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## **Building Online Participatory Systems: Towards Community Based Interactive Environmental Decision Support Systems**

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### **Abstract:**

The importance of broadening community participation in environmental decision-making is widely recognized and lack of participation in this process appears to be a perennial problem. In this context, there have been calls from some academics for the more extensive use of geographic information systems (GIS) and distance learning technologies, accessible via the Internet, as a possible means to inform and empower communities. However, a number of problems exist. For instance, at present the scope for online interaction between policy-makers and citizens is currently limited. Contemporary web-based environmental information systems suffer from this lack of interactivity on the one hand and on the other hand from the apparent complexity for the lay user. This paper explores the issue of online community participation at the local level and attempts to construct a framework for a new (and potentially more effective) model of online participatory decision-making. The key components, system architecture and stages of such a model are introduced. This model, referred to as a 'Community Based Interactive Environmental Decision Support System', incorporates advanced information technologies, distance learning and community involvement tools which will be applied and evaluated in the field through a pilot project in Tokyo in the summer of 2002.

**Keywords:** Community involvement, capacity development, distance learning, ICT, web based GIS, decision support systems.

## **Introduction**

With the advent of ever cheaper and more user friendly computers and the progressive increase in environment related data collected through various monitoring and remote sensing programmes, imply that the need to handle, store, analyze and present data has gained increased significance. Today, it is virtually impossible to think about environmental research without relying heavily on Information and Communication Technologies (ICT). These ICT affect almost every aspect of the environmental debate, such as, research, monitoring, management and, ultimately, decision-making and public involvement.

Decision-making on environmental issues is highly complex, involving semi-structured and unstructured problems, large amounts of diverse data, and the need for the application of human value judgments. ICT provides a means of integrating data and models into a form that is readily understood by the participants in the decision-making process. In order to achieve this objective, however, online decision support systems need to be interactive and promote knowledge sharing and exchange. Ideally, if carefully designed and implemented, online decision support systems can play an important role in promoting a more extensive discourse between experts, decision-makers and the public, than exists today.

It is possible to argue that the development of environmental information systems is closely connected to the increase in environmental awareness over last three decades (Evans, 1999; Haklay, 1999). Furthermore, Geographical Information Systems (GIS) have come to be viewed as an effective technology to aid decision-making and they have revolutionized the way that spatial data is generated, stored, analyzed and disseminated. This information helps people to manage what they know, by making it easy to organize, manipulate and apply the data to solve real problems (Longley et al., 2001). This same technology, however, is of little use, if it is only available to those with technical expertise or the relevant software. Access to GIS, therefore, is a vital component of any online decision-making system.

Likewise, the Internet is a powerful medium in the move to further open up information to public scrutiny. It will function as the next generation GIS platform supporting information distribution and web-based decision support systems. Information and analysis supported by web-based GIS with various multimedia can potentially broaden the user base for this technology. As stated by numerous scholars (Brown, 1999; Doyle et al., 1998; Jensen et al., 2000), recent advancements in the field of web-based GIS have created new challenges, many of which are technical (e.g., bandwidth, internet connection speed; development of multilevel systems to enable full access by different users; limitations of the internet regarding

multimedia and ease of interaction) and social (e.g., techno-phobia; danger of creating an information underclass; lack of commercial and political will; antipathy and apathy; and lack of understanding surrounding public and personal use of the Internet). Nevertheless, the future evolution to web-based GIS is seen as a critical component in the development of online participatory systems which allow the visualizing and modelling of the environment in a networked virtual reality (Batty et al., 1998a; Batty et al., 1998b; Beardsley and Quinn, 1996; Carver et al., 1995; Faust, 1995; Marmie, 1995; Shiffer, 1995; Yigitcanlar and Sakauchi, 2002)).

Rapid progress with the development of the Internet has brought the possibility of computer assisted environmental and urban planning over the networks (Okabe et al., 1998; Plewe, 1997). The possibility of creating three-dimensional virtual environments, in particular, provides the potential to develop an intuitively comprehensive solution to both the process and the output of urban and environmental planning. It could also provide a better chance of citizen participation whereby users can share virtual space to develop and present and discuss their ideas and concerns.

In this context, this paper presents the framework for the development of an online participatory system that links the environmental decision-making process to environmental education and awareness raising. Several key components of such an interactive model called the 'Community Based Interactive Environmental Decision Support System' are introduced including a description of the system architecture and an outline of the key stages of the model. This working paper is therefore essentially descriptive and forms part of a series of research papers on this topic that together constitute a comprehensive (but not exhaustive) exploration of the role of ICT in relation to community participation and environmental decision-making.

