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PLANNING FOR SMART URBAN ECOSYSTEMS: INFORMATION TECHNOLOGY APPLICATIONS FOR CAPACITY BUILDING IN ENVIRONMENTAL DECISION MAKING

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Abstract
Since the industrial revolution, our world has experienced rapid and unplanned industrialization and urbanization. As a result, we have had to cope with serious environmental challenges. In this context, an explanation of how smart urban ecosystems can emerge, gains a crucial importance. Capacity building and community involvement have always been key issues in achieving sustainable development and enhancing urban ecosystems. By considering these, this paper looks at new approaches to increase public awareness of environmental decision making. This paper will discuss the role of Information and Communication Technologies (ICT), particularly Web-based Geographic Information Systems (Web-based GIS) as spatial decision support systems to aid public participatory environmental decision making. The paper also explores the potential and constraints of these web-based tools for collaborative decision making.
Keywords: Urban ecosystems, capacity building, community involvement, ICT, information sharing, Web-based GIS.

1. Introduction

Since the 1850s, the world has witnessed incalculable technological achievements, population growth and corresponding increases in natural resource use. In this new millennium, we recognize the negative effects of our activities: Polluted urban environs; agricultural runoff; regional air pollution; abandoned hazardous waste sites; urban sprawl; habitat loss; declining biological diversity; global climate change; deposition or recycling of pollutants among air, land, and water; landfills at capacity; toxic waste; natural resource and ozone depletion. These pressures are straining the limits of the Earth's carrying capacity and its ability to provide the resources required to sustain life while retaining the capacity to regenerate.

While the world's population continues to expand, implementation of resource efficient measures in all areas of human activity is imperative. The built environment is a clear example of the impact of human activity on natural resources. Buildings have a significant impact on the environment, accounting for one-sixth of the world's freshwater withdrawals, one-quarter of its wood harvest, and two-fifths of its

material and energy flows. These structures also impact areas beyond their immediate location, affecting the watersheds, air quality, and transportation patterns of communities (Public Technology, 1996: 8).

It is projected that more than half of the world's population will be living in urban areas by 2025 (United Nations, 2000). This projection shows the importance of urban ecosystems. It will be vital to consider the physical conditions inside urban boundaries, such as, watersheds, parks, soil systems, mini climates and living ecosystems such as trees, grasslands and biodiversity.

In this context, sustainable development can be a positive change which does not undermine the environmental or social systems on which we depend. It requires a coordinated approach to planning and policy making that involves public participation. Its success depends on the widespread understanding of the critical relationship between people and their environment and the will to make necessary changes.

Sustainable development goals can not be achieved by the efforts of technicians, politicians and environmental groups alone (United Nations Division for Sustainable Development, 2000). Communities are frequently invisible actors in environmental discussions. Specialized environmental departments and groups can bring expert advice to multi-stakeholder dialogues, but must not be expected to bear the burden of the defence of what must be considered an important common and public interest.

A growing number of publications point out the importance of capacity building in communities for urban ecosystem enhancement. To build the capacity and ability in community for creating sustainable futures, community-based decisions and environmental decision making process should be encouraged. Community-based environmental decision making integrates environmental management with human needs, considers long term ecosystem health and highlights the positive correlations between economic prosperity and environmental well being.

Information and Communication Technologies (ICT) are changing the way people communicate by enabling many more people throughout the world to access, share, analyze and use information over time and space. ICT are not only a significant factor in the performance and growth of economies, but also represent a novel and effective tool to help advance sustainable urban development. They do this by enabling multitude of modelling, visualization and simulation solutions that help conserve resources.

This paper aims to answer the question of whether integrating ICT for involving communities in environmental decision making process can support the emergence of smart urban ecosystems. The

paper also explores the potential and constraints of the ICT tools for collaborative environmental decision making.

2. Sustainable Urban Development and Smart Urban Ecosystems

The concept of sustainable development has come to the forefront of scholars' consideration in the last 30 years. It is a concept that recognizes that human civilization is an integral part of the natural world and that nature must be preserved and perpetuated if the human community itself is to survive.

Sustainable development is the challenge of meeting growing human needs for natural resources, industrial products, energy, food, transportation, shelter, and effective waste management while conserving and protecting environmental quality and the natural resource base essential for future life and development. This concept recognizes that meeting long term human needs will be impossible unless we also conserve the earth's natural physical, chemical, and biological systems (Colombo, 2001; Grossmann, 2000; Natural Resources Defense Council, 2001; Public Technology, 1996; Qiming, 2000; Sustainability Portal, 2001).

According to Smith et al. (1998: 213), achieving sustainable urban development depends upon producing sustainable built environments from the cities and towns already in existence. In the short term, only limited changes can be made in a physical sense but more significant changes can be made in lifestyles. In the medium term, the form of built environments can be changed to reflect and facilitate those lifestyles. This requires steering change, where over a longer period of time, behaviour and action leads to substantial changes in the built environment and the enhancement of urban ecosystems.

