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Abstract

We are entering a period of very rapid increase in the availability of global natural resources data. This is fortunate because we are also confronted with a long list of global problems that are resource related. GIS technology offers many advantages in dealing with such problems. These rapid changes are driven by developments in computer technology that have occurred at both ends of the spectrum of computing capability—in supercomputers and in personal computers. For example, personal computer users soon will be able to work effectively with many kinds of global databases on systems that cost less than $500. In spite of this progress, there are problems that still need to be overcome. Existing data resources must be captured in or converted to digital form, and all data must be more widely shared. Despite the problems, a dozen or more global databases already exist; and if the public databases are more widely shared, the effect on global problem solving is likely to be profound. Those persons with an understanding of the nature of these changes and their implications need to share their understanding more widely with others.

INTRODUCTION

We are entering a period in the development of GIS and related technologies in which all of the necessary elements are in place for the creation of global GISs for natural resources and related kinds of information. These elements include (1) computer hardware that is inexpensive enough and powerful enough to be both widely available to users and also capable of dealing with very large databases, (2) GIS and database management system (DBMS) software that is capable of dealing with large and complex databases yet is also user-friendly enough to permit a wide range of persons to become GIS users, (3) data communications technologies that are capable of allowing users all over the world to interconnect in a single network, and (4) remote sensing devices that can capture data for the entire world in a few days and do so at resolutions that are useful for natural resources and related problems. These technologies now make it possible to think seriously about what kind of global GISs we would like to have and how they should be put together; indeed, the first such GISs are now in place.

GLOBAL NATURAL RESOURCES PROBLEMS

Naming a variety of natural resources-related problems that are either global in scale or that have global implications is easy: tropical forest removal; energy resources depletion (coal, oil, natural gas, etc.); soil erosion and desertification; management of water resources for drinking, irrigation, and industry; land management for grazing and wildlife; loss of biodiversity; possible global climate change; acid precipitation; and so on. In each of these cases, the possibility of rational decision-making and management of the problem depends on the availability of timely and comprehensive information about natural resources. Fortunately, in many of these cases, the technology is now in place for providing the required information.

PARTICULAR IMPORTANCE OF GIS FOR GLOBAL PROBLEM SOLVING

GIS technology is of particular importance in dealing with global natural resources problems because the base majority of these problems have important spatial and geographic components. They are problems that occur in real space and time at places around the world. Moreover, their spatial aspects are usually important to the solution of the problems. Further, by sharing the same space, many of these problems are interconnected with one another. Thus, spatial or geographic referencing draws these various problems together, and spatial referencing helps to integrate the various kinds of data that are related to the problems.

In addition, the powerful capabilities of computer-based information processing are important to the process of understanding these problems, communicating about them, and, ultimately, devising solution strategies.

COMPUTER HARDWARE FOR GLOBAL GIS DATABASES

The global databases that are needed for dealing with some of these problems are not of overwhelming size, at least in relation to the computer hardware tools now available to us. While supercomputers costing tens of millions of dollars are used for manipulating some kinds of global databases, such as those dealing with global weather, there are other kinds of global databases that can be managed rather effectively by personal computers (PCs).

Indeed, in thinking about solving some kinds of global problems in which the important decision-makers will be officials in Third World countries, the computer standard that ought to be assumed might be an IBM PC or compatible machine with something like a 286 chip. The memory of such a machine can now be augmented with a CD-ROM drive capable of storing more than 800 megabytes of data on a single CD. By changing disks, such a computer system could deal rather effectively with a database consisting of many gigabytes. (As will be seen below, the first publicly available digital GIS database for the world at a scale of 1:1,000,000 contains something over seven gigabytes of data and is designed for use in a PC environment.) Moreover, CD-ROM storage is quite inexpensive. It is also stable, easy to ship from place to place, and it avoids the problems often connected with network communications in many parts of the world.

Thus, while for some applications supercomputers or mainframe machines or powerful workstations are important, there are many applications of global natural resources GIS databases in which quite inexpensive machines can be useful. This means that a very wide variety of user organizations and even economically weak governments are now in a position to begin taking a broad view of the natural resources problems that face them.

