Data Infrastructure (NSDI) and Web tools hold the potential to improve public access to planning information and the democratic and participatory requirements in the planning process. Understanding the cognitive aspects of GIS-based tools will enhance planners' effectiveness in using these tools to communicate with decision makers and the public. This understanding will also lead to the development of tools that match the cognitive structures of various groups involved in the planning process. Finally, having society as a reference for evaluating the impact of technology is compatible with public nature of most urban and regional planning activities, which strive for increasing community welfare and quality of life.

Urban and regional planning applications will certainly benefit from research in the UCGIS challenge areas. These challenges, however, promise to build on the generic aspects of GIS tools, but do not always address the specific needs of planning practice. The most critical areas that focus on urban and regional planning needs include:

- the development of planning support systems;
- linking of tool developments with planning organizations, process, theory, and methods;
- understanding the impact on planning process and outcomes; and
- the visualization of spatial processes and phenomena.

Development of Planning Support Systems

Planning support systems include the integration of geographic information with other technologies (e.g., hypertext, groupware, audio/visuals, multimedia, models, simulations, and expert systems). Although strides have been made in that direction (as evidenced in the most recent issue of Environment and Planning B - 1999, 26/3 on New Perspectives in Planning Support Systems), many challenges are still ahead. Current developments of customized geographic information and other tools only partially respond to analytical, design, administrative, communicative, and decision-making support needed. The integration of those modules into a functional planning support system and their customization to various planning institutions are yet to be achieved.

Linking Tool Developments with Planning Organizations, Process, Theory, and Methods

Similarly, most of the collaborative research on decision-making support systems is about GIS development rather than about GIS use, without a strong theoretical link between the two. Consequently, broadening and deepening the conceptual underpinnings around GIS-supported collaborative decision making is a major research goal. To advance the GIScience and to be useful in urban and regional planning practice, this broadening must take the perspective of geographic information use. An evaluation of the impact of geospatial technologies and tools is probably the most direct way of providing a link between the science and planning practice. Theoretically founded and systematic evaluation provides knowledge that can inform geographic information diffusion and can be applied in strategies for achieving effective implementation of geographic information technologies and tools.

Once the planning tools are developed, they need to be effectively introduced into planning organizational settings. Technology transfer and incorporation of technology in the planning process is, therefore, a challenge related to the building of planning support systems. This process usually implies a major organizational change and re-structuring to create new organizational forms, processes, procedures, information flows, and responsibilities. The organizational change implies mutual adjustment between the technology and the organization (Nedovic-Budic 1997). While the knowledge base regarding the GIS implementation process has started to consolidate during the past decade (Innes and Simpson 1993, Budic and Godschalk 1994, Campbell and Masser 1995, Huxhold and Levinsohn 1995, Nedovic-Budic and Godschalk 1996, Tulloch 1999, Brown 1997, Azad 1998), the lessons learned are generic and not directly applicable to the planning context. A better understanding of planning organizational contexts and processes is crucial for effective embedding of planning support systems.

Understanding the Impact on Planning Process and Outcomes

Understanding the relationship between planning theory and methods and geospatial technologies is crucial for building and implementing tools that are suitable to planning practice. Esnard and MacDougall (1997) maintained that there is a common ground for integrating planning theory and GIS in data creation, analysis, and presentation. They suggest this integration as part of an educational experience. Guhathakurta (1999) also found that urban modeling and decision support tools could be developed to serve the practice and to link to its theoretical underpinnings. The author referred to a new form of rationality that encompasses both positivist and interpretative epistemology and promised to provide a framework for the development of planning technologies and tools.

In addition to the rational theory, the social theory and postmodernism serve to form vital cornerstones to the planning theory. These theories provide a critique on the use of technology in the planning process and reject the single narrative discourse usually pursued via the information technology (despite the technological capability to handle multiple narratives and views). Both theories relate to economic restructuring and globalization - topics well covered in planning and geography, and certainly assisted by spatial technologies.

Paradigmatic influences on information systems development methodologies are recognized. Hirchheim and Klein (1992) propose four influences: functionalism, which relies on empiricism and analysis; social relativism, which assumes phenomenological processes on social interaction and interpretation; radical structuralism, which reduces physical reality to the objective relations in the production process and action to a dichotomy between acceptance of status quo and revolutionary change; and neohumanism, which differentiates physical from social reality, with critical debate and consensus as major means of knowledge acquisition. Without establishing these linkages between theory and practices in building planning information and decision support systems, technological developments would operate in a vacuum and, consequently, be driven by immediate short-term concerns rather than the overall mission and purpose of planning action.