### **Community based Interactive Environmental Decision Support System**

The application of innovative online tools to support community-based decision-making offers considerable new opportunities particular in environmental planning where institutions need to deal with the spatial, geographical, multi-dimensional and complex characteristics of environmental problems. For example, adaptation of community-based decisions can be helpful in planning new facilities that are sensitive to the natural and cultural requirements of local people; in protecting the visual integrity of historic sites; in reaching decisions related to

environmental impact assessments; when producing environmental statements; for integrated coastal zone management; and when estimating spatial variations in climatic change.

To adapt such community-oriented approaches, decision-makers and technicians (particularly planners) have to consider how innovative technologies can best facilitate improved synergies between development, community and environment. As mentioned previously, GIS is a useful tool in this context. In recent years, web based public participation GIS (web based PPGIS) has become an important research theme in the GIS and planning communities (for more information on web-based PPGIS, see (Boott et al., 2001; Carver and Openshaw, 1995; Craig, 1998; Kingston et al., 2000)). Unfortunately, there are currently few successful online participatory systems available (e.g. (Kakiko Map, 2002; Yamato City, 2002)). In moving forward from the current situation, therefore, existing web based PPGIS applications may need to be customized, new GIS approaches may have to be developed, and large numbers of participatory environmental decision support systems will eventually need to be located on the web. Consequently, in order to explore this issue further, an innovative web based PPGIS approach has been developed and is presented in this working paper.

Community Based Interactive Environmental Decision Support System (CIED) is a web based support system for discussion and collaborative decision-making. It enables various users, such as the public, technicians and politicians to obtain and share information interactively on the environment at different levels, scales, aspects and details. It also facilitates the collaboration of these users in problem solving and throughout various decision-making stages of the community-based planning process (see Figure 1).

CIED is a mechanism to support sustainable development related thinking, identify community goals, draw up planning guidelines and collect data and store them in a GIS environment. Moreover, the main steps of decision-making, collaboration, negotiation and consensus building are integrated into this system.

However, there are several limitations that need to be considered. For instance, to be effective, a collaborative decision-making project system needs to be able to deal with various forms of participation, from individual to community empowerment and from manipulation to citizen control (for more information, see (Arnstein, 1969; Heckman, 1999)). In this paper, we will focus on the notion of community empowerment by interactive participation but we are aware of the potential misuse of this kind of ICT system in terms of promote channels for disinformation and hype. Moreover, it is also clear that while ICT tools can support interactive participation, they cannot directly alter the decision-making processes from top

down to bottom. Nevertheless, it is possible to argue that effective use of these tools could raise awareness and build the capacity of the public to reorient this structure.