The urban ecosystem approach views urban areas as an integrated management system. It takes account of the balance, complexity and interrelations that exist between different communities of interacting organisms and the actual material environment in which they exist. As the proportion of urban residents increases every year worldwide, the nature of urban ecosystems becomes increasingly important. On the other hand, urban ecosystems are just as crucial in terms of the strong impact that urban centres have on their surrounding environs. Urbanization drastically alters soil retention and filtration abilities, and promotes flooding from precipitation. City expansion may also lead to loss of natural habitat and biodiversity.

One of the prerequisites of smart urban ecosystems structuring is to generate smart urban growth. Smart growth is a development that revitalizes central cities and older suburbs, supports and enhances public transit and preserves open spaces and agricultural lands. Smart growth creates communities that are more liveable by developing efficiently within the already built environment (Anderson, 2000;

Association of Bay Area Governments, 2001; Goode et al., 2001; Meck, 2001; Natural Resources Defense Council, 2001). It recognizes the connections between development and quality of life and leverages new growth to improve the community. The features that distinguish smart growth in a community vary from place to place. In general, smart growth invests time, attention and resources in restoring community and vitality to city centres and older suburbs as well as preserving open spaces.

To date, a growing number of scholars have advocated a greater role for public in the planning and administration of local communities and neighbourhoods for enhancing urban ecosystems and sustainable urban development (MacGregor, 1998: 3). Public advisory boards, task forces and round tables on environmental issues, community-based environmental impact assessments, and other forms of participatory democracy are thought to be essential elements of sustainable communities and smart urban ecosystems.

3. Capacity Building and Community Involvement

The pursuit of sustainable urban development can only be effectively achieved through active partnership between all stakeholder groups in society. Capacity building aims to create this active partnership and give communities the ability to direct change instead of being overwhelmed by environmental problems. It is a process of managing change by making training and resources available to people in different communities. Through capacity building, the whole community can be enriched and strengthened, enabling it to devise and implement its own plans for the future.

Capacity building for collaboration involves developing and organizing local constituencies to take part in community involvement programmes. Community capacity building is undertaken primarily by public and grassroots organizations. Local governments and a variety of volunteers can also play key roles in supporting capacity building and increasing communities' awareness of environmental issues.

Community involvement generally refers to empowering local residents to determine their own goals for development, and consulting with locals to determine their hopes and concerns related to their local area. The concept also includes the involvement of other stakeholders and interest groups in decision making. Community-oriented development recognizes that economic, social and environmental considerations need to be included in planning activities.

Community-oriented planning processes involve many aspects essential to the success of advocacy planning such as, concerning community needs, merging natural resources, linking various interest groups, creating investment opportunities, connecting socio-cultural as well as economic priorities. The basic schema for community-oriented planning process is presented in Figure 1. The top three elements

represent the main focus of the process. Community-oriented planning projects are regarded as central to the planning process and hence occupy a pivotal position. The three rectangular boxes at the bottom of the diagram represent the key components that make up development plans. Moreover, all of the processes should be steered by planning committee as an ongoing activity.

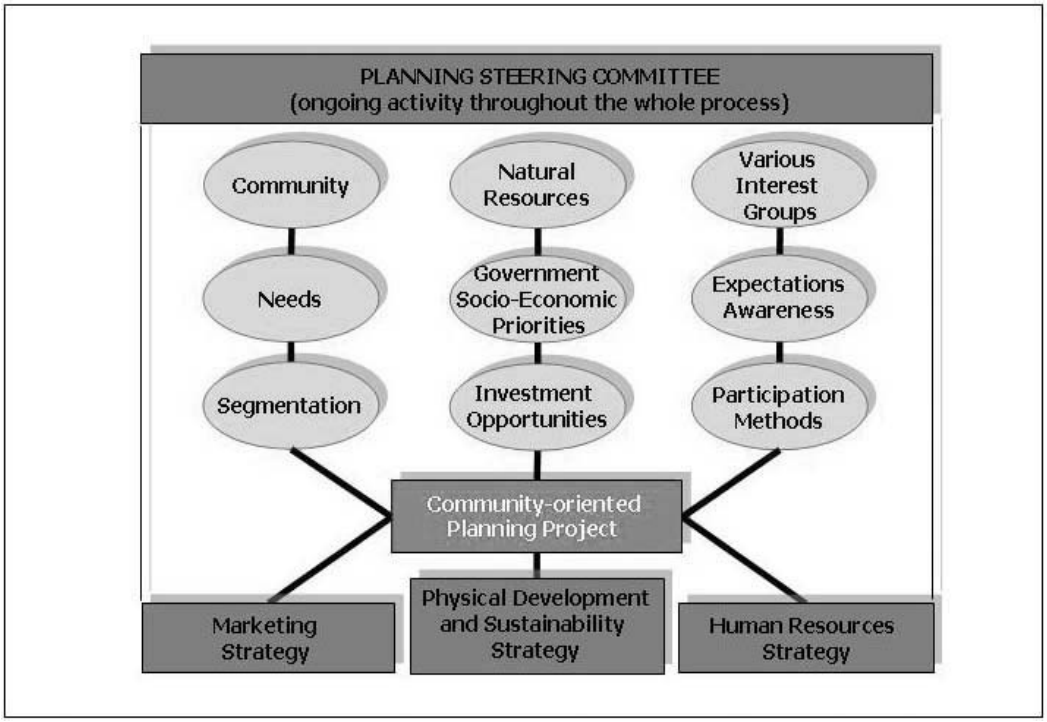

FIGURE 1. COMMUNITY-ORIENTED PLANNING PROCESS (KING ET AL., 2000)

Community-based environmental decision making is a holistic and collaborative approach to environmental protection that brings together public and private stakeholders within a place or community to identify environmental and public health concerns, set priorities, and forge comprehensive solutions. This is a place-based ecosystem approach, where stakeholders consider environmental protection along with social needs, work toward achieving long term ecosystem health, and foster linkages between economic prosperity and environmental well being.