Visualization of Spatial Processes and Phenomena

Finally, visualization of existing urban-related processes and phenomena and simulation of outcomes of proposed plans and policies is in the core of planning practice. Further developments in three-dimensional modeling, virtual reality, incorporation of images, easy graphical manipulation of various urban components, movement through space, changing perspectives, linking with planning and policy documentation and descriptive statements, and annotation tools for dialog and commentary will enhance the communication capacity of urban planners. As with all applicable technologies, to make the visualization tools useful for planning practice, their customization and integration into the planning process will be a necessary aspect of the development.

UCGIS Education Challenges

The UCGIS education challenges[2] (http://www.ncgia.ucsb.edu/other/ucgis/ed_priorities/) have undergone a year-long debate and discussion among the members. Closure on the process was reached during the 1997 Summer Assembly in Bar Harbor, Maine. All educational challenges are applicable to the field of urban and regional planning. The following challenges address most closely the current concerns of urban and regional planning:

- development of training materials to suit the planning professionals;
- securing infrastructure for GIS technology for teaching and research;
- access and equity; and
- developing a code of ethics for GIS development and use.

GIS is described as "another quiet revolution" in the planning practice, and GIS courses have been introduced as an important component in the undergraduate and graduate planning curricula. GIS-related capabilities, techniques, and methods contribute to several skill areas of professional planners, including analytical/research, communication, and data processing (Godschalk and McMahon 1992, Friedmann and Kuester 1994, Kaufman and Simons 1995). Infrastructure for teaching is crucial, but is difficult to secure and make fully accessible in planning schools and departments. The demand for continuing education and training of planning professionals in emerging geographic information technologies also has to be met. The educational materials, however, for both regular programs and continuing education need to be tailored to the disciplinary framework of urban and regional planning by providing examples from planning practice and using methods that are common to planners. In addition, planning educators must consider the distribution effects of GIS technology and the access to technology by disadvantaged and other community groups - the regular participants in the planning process.

As suggested in the list of educational priorities, securing exposure to GIS through research is a desired educational practice among planning programs. Finally, with regard to certification, the American Institute of Certified Planners (AICP) and the American Planning Association (APA), which have both begun to recognize GIS training as a professional requirement, at the present time are unlikely to pursue any GIS-related certification, although this may change in the future. However, other organizations, such as the Urban and Regional Information Systems Association (URISA), have started to seriously discuss the issues of professional education and certification (URISA Web Site). The area where professional planning associations may assume a stronger role is in the program accreditation process. For example, the Planning Accreditation Board may begin to look closely at the programs' provision for education in GIS-based computerized technologies and tools.

Closely related to professional accreditation and certification is the question of ethics. Ethics is also related to the UCGIS research challenge "GIS and Society," which states that it is important to "lessen the likelihood that geographic information technologies will be misused, or their products misinterpreted, or inappropriate decisions be made based on their products." Practicing ethical behavior and possibly developing and adhering to a professional code of ethics are, however, within the realm of education and certification.

Esnard (1998) pointed to the codes of ethics and to ethics in general as critical for good planning practice and suggested that ethics be a high priority for educators who prepare the next generation of professional planners. Esnard questioned how we can seriously consider constructing guidelines that will serve as a simple common language of ethical behavior - guidelines that are easy to remember and build upon. Should the multidisciplinary GIS community have a common code for all GIS users and, if so, what happens to our own professional codes, in the case of planners - the AICP/APA Ethical Principles in Planning. Esnard found the current provisions addressing data analysis and information to be outdated and sometimes contradictory. She called for studying the questionable uses of information technology to understand their ethical and legal implications and impact, and using the examples of misuse as the source of education. Defining a framework that would help GIS practitioners delineate the behavioral boundaries and make judgments about their responsibilities and actions is of utmost priority.

Policy Implications

A policy environment that is conducive to GIScience activities, and stimulates geographic information development and use, is reinforcing for the scientific and the planning process. The policies that would help advance the application of geospatial technologies and tools in urban and regional planning practice are in the areas of database development, standardization, access to data, tool building and integration, technology transfer, and legal framework. Each of the areas is briefly discussed below.