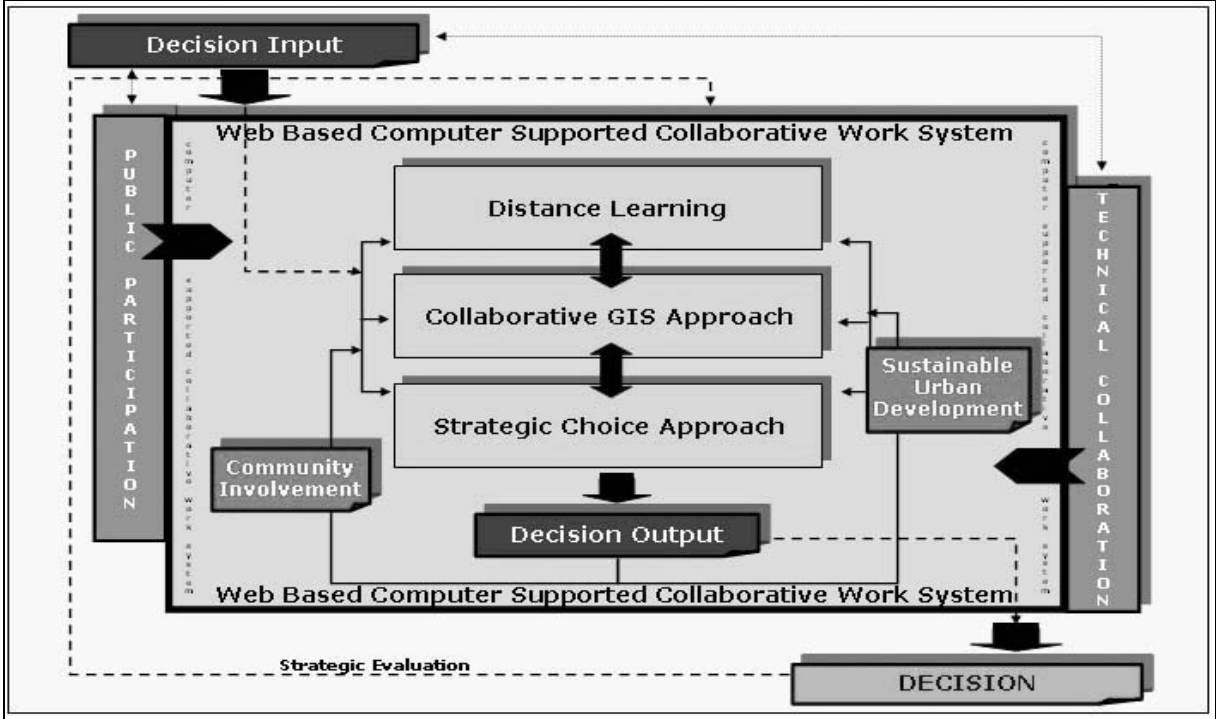


Figure 1. Community Based Interactive Environmental Decision Support System

CIED can also be thought of as a ‘discussion support tool for communities’. This implies the use of GIS not just as a decision support tool, where alternatives are explored, quantified and compared using analytical models (Densham, 1991) but more akin to the concept of ‘tools to think with others for the environment’ (Boott et al., 2001). Although the analytical capabilities of GIS play a major role here, the main focus of the approach is not limited to this role, but rather is on the visual and contextual exploration of the problem situation and issues connected to it.

The ultimate goal of this approach is to ensure that information is made available for users to perform analyses, store and represent their own results within the system. Users also should be able to browse the system, converse with other users, upload and download data, and move towards the design of planning and environmental policies at different scales.

**System Architecture**

The CIED system infrastructure would be designed as a Computer Supported Collaborative Work System (CSCW) enhanced through the incorporation of an online learning

environment. Furthermore, GIS would represent a key tool to support information gathering and presentation. Maps would be supplied from the client side through use of an Internet Map Server (IMS) - an online map publishing facility. User interactivity will be supported through the use of Common Gateway Interfaces - CGIs (online forms, polling, etc.) and other means of supporting online communication (forums, chat-rooms, etc.).

Computer Supported Collaborative Work System (CSCW), as its name suggests, is a system that supports the cooperative decision-making. CSCW has numerous benefits for environmental decision-makers (Ackerman, 1996; Bentley et al., 1998; Craig, 1998; Dourish and Bellotti, 1992; Hirscheim and Klein, 1989; Jones, 1998; Prinz et al., 1998). Hirscheim and Klien (1989) assert that a good CSCW must not be designed in what they term as the 'usual sense', but must be designed and developed within the framework of the social interactions that are embedded in the environment in which distance (collaborative) learning technology is to be incorporated. The caveat that must be stressed here is that in no sense is there an objective set of criteria that form a typology for an effective system. The system must be developed within what they term as the community's perspective. However, the CSCW system is not simply an electronic cloning or duplication of the working environment. In contrast, it is a pragmatic attempt to support the cooperative tasks of work in the context of the natural, social and physical environment.

Web-based collaborative tools have the potential to significantly enhance the ability to train and educate the public electronically. Whether the materials are a stand alone tutorial or a full-fledged online workshop, the web provides significantly new functionality in transmitting information to the user and providing forums for exchange. For instance, distance education and virtual classrooms are useful tools for delivering knowledge remotely, since they allow users to create their own instructional paths by using different technological alternatives (such as accessing electronic resources on Internet, electronic mail, conferences online, cooperative work, etc.). These technologies create a distance education environment which can exist beyond the traditional boundaries of a particular location and is accessible to a broad range of people, involving them in a highly interactive participatory process (for more information, see (Dwyer et al., 1995; Fiorito et al., 1995; Ibrahim and Franklin, 1995)). Sharing perspectives and experiences helps people to come up with ideas, and to recognize the complexities of concepts and skills. From the other side, evidence shows that if collaborative learning is effectively implemented, people can solve much more complex

problems and come to far more sophisticated understandings than they could do on their own (Kolodner and Nagel, 1999).

The architecture of CIED, therefore, would be comprised of a CSCW system with clients and servers distributed across the Internet as an open forum for all collaborators. This architecture can easily accommodate all of the relational infrastructures between planning committees, community centres and individual collaborators. These infrastructures should also incorporate transparent, secure, fast and cooperative network configurations.