Community ecosystem protection initiatives often begin at the grassroots level, when friends and neighbours share a common interest in protecting or restoring the local environment. These initiatives may be spurred by noticeable air or water pollution, a development that causes ecosystem damage, some obvious ecological effect such as a fish kill, the gradual loss of desired species or some other symptom of an underlying ecological problem. Alternatively, a community might come together to protect local ecosystems before they become threatened.

There are several traditional ways to raise community awareness and involvement over issues such as those outlined above. They include, using existing forums for public participation, publishing information in the newspaper or running an ad on a local radio station or on community access TV, handing out leaflets, sending out mailings, writing op-ed articles or letters to the editor of the local newspaper, calling local talk shows, posting bulletins on local boards, public surveys, focus groups, public task forces, consensus building meetings, and so on (for more information see (Citizen Participation Centre, 2001)). These ways of community involvement were analyzed by (Arnstein, 1969; Sewell and Coppock, 1977; Vindasius, 1974) and shown in Table 1 (according to Vindasius 1974, quoted in (Sarjakovski, 1998)).

TABLE 1. TYPES OF COMMUNITY INVOLVEMENT (VINDASIUS 1974, QUOTED IN (SARJAKOVSKI, 1998))

Type of public involvement mechanism (Vindasius, 1974)	**Descriptive dimensions**				
	Focus in scope	Focus in specificity	Degree of two-way communications	Level of public activity required	Agency staff time requirements
Informal local contacts	*	***	***	**	**
Mass media (newspapers, radio, TV)	***	*	*	*	*
Publications	***	**	*	*	**
Surveys, questionnaires	**	***	*	**	**
Workshop	*	***	***	***	***
Advisory committees	*	***	***	***	***
Public hearings	**	*	*	***	**
Public meetings	**	*	**	**	**
Public inquiry	***	*	*	**	**
Special task forces	*	***	***	***	***
Gaming simulation	*	***	***	***	***
Legend: * Low, ** Medium, *** High					

These traditional ways have not been completely successful and could be improved with the application of new tools to raise awareness among the public. It is essential, therefore, to find new ways to engage the public in environmental issues, which can cause a realization that they can have an important contribution to make, and that they can become full participants in the environmental decision making process.

4. ICT for Community-based Environmental Decision Making

ICT are basically devices and systems designed to transfer information through telephone, fiber optics lines or airwaves, the computer hardware that receives and stores the information transferred and the

computer software programs and data storage devices that facilitate such transfer and allow the recipient to use and analyze data to create information for a specific purpose.

ICT allows faster delivery of user friendly content in a variety of sectors ranging from distance education, environmental management to strengthening of participatory approaches and the raising of environmental awareness. ICT supports increased access to information sources worldwide, promote networking by transcending borders, languages and cultures, fosters empowerment of communities, women, youth and socially disadvantaged groups, and helps spread knowledge about best practices and experience. (United Nations Development Programme, 2000: 1). ICT also presents novel and effective tools to help advance sustainable development and enhance urban ecosystems through the use of modelling, visualization, and simulation solutions that help conserve resources and facilitate sustainable urban development.

ICT applications are able to support the search for new solutions and uses to the related fields. GIS enables spatial and attribute data to be presented in the virtual environment. GIS is a set of powerful computer-based tools for collecting, storing, retrieving, mapping, analyzing, transforming and displaying spatial and non-spatial data. GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by intelligent maps. Not only can existing situations and impacts be displayed on cartographic representations of the areas, but also projected patterns and usages of environments can be modelled, simulated and their outcomes envisaged (Figure 2).

FIGURE 2. GIS AND REMOTE SENSING APPLICATIONS (ERDAS, 2001)

GIS combines physical, social and economic information collected through surveys and raster information such as ground cover data from satellites. Selected layers of map objects representing vegetation, buildings, roads, coastlines are superimposed on social territories such as counties and census tracts to identify overlaps (Cole, 1997: 405). Although our world and the objects situated therein are three dimensional, most GIS provide a static view of the world or a sequence of snapshot images, in such a way that the full potential of space time models remains unrealised. GIS also reduced spatial data by its third dimension onto two dimensions, or involve relatively poor 3D visualization.