Support for Development and Maintenance of Local Databases

One of the most time-consuming and difficult tasks performed by planners is data collection in support of a particular project and/or agency function. In addition to collecting primary data, planners draw on numerous secondary data sources, including other agencies and government censuses, to acquire and integrate data into a useful database. External support in developing local databases (e.g., on properties, streets, utilities, and detailed neighborhood characteristics) would be of great value to local planners. This support could come in the form of technical assistance, staffing, and/or financing options, and would not necessarily need to be managed within planning agencies, as long as the planners' have access to other databases developed with public funds. The framework initiative of the Federal Geographic Data Committee (FGDC) and its attempt to develop and institutionalize the NSDI, promise improvements in data availability and access (FGDC Web Site).

Standardization

While integrating data from a variety of sources, planners continually deal with issues of data format and quality. Standardization of data, formats, and metadata would help alleviate some of the difficulties in physically integrating the data and would promote common terminology and contents in describing data. As in the case of database development and maintenance, the focus should be at the local level, where it is most difficult to establish and adhere to the common features that would be acceptable to a multitude of local data providers and users. Awareness about the existing standards and standardization efforts is the first step in preparing local GIS communities to consider and accept standardization of geographic information technologies and products. Again, the FGDC and many associated organizations are making tremendous progress in this direction.

Access to Data

Similar to standardization, access to data has technical and non-technical aspects. Technically, the tools for accessing data of various formats and proprietary codes are yet to be developed. The non-technical issue has to do with the legal right to access government-generated data and records, as well as with organizational motivation and willingness to provide open access to their data holdings. The easier it is to import and convert various geographic and attribute data formats, and the more open database owners are toward free access to their material, the more firm the foundation for building the NSDI. Onsrud and Rushton (1995) provided extensive discussion on various aspects of sharing geographic information that, in addition to access issues, addresses legal, economic, and organizational topics.

Tool Building and Integration

Planning support systems are applied in a unique organizational and social environment and under specific circumstances. Most of the planning support systems would be employed in a local government setting where the nature, intensity, and impact of urban development and re-development are contested daily between various public and private stakeholders and decision makers. While generic research in decision support systems provides relevant frameworks, concepts, and tools to be applied in planning situations, only the research conducted in planning specific context would secure achievements that are useful to planning practice and would hopefully enhance it. Therefore, sponsorship by the major funding agencies in the U.S. and abroad should be encouraged to explicitly address the needs of local planning. This research is very broad in scope and includes tool integration, decision systems, simulation, visualization, and modeling in planning specific settings.

Education and Technology Transfer

Education is one way to prepare for the future use of geospatial technologies and tools. Encouraging such geographic information-focused educational programs throughout the college experience and later during professional continuing education is an important step in raising awareness about the existing technological potential and in providing skills for operating and developing geospatial technologies and tools. To aid the actual diffusion of such technologies and tools, the inventors of new planning support tools should be required to disseminate their products in the real organizational/user settings. While commercial geographic information products generally find their way quickly to the market, the developments from academia that are often rather sophisticated and potentially useful tend to remain buried in research reports and articles. They seldom reach the wide range of professional and voluntary groups that could benefit from those developments.

Legal Framework

In addition to general data access, there are a number of other legal issues that pervade the use of geospatial technologies and data in the practice of urban and regional planning (Onsrud 1995). These other issues include liability, copyright, cost recovery, and public access. While the general framework on these issues with regard to government and private-sector data and practices has been established, the applicability to digital geographic information is debated. The legal environment in which geographic information is produced and used is highly uncertain and often discouraging to creative geographic information-related activities and developments. The current legal structures are subjected to numerous interpretations and new rules and procedures established locally and by state. A well-articulated legal framework would help private- and public-sector organizations and individuals define their roles and responsibilities with respect to spatial data and would help stabilize their practices and relationships.

Conclusion

The use of computing in support of urban and regional planning and the development of urban transportation and land use models dates back to the late 1950s. The main thrust of computing applications, which by the early 1980s increasingly included the use of geospatial technologies, is their contribution to better planning and decision making. The computing tools and technologies are designed to enhance the planners' capability to deal with complex urban environments and to plan for prosperous and livable communities.