There are two basic approaches to deploy GIS or any other complex, data driven applications on the Internet, which are server side and client side applications. In the case of the server side, a web browser is used to generate server requests and display the results. They comply with Internet standards because all the data processing is carried out by the server and the result is usually an image and a row from a database that can be wrapped in Hyper Text Mark-up Language (HTML) and sent back to the client. When a new user arrives at a server side application site, they receive an initial response more quickly than a client side web-based GIS can provide.

The client side web-based GIS are enhanced to support GIS operations. This can be achieved by downloading a certain amount of GIS functionality to the client or involves downloading a full-blown plug-in. This enhances the user interface slightly, removing the need for processing to take place on the server, and implement solutions using vector data (for a full review of client and server architectures, see (Gifford, 1999)).

In order to be effective, the CIED would need to break down the functionality of collaboration systems into smaller functions, because of the relative newness and complexity of these systems. Like in the other basic models with multiple phases, feedback from subsequent phases would need to be used to modify the results from the previous phases. The system constructs the trio of communication, collaboration and coordination among all of the participants (Figure 2).

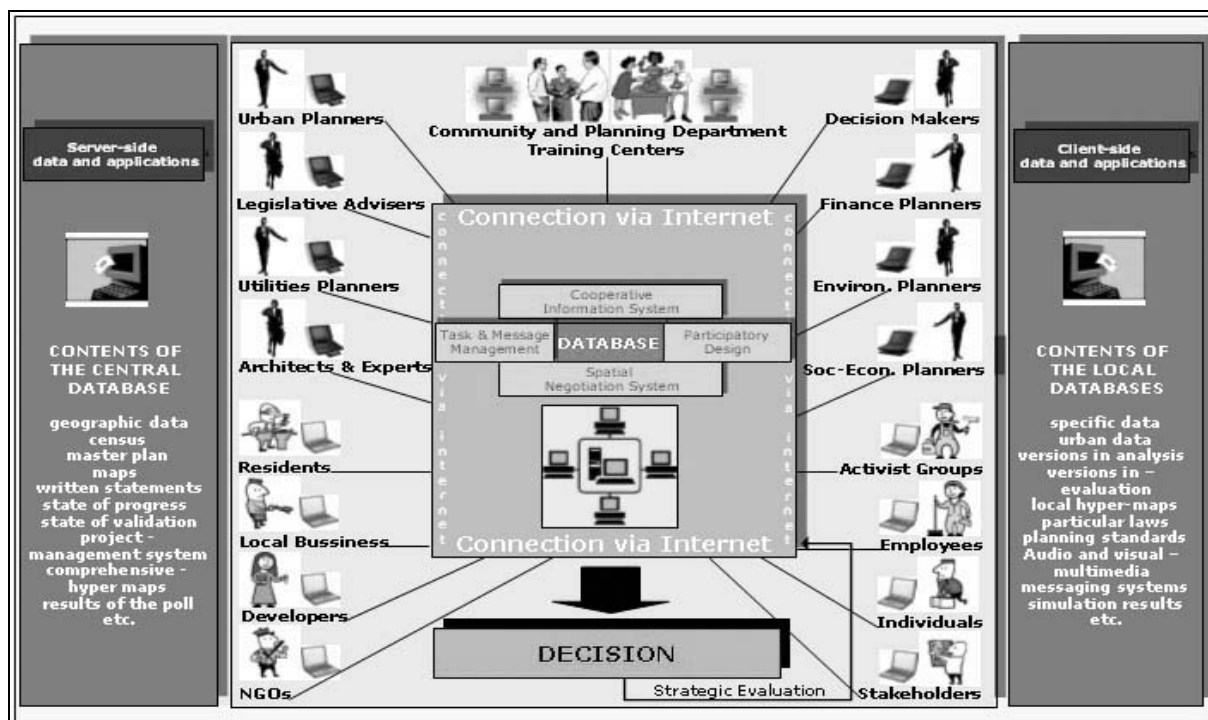


Figure 2. System Architecture of CIED

Turning to the discussion of how best to promote online interaction, it is important to recognize that a great deal of online interaction relies on programmes called Common Gateway Interfaces (CGIs), which negotiate a dialogue between the user and the web server. The dialogue goes something like this: The user types information into a form on a web page and submits the information to the web server. The server accepts the information and processes it in some predefined fashion, adds it to database, emails it to someone, appends it to a web page. The server often sends a confirmation to the user, perhaps an acknowledgment of receipt or a page that displays the submission.