In comparison to the advancements in 3D visualization, comparatively little has been accomplished in the realization of a practical 3D GIS (Figure 3). Still, ongoing improvements in hardware and software technology will ensure that a 3D GIS becomes easier to implement and finds some unique uses in environmental decision making (Swanson, 1996). In addition, with rapidly advancing technology the level of realism of GIS is likely to increase to become film like and indistinguishable from 3D media representations of the real world.

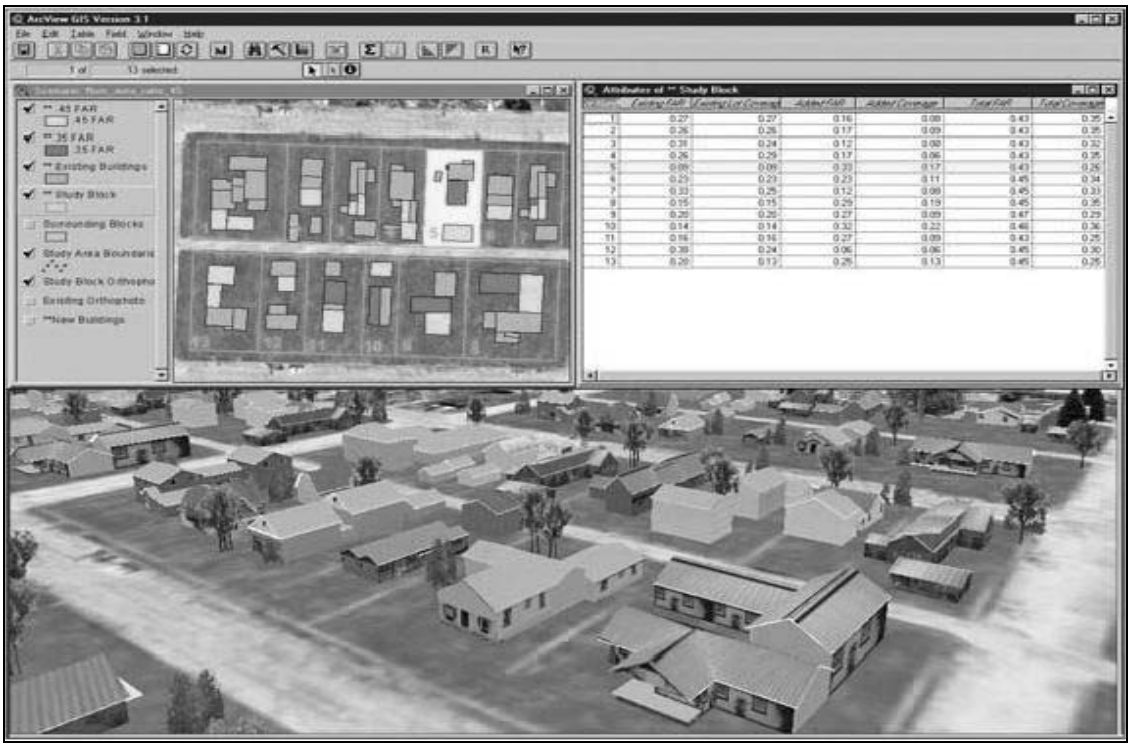

FIGURE 3. THREE DIMENSION GIS (ENVIRONMENTAL SIMULATION CENTRE, 2001)

Much emphasis has been concentrated on development of information systems, with relatively little attention to improving modes of access, and providing mechanisms for enabling information users to

utilize available data. Turning data into accessible information to enhance decision making, capacity building and operational uses are very important.

The concept of public participation or community-based GIS was initiated at the National Center for Geographic Information and Analysis. Community-based GIS has been conceived broadly as an integrative and inclusive process based on a set of methods and technologies amenable to community involvement, public participation, multiple viewpoints, and diverse forms of information (Krygier, 1998). Subsequent to this meeting, GIS, 3D visualization and simulation technologies have been integrated into a system designed to be individualized by each community. New generation GIS software and applications provide an interactive, real time multidimensional environment in which the public and professionals can reach consensus on goals, objectives, and policies, and can design the future of their community and environment. Public, planners, designers, and public officials can operate in a virtual world in real time, and will have the ability to propose policies, formulate and design alternative scenarios (Figure 4). Over time, they see how these changes impact their environment physically, fiscally and socially.

