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Information Technology and Sustainable Development

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Abstract

A recent United Nations (UN) study concludes that degradation of the world's ecosystems over the past century "…could have devastating implications for human development and the welfare of all species." (United Nations, et al., 2000, p. 6). The report calls for an "ecosystems" approach to environmental problems that would foster "sustainable development," development capable of meeting the needs of today without sacrificing resources needed by future generations. The ecosystems approach would take a holistic view of problems; include the public in the management of ecosystems; integrate social and economic information with environmental information to address the ecosystems "information gap"; and bring urban planning into ecosystem management, as urbanization places severe pressures on ecosystems today. This paper argues that ecosystems management constitutes a "wicked" problem (Rittel and Webber, 1973) or a "mess" (Ackoff, 1999), and that Singerian inquiring organizations (Churchman, 1971; Courtney, Paradice and Croasdell, 1998; Richardson, Courtney and Paradice, 1999) can provide a framework for ecosystems management. A study of infrastructure decision making in Houston, Texas (Lomax, et al., 1998) is presented as an example of using the Singer model in ecosystem management. The objective of the study is to develop decision support systems for Houston's infrastructure systems, including roads, sewers, water supply, and drainage. A very broad perspective on infrastructure decision making is being taken. The relationships among built, human and natural environments are being considered. Preliminary results show that infrastructure decision environments are indeed wicked, that the Singerian model does provide a useful framework in which to investigate them, and that decision factors tend to cluster into political, need, economic, and environmental categories. The wicked domain presents special problems for DSS development. However, an effective DSS may be help alleviate the present lack of communication among stakeholders, especially if it is integrated with a geographic information system currently under development.

Introduction: The Problem

The summary of a United Nations–sponsored report on the status of ecosystems worldwide states that "The current rate of decline in the long-term productive capacity of ecosystems could have devastating implications for human development and the welfare of all species." (United Nations, et al., 2000, p. 6). The study, conducted by 197 scientists around the globe, found that:

- Half of the world's wetlands were lost in the last century.
- Logging and conversion have shrunk the world's forests by as much as half.
- Some 9 percent of the world's tree species are at risk of extinction; tropical deforestation may exceed 130,000 square kilometers per year.
- Fishing fleets are 40 percent larger than the ocean can sustain.
- Nearly 70 percent of the world's major marine fish stocks are over-fished.
- Soil degradation affects two-thirds of the world's agricultural lands.
- Some 30 percent of the world's original forests have been converted to agriculture.
- Since 1980, the global economy has tripled in size and population has grown by 30 percent to 6 billion people.
- Twenty percent of the world's freshwater fish are extinct, threatened or endangered.

To address these issues, the report calls for an "ecosystems approach" to managing the world's resources. The ecosystems approach:

- Is an integrated approach that recognizes the "system" in ecosystem and manages them holistically rather than sectorally, and realizes that they cross jurisdictional boundaries.
- Includes people and "integrates social and economic information with environmental information, …thus explicitly linking human needs to the biological capacity to fulfill those needs." (p. 21)
- Assembles information to allow a careful weighing of the trade-offs among various ecosystem goods and services, and among environmental, political, social, and economic goals.
- Includes the public in the management of ecosystems, particularly local communities, whose stake in protecting ecosystems is often greatest.
- Addresses what the report calls the "information gap," (p. 21) by assembling, organizing, and distributing knowledge and information about ecosystems and the political, social, cultural and economic environment in which they exist.
- Involves local communities and integrates urban planning into ecosystem management, as "urbanization and urban consumers are among the most significant pressures on ecosystems today." (p. 22)

The report goes on to say that "We can continue blindly altering Earth's' ecosystems, or we can learn to use them more sustainably." (prologue)

Sustainable Development

As the report implies, governments and businesses have already begun to address the problems noted above in the movement for "sustainable development." The World Commission on Environment and Development (WCED) suggests that development is sustainable when it "meets the needs of the present without compromising the ability of future generations to meet their own needs." (www.wbscd.ch) The WCED and many other organizations, including the World Business Council on Sustainable Development (www.wbscd.ch), the Global Reporting Initiative (www.globalreporting.org), the Institute of Social and Ethical Accountability (www.accountability.org.uk), and SustainAbility (www.sustainability.org.uk) are working on standards and reporting requirements for business organizations that would encourage much broader considerations, including ecosystems concerns, in corporate reporting. The UN has also sponsored an extensive study which catalogs a wide variety of ways in which information and communications technology can be used to facilitate the development of sustainable communities (Mansell and Wehn, 1998).