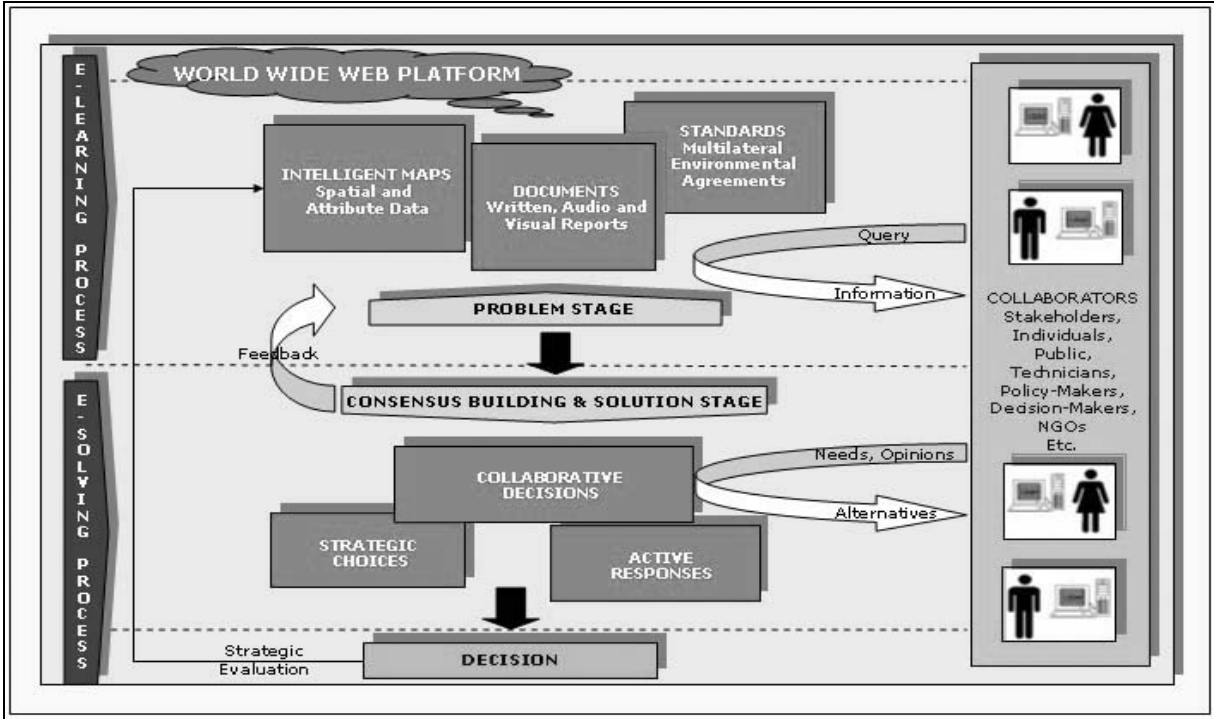
Other tools to support interaction include discussion modules, the 'chat room' and the 'discussion area.' The main distinction between the two is time. Participants in a chat room post and are responded to in real time. If they are not in the 'room' while the dialogue is taking place, they are not part of the discussion. The chat room model provides synchronous communication; it is like a phone conversation or a face-to-face dialogue. People who post to discussion areas, by contrast, are asynchronous participants in online conversation: to contribute to a discussion they need not be online when a comment is submitted and a posting can be responded to days later. In an endeavour like the CIED web site, a discussion area is likely to be more useful than a chat room. The type of user dialogue sought by system

administrators is better suited to the discussion format than the less structured and somewhat ephemeral chat room model.

Having discussed the basic architecture underpinning the CIED model, it might now be useful to explore the various stages involved in the model utilization.

**Stages of CIED**

Environmental management is a daunting task, because so many factors must be taken into account, and environmental decision-making requires that the participants understand not only for the immediate impact of human activity on the environment, but also requires appreciation of other factors including human health, equity, economic costs, as well as current and pending regulations. CIED, therefore, contains distance learning or e-learning and problem solving processes to give the collaborators basic knowledge on relevant issues. Environmental problems, solutions, spatial and attribute data, various documents and standards are also presented on the Internet platform by CIED (for schematic presentation of the contents of CIED, see Figure 3).



*Figure 3. Contents of CIED*

Environmental and planning information systems rely heavily on GIS capabilities to work with complicated data and the ability of the expert user to understand, facilitate and

perform the analysis on the spot using the full toolbox of GIS capabilities. Moreover, CIED, contains distance learning and problem solving tools to give collaborators a basic background on how to use the system (Figure 4).