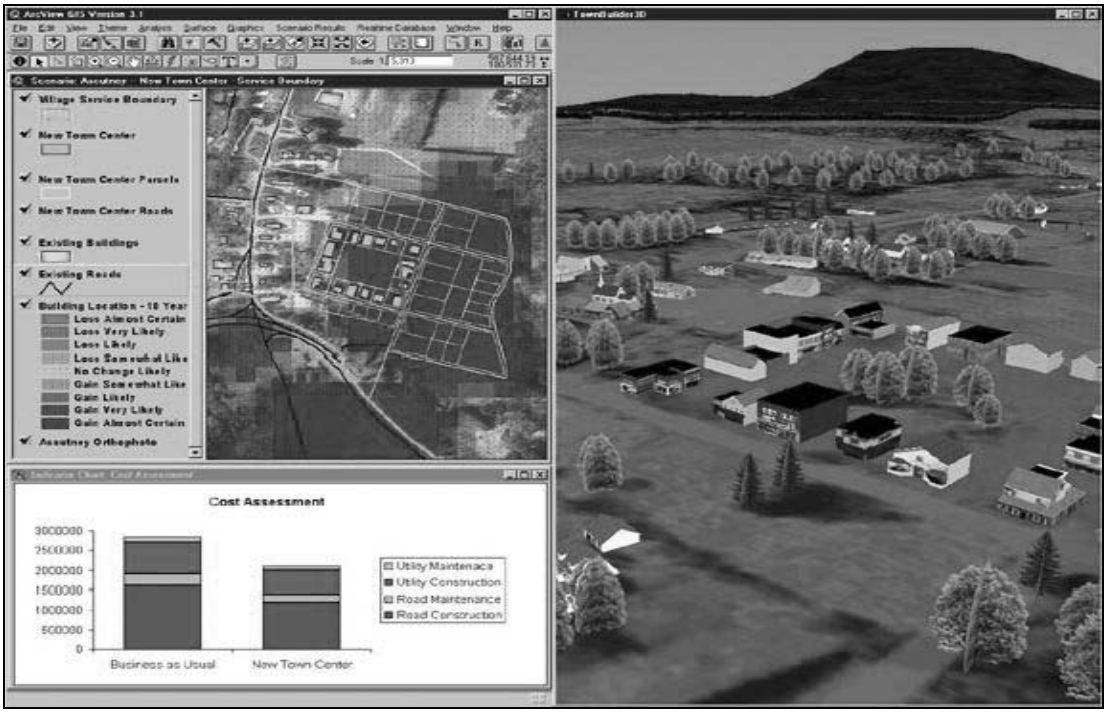

FIGURE 4. COMMUNITY-BASED GIS (COMMUNITYVIZ, 2001)

Communication and information sharing play a central role when we think about how to prepare stakeholders for their role in the environmental protection or the decision making process. Information sharing among organizations and individuals is an important aspect in the formulation of comprehensive

and practical approaches to prevent environmental problems. Information on threats and incidents experienced by others can help an organization identify trends, better understand risks, and determine what preventative measures should be implemented. Since 1993, the Web has revolutionized communications and now offers an excellent way for information sharing among all interest groups.

The Web was designed for information browsing and sharing, but recently the interest of the Internet community has begun to focus more on interaction. There is an increasing requirement for an infrastructure to enable user interactions and collaborations based around mutual goals and shared data. Geographically distributed organizations require this support for their internal operations, as do groups of organizations that collaborate. Moreover, Internet users in general could benefit from being able to meet when they access the same data, allowing them to interact and form collaborations based around their mutual interests (Kindberg, 2001: 1).

GIS vendors, software developers and spatial data providers have recently realized that the Web will be the next generation GIS platform for web-based computer supported collaborative work and web-based decision support systems. The Web provides a powerful medium for geographic information distribution, as well as a particularly lucrative new market to exploit. Internet GIS activity is facilitating innovative development in the dissemination, visualization and analysis tools for planners of the built environment (Figure 5). In the last few years a series of technologies has matured and web-based mapping and GIS are now commonly found on the Web (Yigitcanlar, 2001: 163) (for more information and samples see (GIS Planning, 2001)).

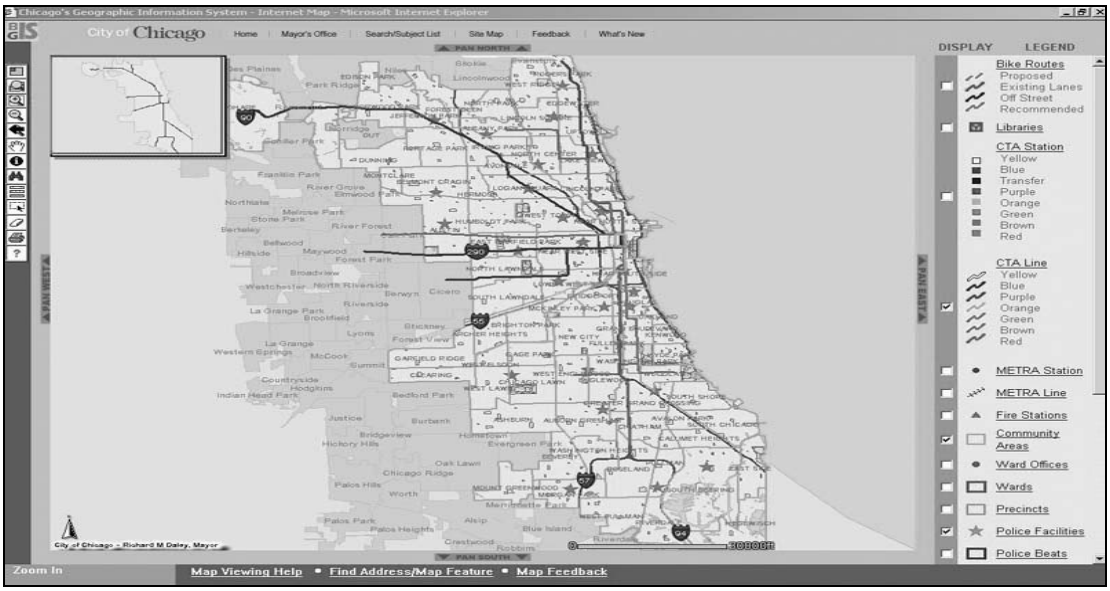

FIGURE 5. WEB-BASED GIS (CITY OF CHICAGO, 2001)