The time is not far off when complete computer hardware/software systems for dealing with global natural resources problems will cost less than $500. When this occurs, it may lead to quite a different approach to global problem solving.

Similarly, the time is not far off when the capabilities of present supercomputers will be available in desktop machines that will also store gigabytes of data quite compactly, which is also likely to revolutionize our approach to global problem solving.

A final revolution now under way is the revolution in data communications. In various places in the developed world, fiber-optic communications networks capable of transmitting hundreds of gigabytes of data per second over long distances are being put in place. When such a network links the countries of the world, global GIS databases can be centrally maintained and yet widely shared. This process of sharing may even beget international cooperation in solving global natural resources problems.

PROBLEMS WITH GLOBAL SHARING OF GIS DATA

Despite these encouraging circumstances, there are still numerous problems that must be overcome if true global sharing of natural resources GIS information is to be achieved.

At the present time, much of the data needed for approaching global problems is not in a form that can be combined with other data into a single, coherent database. Numerous hurdles must be overcome. In many cases, the required baseline data, which would permit comparisons between present conditions and those of the past, are simply not available or they may be available only in nondigital forms or they may be widely scattered.

In many cases, the data are in the form of paper maps. An effective means of rapidly, inexpensively, and accurately capturing such data is still needed. Although scanning has come a long way, it still does not fully meet the needs in this area. Nevertheless, there is hope that within the next decade or so, with wider use of expert systems technology, the remaining hurdles to effective scanning will be overcome.

Where data are in digital form, they are often in forms that are incompatible with one another. This is often more than a data conversion problem: The classification systems (for soils, vegetation, etc.) may be incompatible with one another; the scales at which the data were gathered may make them mutually incompatible; other kinds of problems with bringing the data together may be present. In many cases, these problems can be overcome by labor-intensive manual methods of integration and standardization. Unfortunately, such methods are not widely understood or practiced. Much work needs to be done in this area, and the costs are likely to be considerable.

In some cases, all that can be done is to attempt to establish data standards for future data-gathering efforts in order to ensure mutual compatibility. A large number of organizations are working now to establish just such standards, and new international standards for GIS data are being tested at the present time. Once accepted, it will be necessary to work to obtain wide compliance with such standards.

Even where data exist in a suitable form, they are often not effectively shared. There may be economic, business, political, or bureaucratic reasons for this problem. Arrangements that foster much wider sharing of available global natural resources data are needed. Where successful examples of sharing are found, they should be widely copied. The end of the cold war offers a unique opportunity, unavailable in seventy years, for global data sharing: We ought to take advantage of this opportunity.

BEGINNINGS OF GLOBAL NATURAL RESOURCES GIS DATABASES

Ten public global databases of various kinds are maintained by about an equal number of international organizations. The latter include United Nations organizations as well as international scientific organizations. Most of these databases were created within the last decade or so. Most deal with natural resources in one way or another. They include data on such important natural resources as tropical rain forests and rare, threatened, or endangered species; they are designed to deal with such important problems as desertification and global climate change; they go by such now familiar names as GRID and GEMS.

While they are important, these databases are but the first of the global GIS databases and are not necessarily representative of what global databases will be like in the future or how such databases will be created, maintained, and used. Many have been compiled at considerable cost over many years through the efforts of often widely scattered groups of devoted workers. The negotiations required to produce the databases have often been tedious and time-consuming. Each such database is a pioneering effort in its own way; but it may be that in the future the creation of such global databases will be accomplished more rapidly and efficiently, both because of what has been learned through these pioneering efforts and because of rapid improvements in technology over the last two decades.

Very recently, for example, the U.S. Defense Mapping Agency (DMA) has converted more than 270 of its 1:1,000,000 aerial navigation charts to digital cartographic data in the form of a single Digital Chart of the World (DCW). The database is on four CD-ROMs that contain a total of about seven gigabytes of data, and these digital data conform to a single, well-defined set of standards. They probably represent the largest-scale publicly available digital GIS database ever assembled. The cost of the data on the original charts has not been calculated, but the cost of the conversion process alone approached 10 million dollars. Yet the data on the set of four CD-ROMs can be purchased by anyone for a few hundred dollars. It now seems likely that the DCW will become the de facto basemap for a wide range of new global geographically referenced databases. This project may be the prototype for other global database efforts in the near future, especially as various kinds of intelligence information gathered over the last forty years is declassified and released by the United States, Russia, and other nations.