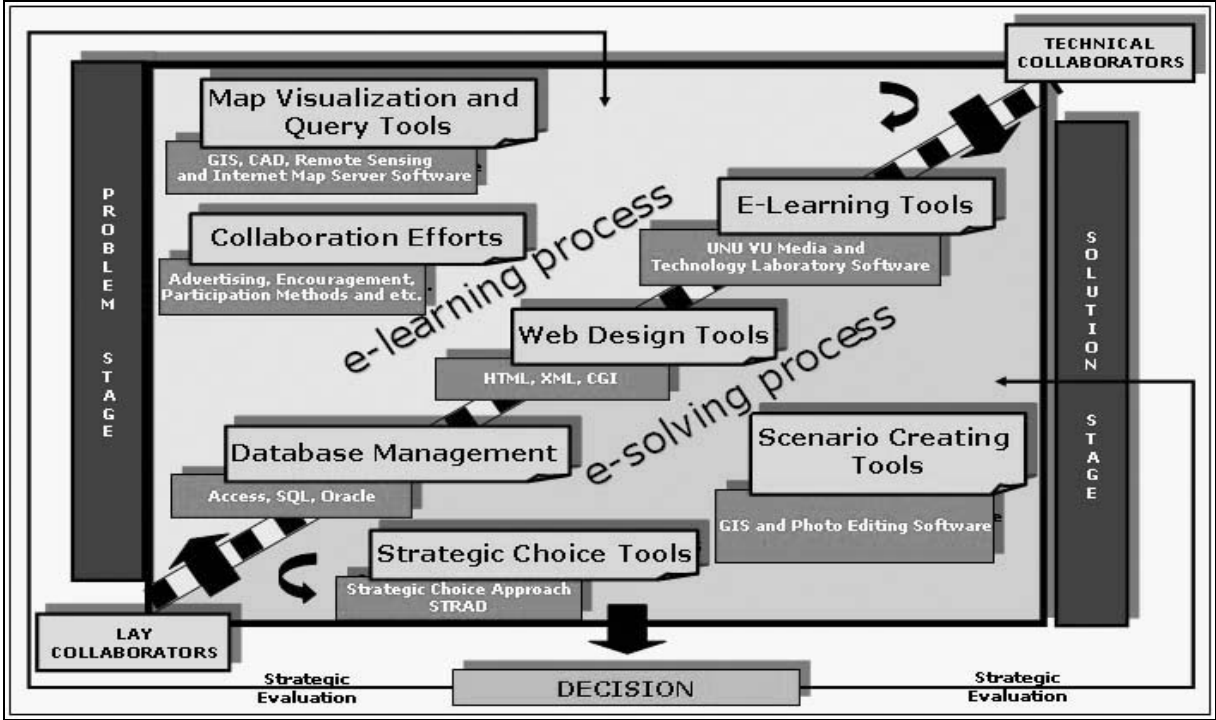


Figure 4. System Overview of CIED

Nine functional steps of such environmental decision making model are as follows: (1) introduce the tools and issues to the collaborators; (2) application of the tools to aid environmental decision-making; (3) identification of environmental values; (4) characterization of the environmental setting; (5) application of the tools to develop an understanding the socioeconomic and political setting in environmental decision making; (6) characterization of the regulatory and judicial setting; (7) integration of information; forecasting for environmental decision making; (8) assessment, refinement, and narrowing of options; and (9) post-decision assessment.

CIED is comprised of ‘problem’ and ‘solution’ stages. Both stages are connected through a series of five sections and fourteen steps. The problem stage would involve the use of various e-learning tools to raise awareness of the public on the system and environmental issues that they are facing. Moreover, at this stage, the system endeavours to provide basic information on how to undertaken environment, planning and decision-making in a collaborative manner. This stage supports community based environmental decision-making

by offering a range of new approaches for the users to select from. It assists the public in better understanding, forecasting and visualizing the consequences of alternative scenarios for their environs. This can be accomplished through the application of ICT, such as, GIS, image, multimedia, interactive, and other computing technologies, coupled with professional planning assistance and training (Figure 5).

There are two sections in the first stage. The first section of CIED is the introduction section where collaborators get basic information about the system and log on to it, specifying a member profile (basic information such as, name, gender, age, occupation and contact information). The CIED system is an open platform for anyone who wants to be a part of the environmental problem solving process. CIED can be seen as an open communities' network that accommodates real time processing and establishes online relationships that strengthen environmental protection and decisions of local governments, institutions, communities and individuals.

The second section is the issues and information sharing section and this contains a basic introduction to the system. It incorporates text and graphic based information on general strategies about the case studies, spatial and non-spatial data, related global multilateral environmental agreements, national and local environmental regulations, and local planning and environmental standards. Collaborators can view the list of factors, constraints and opportunities, and comment on existing preferences at the final step of the second section. If the collaborators understand the different facets of the problems and existing conditions, and have enough knowledge to be able to cope with them, then they can continue to the next section. Otherwise they can go back to the earlier steps to gain the knowledge to continue further sections of the CIED process.