Distributing geographic information via the Web allows for real time integration of data from around the world. Internet Map Server is a solution that provides a common platform for this exchange. With an Internet Map Server such as ESRI ArcIMS people can access resources on the Web for more informed decision making (for more information see (ESRI, 2001)). Internet Map Server lets users exchange, integrate and analyze data in new ways. Users can combine data and information accessed via the Internet with local data for display, query and analysis. Internet Map Server establishes a common platform for the exchange of web-enabled GIS data and services and is a framework for distributing GIS capabilities via the Internet (Figure 6). As a publishing technology, it features unique capabilities for supporting a wide variety of GIS clients.

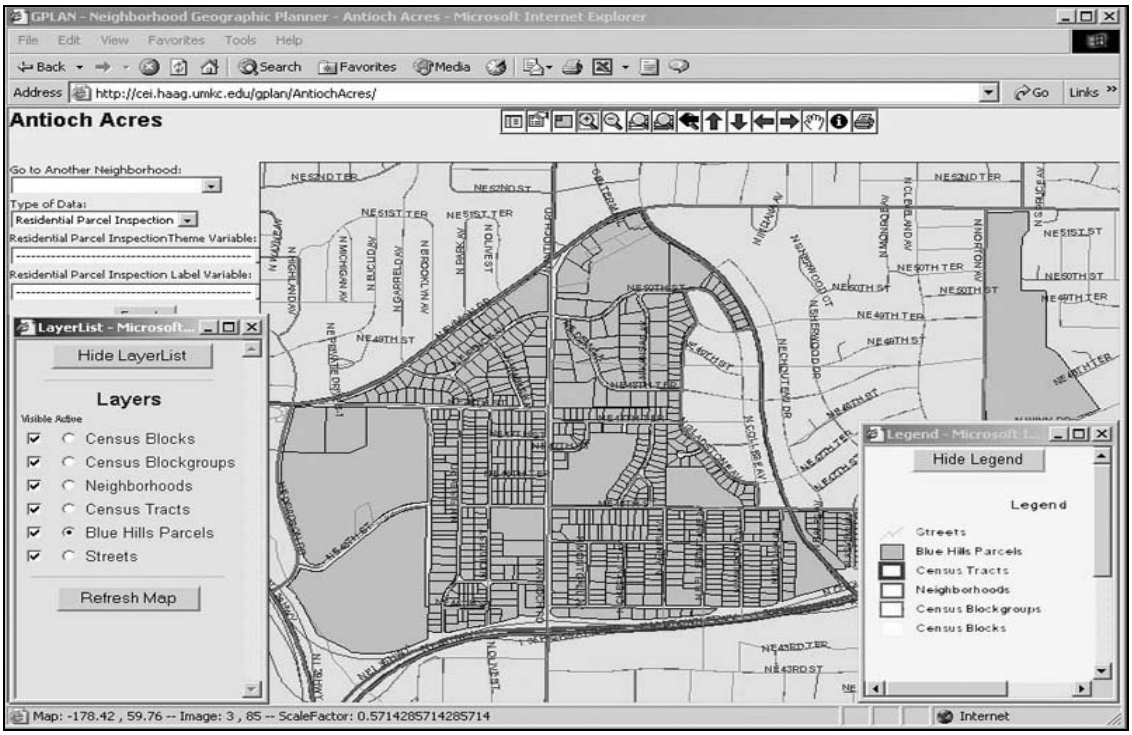

FIGURE 6. WEB-BASED GIS BY INTERNET MAP SERVER (GPLAN, 2001)

As stated by Jensen et al. (2000) recent advancements in the field of web-based GIS have opened up new challenges as well as opportunities in the way we have been developing models and decision support aids. It is not only the medium of information access and communication but also a flourishing platform to develop a new generation of applications. With the emergence of revolutionary technology of web-based GIS, now it has become possible to develop information systems distributed across different locations and heterogeneous platforms. This holds great promise for applications in web-based environmental decision support systems which are highly needed.

Small amounts of statistical and geographically referenced data are currently available on the Web and large volumes of these data can easily be accessed by data providers. Unfortunately, most of the potential users do not attempt to use these complex data, because only specialists have the technical expertise required. GIS for all or web-based common GIS applications aim to promote the dissemination and exploitation of geographically referenced data to a broad cross section of the public (Figure 7). The key idea is to make geographically referenced data commonly accessible and usable for everyone, by providing a web-based GIS with specific functions for the automatic generation of thematic maps (Common GIS Consortium, 2000b: 1).