Sustainability has ethical dimensions, as described by C. West Churchman in his "Ethics and Sustainability Online Forum" (haas.berkeley.edu/~gem/gift.html). Churchman celebrates the new millenium in "A Gift to Future Generations," saying that:

Since it's about the whole of humanity, this celebration is global. Since it's about the good things and the bad things in human life, the celebration is ethical. And since the overall condition of humanity is a result of our decisions, the celebration is management. The acronym is gEm [Global Ethical Management], a jewel with plenty of sparkle and a lot of flaws.

Clearly ecosystem management, sustainability and global ethical management raise broad ranging, complex, and vexing issues. They are linked, in that they embrace a long-term view of development, one that considers the needs of our progeny. They are "messes" (Ackoff, 1999) in the sense that each element of the mess is itself a complex problem that strongly interacts with every other element of the mess. They are "wicked" problems (Rittel and Weber, 1973) in that they have no definitive formulation, and no clear cut solution, except perhaps from the perspective of a single group of stakeholders. Problems that are this complicated and ill-structured require thinking that recognizes their complexity and attempts to deal with that complexity in a holistic way, rather than via reductionism, which tends to rob such problems of their richness and leads to simplistic solutions that only make the problems worse. Churchman's (1971) Singerian inquiring system, and Mitroff and Linstone's (1993) Unbounded Systems Thinking provide a framework for dealing with problems of this ilk.

Singerian Inquiry and Sustainable Development

It has been argued that Churchman's Singerian inquiring system is well suited to dealing with wicked, messy, highly ill-structured problems (Mitroff and Linstone, 1993; Courtney, et al., 1998; Richardson, et al., 1999; Richardson, et al., forthcoming; Courtney, 2000) such as those of ecosystems management. In describing the Singerian inquirer, Churchman says it, "… is above all teleological, a grand teleology with an ethical base." (1971, p. 200) Singerian inquirers seek a highly idealistic purpose, the creation of "exoteric" knowledge, or knowledge for "every man", as opposed to scientific, esoteric knowledge that, as it matures, becomes relevant to an increasingly smaller audience. It seeks this knowledge in such a way as to take human and environmental considerations into account. In other words, the Singerian inquirer seeks the ability to choose

the right means for ethical purposes for a broad spectrum of society, it seeks the same goals as ecosystem management and sustainable development.

The Singerian inquirer views the world as a holistic system, in which everything is connected to everything else. From the Singerian perspective, problems and knowledge domains (disciplines) are highly non-separable. Complex social and managerial problems must be analyzed as wholes (Mitroff and Linstone, 1993). The artificial division of knowledge into disciplines and the reduction of complex problems into simple components inhibits the solution to social and management problems. Solving complex problems may require knowledge from *any* source and those knowledgeable in *any* discipline or profession. Thus, Singerian inquiry, consistent with the needs of ecosystem management and sustainable development, integrates knowledge and information from a variety of domains, including both social and "hard" sciences, politics and from the public.

Applying the Singerian Model to Urban Infrastructure Management

A project underway at Texas A&M University (Lomax, et. al, 1998) exemplifies use of Churchman's Singerian inquirer and unbounded systems thinking in studying sustainablility. The objective of the project is to develop decision support systems that will lead to improved decision making regarding urban infrastructure investments, that is, investments in roads and bridges, fresh water supply systems, waste water treatment, drainage systems, and the like. Infrastructure constitutes a complex system of public assets, which vary in their nature, but which serve the common purposes of fulfilling basic needs of the public, improving quality of life, preserving environmental quality, and providing for the well being of citizens in general. The project adopts a holistic view of infrastructure as a system, consisting of a confluence of natural, built, and human domains. The natural domain is the ecosystem; the built domain consists of infrastructure assets themselves, plus buildings and other structures; the human domain includes all the various stakeholders, involved in providing, managing and using infrastructure assets. A plethora of stakeholders is involved, ranging from citizens, who use the services, to the mayor and city council, who make the final decisions, city departments, such as public works, that plan and maintain the infrastructure, and finance that administers funds. Also heavily involved are contractors and developers that build infrastructure, citizens, neighborhood residents and the public in general who use it, and numerous other city, county, state and federal agencies that regulate or otherwise affect infrastructure decision making in some way. Thus the scope of the project is quite vast, and coincides well with the call for urban management studies in the UN-sponsored world ecosystems report mentioned above. The city of Houston, Texas, which is cooperating in the project, is serving as the test bed for the development of the infrastructure DSS.