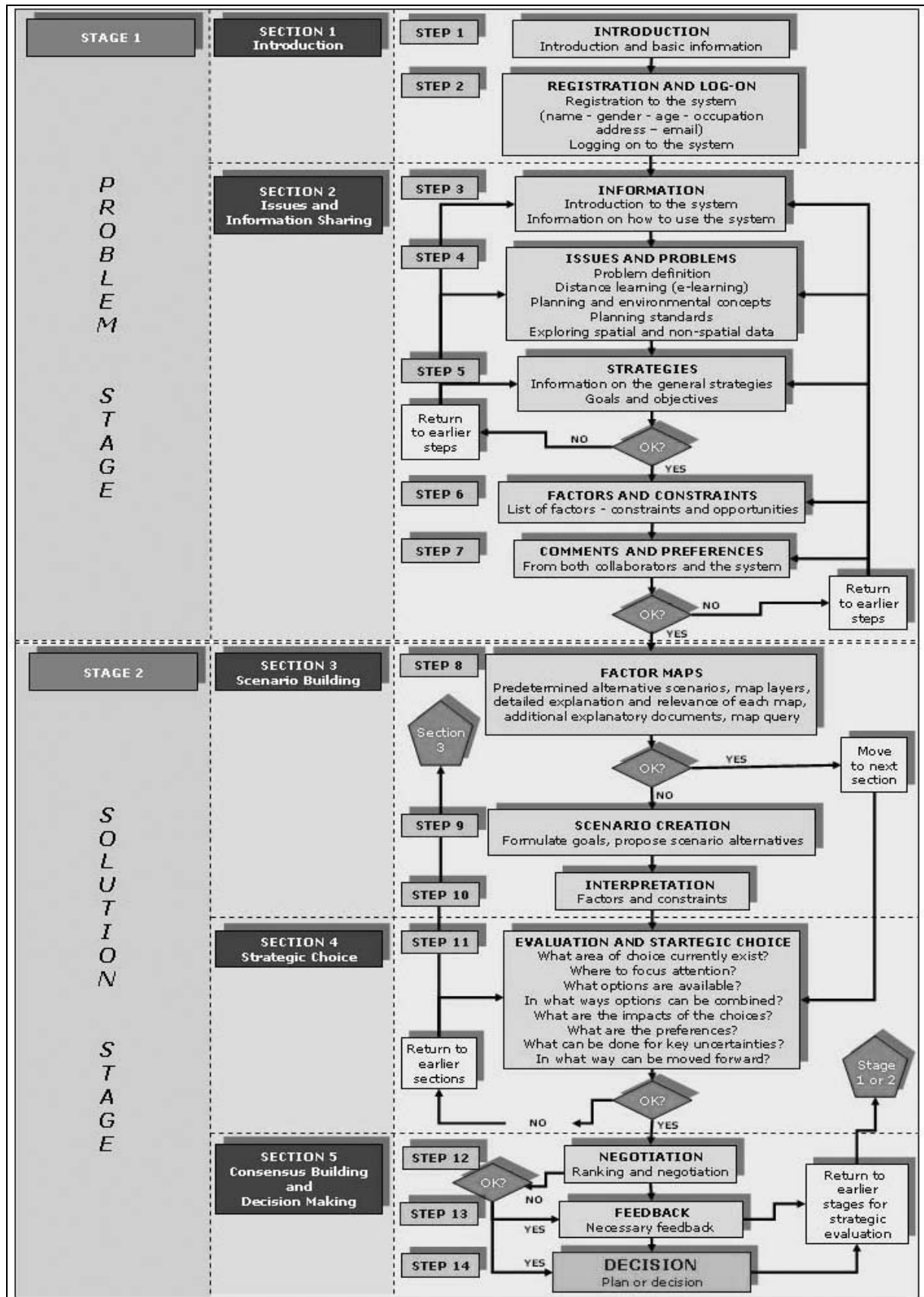


Figure 5. System Flow Chart of CIED

The second stage of CIED is the consensus building and solution stage and it contains an interactive collaborative solving or e-solving process. This is the stage to develop and evaluate alternative scenario and to shape strategic decisions. It is important to recognize here that spatial decision support systems are often designed specifically to address semi-structured problems. They often lack support for collaborative decision-making. Hence, for this reason, CIED accommodates collaborative GIS (for more information, see (Faber, 1997; Sapien, 2000)) and decision tools to support the decision making process. The solution stage of CIED employs new tools, which are needed to form explicit links between criteria space and the geographic space that is being managed. Environmental problems often result from the distributed and uncoordinated land use management practices of individual decision-makers. Taken together, they cause significant environmental impacts. In developing feasible and politically acceptable solutions to such problems, it is often necessary to foster cooperation and consensus among a diverse set of special interest groups who have overlapping sets of objectives. Participants must discuss their opinions on the specific cases and try to search for a solution at the CIED's consensus building and decision-making section.