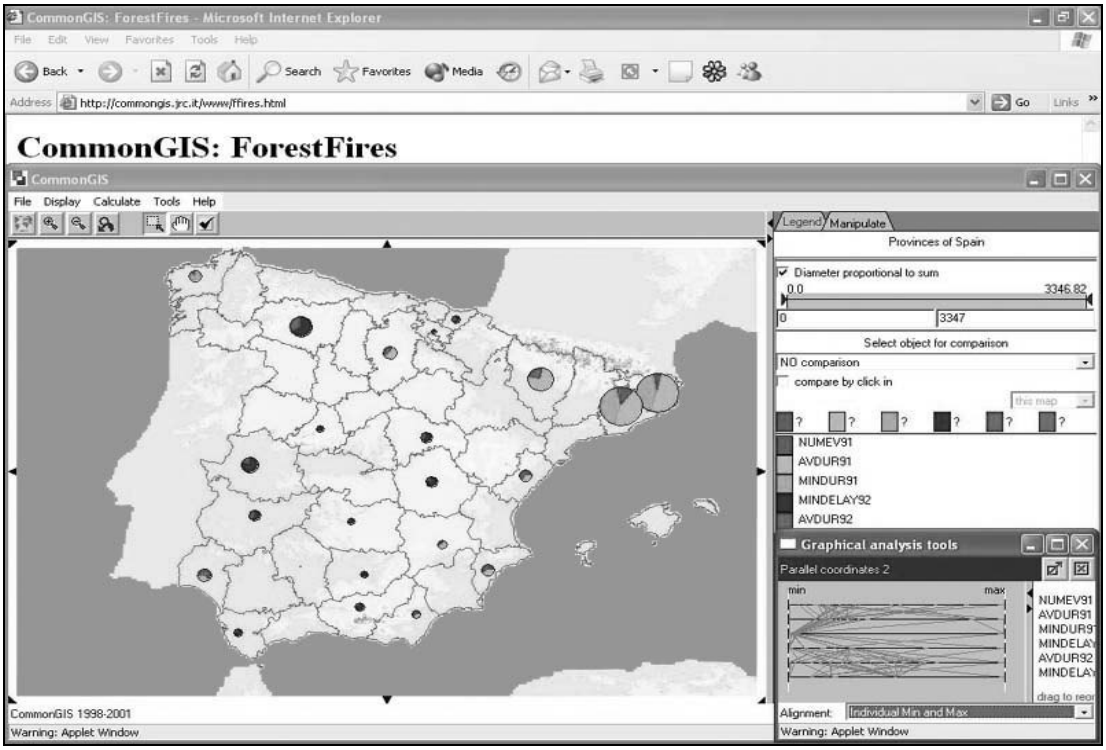

FIGURE 7. WEB-BASED COMMON GIS (COMMON GIS CONSORTIUM, 2000A)

Most of the online web-based GIS tend to be demonstrative in approach and academically oriented. They use simple data that is not problem specific and do not deal with complex real world issues. They do not implement interaction with the information in the sense that the user does not get to play with the data and send information back to the server. In order to test an interactive virtual decision making environment on the Internet, a planning for real exercise was conducted in June 1998 in the village of Slaithwaite in West Yorkshire, England by a local community action called Colne Valley Trust. Figure 8 is snapshot of the Slaithwaite web-based GIS, which illustrates how the public can input comments and

view other comments on planning and environmental policies pertaining to features in different geographic locations.

As indicated by Kingston et al. (2000) (quoted in (Sadagopan, 2000: 42)), the results seen from the Slaithwaite Web site's log files showed an increased public awareness and interest in the decision making process. The accuracy, appropriateness and accountability of decisions also improved through the use of virtual decision making environment. Since the Web is used for public participation, interest and awareness seemed to be generated among members of the community who did not usually participate. The younger generation particularly seemed to be excited by the use of Internet as the medium of public participation.