Recent advancements in data collection, remote sensing, image processing, and other technical areas are likely to make the creation of global natural resources databases somewhat easier. For example, since the end of the cold war, the resolution of some kinds of unclassified satellite remote sensing data, available to the general public, is now about 2 meters. This means that satellite remote sensing of some kinds of complete global natural resources (forests, waters, etc.) is now within reach of anyone who can afford the price of the imagery. Rather than making use of ground survey methods or aerial remote sensing globe circling, repetitive satellite remote sensing can be used instead. This is an extraordinary step forward.

In the next decade, a revolution in ground-based sensing devices will likely occur, providing a wide range of inexpensive, highly accurate ground measurements of variables such as soil acidity, ambient gases, etc., which cannot be obtained by remote sensing. Combined with advances in remote sensing, this development offers extraordinary promise for global natural resources databases.

WIDER PARTICIPATION IN GLOBAL NATURAL RESOURCES PROBLEM SOLVING

While these developments offer great promise for specialists who deal with global natural resources problems, other technical developments promise a revolution in how such problems are approached.

Developments in GIS technology, especially in the user interface to GISs, now make it possible for untrained, nontechnical users to examine GIS data in much the same way that they would look up information in a printed reference work. When such interfaces are coupled with global natural resources databases, the effect will be to provide average citizens with the possibility of gaining direct insight into global problems without the need for technicians, scientists, and others as intermediates or interpreters. This will likely produce a revolution in the way we approach these problems. For example, it may lead to true grassroots problem solving and will likely produce new perspectives on the problems themselves and new suggestions for solutions. It will certainly affect the way in which various government and organizational decision-makers approach global problems.

As with the technical developments in computer and communications hardware, the developments in user-friendly GIS software are likely to continue and perhaps even speed up. We are only just beginning to see what the implications of these changes are going to be.

ADDITIONAL NEEDS

Despite all of these promising advances, it is likely that some additional kinds of global data will be required before we can be confident that we have the right information to move forward with problem solving.

Computer capabilities and data-gathering capabilities may make it possible to think about global time-series data that go beyond merely a series of satellite images. Very little is known about how most aspects of the global environment change over time. Perhaps in the next decade or so we can change that. Similarly, data about a much wider range of variables is needed. To a considerable degree, we are constrained now to think about and model with those data that it is convenient to gather. Many kinds of data would be useful to have, but we cannot obtain them because of a lack of appropriate sensors, because of the costs of gathering the data, and for other reasons. That may change also. If so, in the future we may be able to create true multidimensional global databases of the kind required for global problem solving.

Much of the data that has been gathered over recent decades is in danger of being lost forever because it is not properly recorded and stored. While the costs of preserving these data are not small, the costs of losing them are incalculable. Those concerned with global natural resources data need to make much greater efforts to preserve this important legacy for future workers.

NEW USERS OF GLOBAL NATURAL RESOURCES INFORMATION

At the present time, the people concerned about global natural resources databases belong to a very limited group of specialists; but as the coming revolutionary changes in processing these data occur, the number of interested people will grow rapidly. With reasonable costs for the data, easy to use GIS software, and wide availability, global natural resources data will be used not just by scientists, governments, and a few nongovernmental organizations but by businesses, educators, and the public. As a result, more and more people will adopt a global perspective in thinking about their own work and their personal decisions. Newspapers, television, and other media can be expected to take a more global view in describing and explaining the daily news. The school children of the future may become as accustomed to thinking in global terms as they are now accustomed to thinking in terms of their own country, their own city, and their own neighborhood. The effect of such changes is likely to be profound.

CHALLENGES

All of these developments present those of us who work with these data and these technologies with many kinds of personal and professional challenges. We must keep abreast of the developments technically; we must understand their implications; and we must foster change where it seems useful and wise to do so. More than this, we must take the time to explain to others, outside our narrow fields, the significance of the information revolution that we can see so clearly. We must, in particular, help decision-makers as well as the public understand the implications of the coming wider availability of global natural resources data.