The first phase of the project consisted of the project team familiarizing itself with infrastructure management on a general level, by reading and sharing extant knowledge in presentations and meetings. The team itself is quite diverse and consists of individuals knowledgeable in transportation systems, water supply and waste water treatment, ecosystem management, political science, sociology, economics, geographic information systems, and decision support systems. Once each team member's specialized knowledge had been broadened with general knowledge of infrastructure management, the team prepared to interview relevant stakeholders. Questionnaires reflecting the Singerian perspective were developed to guide structured interviews for five different categories of interviewees: politicians, technical personnel, contractors and developers, citizens, and media representatives. When the questionnaires were done, the team was ready to begin interviewing people in Houston to understand specifically how infrastructure decisions are made there. Approximately 200 interviews are planned, and about 25 have been conducted at the time of this writing. While it is far too early to make many definitive conclusions regarding the project, some tendencies have been noted, among them:

- Urban infrastructure decision-making environments indeed qualify as one of Ackoff's (1999) messes. Every subsystem is related to every other subsystem and each is caught in a quagmire of political, social, economic, cultural, technical and environmental factors that defy easy solutions.
- Consistent with previous studies (Richardson, et al., forthcoming), results thus far in this project seem to indicate that the Singerian model, unbounded systems thinking, and Courtney's (2000) paradigm for DSS decision making provide a holistic perspective and a structure for dealing with the "mess."
- The decision factors tend to cluster into four broad categories: need, based on engineering studies, health care concerns and so forth; economics, based on the revenue and expenses the city expects, and the expected cost of possible projects; environmental, the ecosystem itself; and politics, based on parties in power and their constituents.
- Each group of participants in the "process" (if it is a process) uses factors from all three categories in making their decisions. For example, it's not just the politicians that use political considerations in their decisions. Public works dedicates a percentage of its infrastructure budget to members of the city council, who can choose projects in their district however they want. This helps to keep the council members from complaining to public works that they don't get their share of infrastructure dollars, and allows council members to direct resources at specific

problem areas in their district, or to specific target populations.

- Agencies and departments and other stakeholders tend to be "silos," sharing little information about projects and the status of systems. A geographic information system (GIS) being developed in the planning department may help to alleviate this problem somewhat.
- Developing decision support systems for factors in the needs and economics categories will probably not be difficult, at least not nearly as difficult as dealing with political considerations.
- There is a basic need for sharing more information among all groups involved in infrastructure, especially between the mayor's office, city council members and public works.
- Since so little information is currently shared, an effective DSS could go a long way towards improving communication among stakeholders, especially if it is integrated with the GIS currently under development by the planning department.

Summary

In recent years increased attention has been given to the negative impact of contemporary lifestyles on the environment. Current rates of population growth, agricultural practices, and energy use have made evident the effects of individuals, governmental, and business impacts on ecosystems. Issues such as the environment, financial accounting practices, business decision making, city infrastructure, and governments, each historically viewed as separate or abstract, are now being incorporated into a holistic approach to solving sustainability problems. These recent trends in thought have taken the focus away from blaming environmental problems on those organizations whose impact is most obvious, such as logging, and industrial plants, and toward viewing environmental problems holistically, recognizing numerous factors are involved on every level. This paper first recognizes the current issues facing the environment and then defines sustainability and points out the business impacts and implications on sustainability. The Singerian model is proposed as an effective approach to working though complex issues, and lastly an example of some current work is provided to illustrate the role of urban infrastructure decision making on sustainable development.

As increased attention is directed toward issues of sustainability three important issues have emerged. First, if the status-quo is maintained the planet may not survive; second, the issues surrounding changes in practice are exceedingly complex; and third, better information systems are needed to help in making ecosystem management decisions.

The Singerian model is proposed as a useful tool for solving the current problems, as this is a model born in complexity. It views all things as being related, pulls in knowledge from every conceivable source without regard for traditional compartmentalization of knowledge, emphasizes a team approach to problem solving necessary for bringing together all of the players involved, and encourages working cooperatively toward the benefit of all mankind, and in this case the planet as a whole.

The Houston project, an example applied to the sustainability issue through the Singerian model, allows us to begin to see the complexities of the problems. This model also illustrates ways in which previously fragmented players can come together to address environmental issues, recognizing the role that they each plays in the overall picture. Also emphasized is the importance that sharing of information may have in solving complex, messy problems.

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