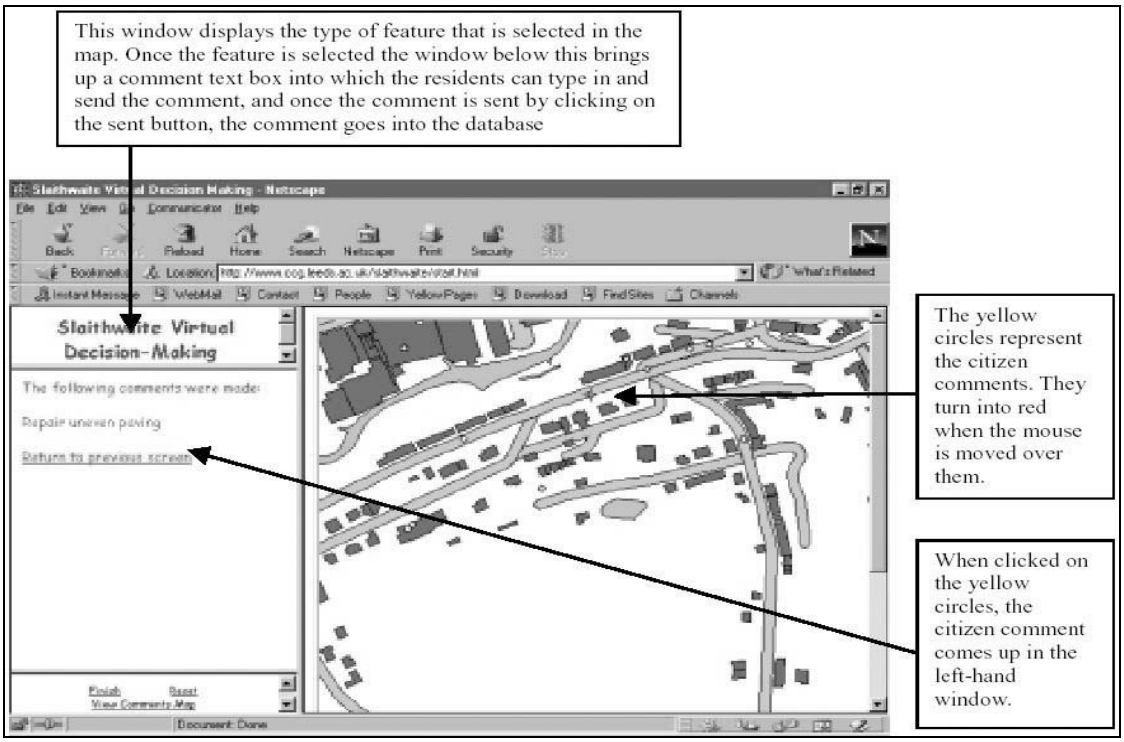

FIGURE 8. SLAITHWAITE WEB-BASED DECISION MAKING (SADAGOPAN, 2000)

Web-based decision support environments have various advantages. The ability to instantaneously update the database and profile users online was one of the most useful advantages of these systems. The web-based systems have a long residence time allowing people to use these systems anytime and from anywhere. The public does not need to attend a meeting at a particular time or place. These systems allow faster collation of results from log files and the Web sites can be used to disseminate results and feedback. Affordable and widespread access to data, information, and computer systems

can be provided by decision support systems on the Internet. Web-based decision support systems can also increase public awareness and encourage feedback from the public regarding important decisions.

It is important to remember that, there are some practical and ethical problems associated with web-based spatial decision support systems. Problems include: Whether community life will be harmed if electronic communication replaces face to face contact. Whether there will be miss-usage of the system that prevents community networks by only including those who have access to information technology. Accessibility and affordability is a problem for people in distant areas and for elderly individuals who may access the resource from community centres. The complex conflict between privacy and data availability is concerned with public access without discrimination. Web-based spatial decision support systems have the potential to trivialize the decision making process, in spite of the fact that planning and decision making are complex and difficult tasks (Martin, 1991; Pickles, 1995; Sadagopan, 2000; Saygin, 1997; Sui, 1994).

These problems are not insoluble. They must rather be seen as challenges to the development of true capacity building and community involvement for these systems. Technological advancements and time can partially resolve some problems. Advancement in hardware, software and network technology will further alter the way planning and decision making are viewed and practiced all over the world.

5. Conclusion

Geographic information technologies on the Internet possess the potential to provide tremendous support to public by empowering them with information. A virtual decision making environment is created when web-based GIS, is integrated with other technologies such as multimedia, virtual reality or visualization, to disseminate information for better public participation. Such an environment can make complex information more easily understandable to lay people. Web-based decision making environments can mould today's society by providing efficient public access, and may support empowerment of the public's capacity to work with data and to participate in the discussion of community development initiatives, environmental problems and decision making.

Distributing geographic visualization tools on the Internet to develop a virtual decision making environment may encourage community involvement and provide focus for a community's discussion of diverse ideas as well as guiding them through the planning and design process. When combined with a community involvement programme, it may raise awareness of environmental and urban planning problems, design and decision making issues and facilitate better communication.

There are a limited number of successive decision-sharing samples located on the Web, but there is still an urgent need for a comprehensive web-based collaborative decision support model. This model should accommodate e-learning tools to share knowledge and information among collaborators and raise awareness in environmental problem solving process. Furthermore, the model should include effective web-based decision support systems through which individuals can make representations directly to the decision makers.

According to Kingston et al. (1999) basic assumptions relating to web-based public participatory GIS include: It should provide equal access to data and information for all sectors of the community: It should have the capability to empower the community by providing the necessary data and information in a way that matches the needs of the members of the community who are, or will potentially, participate: A high degree of trust and transparency needs to be established and maintained within the public realm to give the process legitimacy and accountability.

In other words, accessibility, clarity and accountability are the key issues for success in community-based environmental decision making using GIS. The answer of whether integration of ICT for involving communities in environmental decision making processes, causes the emergence of smart urban ecosystems or not, therefore, is not clear yet. It depends on good design, public interest, and appropriate technology, culture, economics and politics.

Nevertheless, we can say that smart urban ecosystems can only be created by applying proper ideas, proper technology and tools, and appropriate planning approaches that comprise decentralized administration, participatory planning combining productive and environmental objectives, and collaboration between government, NGOs and civic movements. As a concluding remark it can be said that, utilizing proper technology, such as Web-based GIS, to involve a wide range of the community actors and taking appropriate actions seems to be one way to achieve sustainable urban development and support the emergence of smart urban ecosystems.

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