The third section is the scenario building section. At this step, map layers can be switched on and off and detailed text based information can be viewed by the collaborators. Moreover, predetermined scenarios and additional explanatory documents can be studied to understand the situation and the alternative solutions available. If collaborators do not want to create their own scenarios, they can jump to step four and run the evaluation model for the predetermined scenarios generated by the system or by other collaborators. Otherwise, they can proceed to the next step to propose their own alternative scenarios. After they create their scenarios, they can reinterpret factors and constraints and then move on to the next section.

The fourth section is the strategic choice section, whereby scenarios are evaluated using the strategic choice approach (for more information, see (Friend, 1997a; Friend, 1997b; Friend, 1999)). If collaborators are satisfied with the evaluated results, they can proceed to the next section. If not, they can return to the earlier sections for feedback and scenario correction.

The fifth and final section of the CIED is the consensus building and decision-making section. At this section, interactive negotiations between all collaborators, and ranking between all chosen scenarios occurs until a consensus is built between them. However, developing a consensus between collaborators can be very difficult and time consuming. If further feedback is necessary, collaborators return to the earlier stages of CIED for strategic

evaluation and feedback. Before the final decision is approved, the entire process may need to be reviewed one more time or in another words a post-decision assessment will be required.

CIED is a continuous and dynamic decision support process. Consequently, the decisions have to be evaluated in an iterative and cyclical way until all uncertainties are removed. This kind of approach can only facilitate better (smart) decisions through the adoption of an open platform for all contributors, promoting consensus building, while adopting user-friendly technologies, and accommodating strategic decision support systems.

Collaborators, in the context of environmental problem solving, represent several interests and bring to the negotiation table different types of training, levels of education, experience with computing technologies, and familiarity with the problems that are being addressed. This dissimilarity of knowledge can have significant effects. In spite of their differences, these people often cannot easily work together to devise solutions unless they have been trained to do so. In this context, if supported by effective user training, it is possible to argue that CIED could potentially evolve into an important tool to overcome the conceptual and technical barriers that inhibit the effective use of innovative technologies for environmental problems.

## **Conclusions**

This working paper has proposed that spatial data related to environment should be increasingly represented virtually on the Internet in order to enhance information and decision sharing. It is argued that online participatory systems provide the opportunity to open up important national, regional and local decision-making on environmental and other problems to a much greater audience and could actually involve the public more directly in the decisions which matter. This is not as straightforward as it seems that there are a number of possible limitations that need to be addressed. As mentioned in this working paper, these limitations are both technical and social.

Nevertheless, the integration of community based interactive environmental decision-making support systems to planning mechanisms could similarly have numerous technical and social benefits. However, it is clear from this working paper that a number of key research questions remain to be more fully explored in relation to CIED in the subsequent stages of this research project.

First, does CIED have the potential to incorporate more social issues compared to other technologies and to supply equal access to data and information for users over Internet?

Second, to what extent can CIED encourage individuals to share their opinions on the environment, help communities maintain a smart and healthy balance, aid in the conservation of natural resources, assist with the incorporation cultural identity in decision-making (by enhancing citizen consciousness) and also help to bridge the gap between decision makers, technicians and the public?

Third, to what degree can CIED accommodate an equitable representation of diverse views, preserve contradiction, and at the same time endorse the role of individuals and communities in creation and evaluation of development plans and strategies by promoting online citizen participation in environmental decision making?

Fourth, through the application of CIED in the field, will it be possible to promote environmental planning and the integrated management of resources based on the sensitivity and needs of communities?

Finally, will the application of CIED support the appropriate use of analytical tools and data sets in policy making and planning so as to ensure the effective examination of possible short and long-term outcomes on the environment?

With the current state of development of CIED, it is possible to assert that this approach has the potential to become a key framework for the incorporation of collaborative spatial decision-making tools at the local level. Generic ideas presented in this working paper may be of interest to people who are developing online environmental information systems and communities that are willing to integrate them. However, the true potential (and limitations) of CIED will only become apparent after the completion of a pilot project in Tokyo in the summer of 2002. Subsequently, a follow-up working paper will be prepared and disseminated.

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