Over the past couple of decades, GIScience has contributed significantly in advancing planning support tools and systems. Achievements in various areas of GIScience are impressive. They include: data acquisition techniques, database integration, and interoperability; the incorporation of urban models in GIS environment; the building of planning information, decision, and spatial understanding support systems; raising awareness about the importance of using technology to facilitate planning discourse and to enable equal participation of all interested and/or affected parties in the planning process (community and disadvantaged groups, in particular); and the use of geospatial technologies and tools to assess the quality of planned communities and to determine whether the use of technological tools in planning make a difference in the resulting quality of life and urban environments. The contributions of GIScience are broad in scope. They address the analytical, functional, and quantitative aspects of urban and regional planning, but they also address the communication, qualitative, and perceptual aspects of the planning process. For example, recent discussions of the bottom-up, resident-based GIS technology demonstrate a broadened paradigmatic base, expanded almost to a full range of paradigms suggested by Hirchheim and Klein (1992). The authors advanced four main paradigmatic influences on information systems development methodologies: functionalism, social relativism, radical structuralism, and neohumanism. Neohumanism embraces the first two approaches and postulates the need for multiple epistemologies, reflecting both physical and social reality.

Despite the considerable progress in GIScience and its relevancy to urban and regional planning, the applicability of its results is somewhat limited. This can be attributed to several possible reasons including: 1) a primary emphasis of scientific efforts toward understanding and explaining planning and spatial processes and phenomena; 2) a generic quality to most except a few research and teaching tools to directly address the specific needs of the planning process; 3) a focus on narrow planning issues and/or only on one aspect of the planning process; and 4) a lack of diffusion of planning tools to the user communities. These are difficult but important challenges to overcome. The enhancement of existing planning support systems and visualization tools and the development of new integrated ones that deal comprehensively with the planning process and issues are the first steps in increasing the utility of GIScience to urban and regional planning. More important, however, is the effort to operationalize those systems and tools and to put them in the hands of planning professionals. Close attention to the methods of planning and to the way that planning organizations function is a prerequisite for the successful transfer of technology. Further understanding of the impact of various geospatial technologies and tools on the planning process and outcomes is necessary for matching the tools to the planning process and methods. Unfortunately, evaluative studies that would provide such knowledge are still lacking.

A well-developed, relevant educational process, supported with adequate infrastructure, has the potential to alleviate some of the technology transfer and operationalization problems. Bringing up a cadre of planners versed in applying various geospatial technologies and tools is the most effective way to secure their use in the planning process. Ideally, some users will be capable of customizing the tools to fit the planning process and to put them to regular use in their planning environments. However, many struggles on the educational front make it difficult for urban and regional educators to fulfill their role. Keeping technologically up to date, providing instruction tailored to the needs of professional planners in both regular and continuing education courses, providing educational experience to various other potential participants in the planning and policy-making process, and raising awareness about the possible misuse of information and related ethical issues are a few examples of those educational challenges.

Along with education, general public policy can facilitate the diffusion of geospatial technologies and decision support tools to planning organizations and communities. To improve the utility and effectiveness of geographic information and decision support systems in local urban and regional planning, it has been suggested that the following are critical: secure support for the development and maintenance of databases at the local and regional level; promote open access to geographic information in digital form; make supporting the development of planning-specific tools a priority; develop a technology transfer policy that links funding for scientific research and dissemination of systems and tools; and address the legal issues related to data exchange and use. In summary, the main areas of current and potential contributions of GIScience and policy to better urban planning are the following actions:

- building tools that meet the needs of planning practice for policy making, decision support, and visualization;
- strategic information resource management through incorporation and institutionalization of technological developments into the planning process; and
- diffusion and capacity building by transferring the technology to the participants in the planning process and/or by enabling them to build their own tools.

Author

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Footnote [1]

1. Spatial Data Acquisition and Integration
2. Distributed Computing
3. Extensions to Geographic Representations
4. Cognition of Geographic Information
5. Interoperability of Geographic Information
6. Scale
7. Spatial Analysis in a GIS Environment
8. The Future of Spatial Information Infrastructure
9. Uncertainty in Geographic Data and GIS-Based Analyses
10. GIS and Society

Footnote [2]

1. Emerging Technologies for Delivering GIScience Education
2. Supporting Infrastructure
3. Access and Equity
4. Alternative Designs for Curriculum Content & Evaluation
5. Professional GIS Education Programs
6. Research-based Graduate GIS Education
7. Learning with GIS
8. Accreditation and Certification