

# **Institutional Partnerships in Using and Developing Information Technology for Community Environmental Monitoring**

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## **Introduction**

The notion of “real world” geographic information systems (GIS) technology can be examined through reviewing how one of Brazil’s largest non-governmental organizations (NGOs), Fundação SOS Mata Atlântica, has evolved in an iterative process with the development and use of GIS technology. Examining the actual ways in which GIS is incorporated into the activities and actions of NGOs, such as Fundação SOS Mata Atlântica, reveals that geographic knowledge is constructed and represented in innovative ways. This suggests a need for GIS scholars and practitioners to reconsider how GIS itself is conceptualized and constructed. I argue that through an analysis of the iterative relationship between technology and decision making within Fundação SOS Mata Atlântica we can better understand the nature of the organization itself, that it fundamentally serves a unique political mission, and societal beginning points for accessing and acquiring geographic information and information technology.

## **“Real World” GIS**

In the “real world” of GIS adoption, and particularly within low-resource settings, geographic information technologies there are many reasons that systems are developed that broaden the intended uses of these technologies as they were designed. For example, many limit the use of geographic information system software to the generation of map illustrations, failing to fully utilize data management and display capabilities of software, even when spatial information is developed and available in digital form. Alternatively, in some GIS use settings, GIS is seen as a tool to demonstrate technical capacity, even if system outputs are not linked to the organizational decision making processes that GIS was meant to support. Yet another aspect of GIS use in the “real world” is that in many NGO settings the use and development of GIS is

initiated by individuals who seek to expand on their technical skills, identifying from their skill and knowledge base some unique features of GIS software that will enhance organizational capacity.

Many GIS scholars and practitioners recognize that there is a gap between an optimal use of GIS resources and the limitations that arise during the actual practice of integrating GIS into organizational activities. However, case studies examining the actual approaches to adopting GIS and impacts of using GIS within specific organizations have focused primarily on GIS use in planning and governmental settings (Calkins, 1991; Campbell and Masser, 1995; Masser and Blakemore, 1991; Obermeyer and Pinto, 1994; Lopez, 1998; Worrall, 1991). Taken together, these provide a basis for arguing that organizational settings differ in their approach to and need for GIS, and this in turn suggests that other types of organizational settings -- such as NGOs and other community based organizations -- might also present unique spatial information, management and analysis needs.

Fundação SOS Mata Atlântica (SOS) provides one example of how NGOs approach technology adoption and measure outcomes. But, in looking at geographic information technology use within SOS, I do not intend to generalize about NGOs as a class of organization. Instead, I argue that from the example of geographic technology development and use within SOS we gain insights into the subsequent outcomes that represent one realm of the actual geographic information technology development.

SOS's approach to technology use, partly based on its unique societal niche (identified by SOS as "defending and preserving" the "nature" and "natural beauty" of Brazil), represents an alternative scenario of technology adoption which can be understood from the basis of its outlook as a non-governmental organization. Fundação SOS Mata Atlântica's measures its success in contributing to the formulation of state and national environmental policy in Brazil through its ability to build and sustain large scale public participation on SOS projects. One critical strategy for communicating within this public-organizational relationship is through the construction of easily recognized images, including maps, symbols and logos. SOS's development of geographic information technology has been closely linked to this public communication objective, and suggests that we can question whether or not geographic information technology creates real world *understandings*?

## **NGO Approaches for Decision Making**

One approach for understanding the institutional organization and aims of NGOs is to view them in terms of how decision-making is related to social action (Leitman et al. 1993). Perritt and Masucci (1997) suggest that there are several interrelated tasks that comprise the overall decision making framework for environmental NGOs, including: identifying stakeholder

frameworks for involvement in environmental problems; monitoring environment quality; overseeing how local problems are handled; conducting technical research and writing; presenting research in multiple forums; taking steps to get better access for NGOs into “mainstream” decision-making processes; supporting negotiated policy making and dispute resolution; and redefining problems from disputes toward establishing policy. This depiction of the decision-making framework of NGOs is based on a view of NGOs as one among many critical actors in society that interact in relation to the tensions that arise around environmental problems and management at intersecting problem scales.

In contrast to public sector planning and environmental management organizations, whose missions may include environmental quality monitoring, NGOs often address the environmental concerns that help to complete government environmental protection and monitoring programs, thereby providing the impetus for the creation of new governmental policies and programs. But NGOs and other community-level organizations can also be seen as part of and in support of social movements to represent marginalized environmental problems and the environmental concerns of marginalized people (Pulido 1998). These differences in focus compared with mainstream planning and environmental management organizations constitute a very different beginning point for the use of geographic information technology as well. From an NGO perspective, using technology can position the environment as worthy of public concern, and mastery of technology to document environmental quality provides a point of entrance into the mainstream public policy making arena.

In the case of Fundação SOS Mata Atlântica, the general focus of organizational activities and strategizing is to raise citizen involvement in managing local environmental problems. It is one of the larger NGOs in Brazil, established with the original objective of raising environmental awareness in the assessment of problems associated with deforestation of the Atlantic Rainforest. The organization has evolved from one that coordinated the development of a scientific understanding of the geographic extent of deforestation of Mata Atlântica (the Atlantic Rainforest) into an organization which provides leadership on the formation and implementation of state and national environmental policy in Brazil. SOS is not only situated at the center of a now international group of organizations that form a coalition of support for environmental protection policy in Brazil, it also assists other grassroots organizations and community efforts in local environmental monitoring. The development and use of geographic information technology played a critical role in the SOS strategy to gain credibility in its effort to “protect and defend” the Atlantic Rainforest, and has evolved to include extensive use of the Internet in support of organizing over fifty NGOs that form Rede Mata Atlântica (Atlantic Rainforest Network).

## Using GIS to Delineate the Atlantic Rainforest and Map Land-use Change

In the case of Fundação SOS Mata Atlântica, the use of GIS emerged as the primary means of establishing awareness on the part of the public that deforestation was in fact a problem in the State of São Paulo. Using spatial data, primarily remote sensing imagery shared with national and international organizations, and through the technical support of cooperative agreements with government, industry, and international NGOs, SOS provided the coordination for establishing a baseline inventory of the geographic extent of remaining fragments of the Atlantic Rainforest and associated ecosystems. The result was a widely disseminated map of the rainforest domain used primarily by NGOs in the Atlantic Rainforest network, but also including international NGOs. The significance of the mapping project was to propel the problem of deforestation of the Atlantica Rainforest as one of the critical international zones of environmental concern by international environmental NGOs and the World Bank (Dinerstein et al. 1995).

SOS has continued to coordinate an Atlas project, updating baseline information by mapping changes between 1990-1995 in the geographic extent of rainforest and associated ecosystem fragments (Fundação SOS Mata Atlântica 1998). It has expanded mapping to more detailed area studies of ecosystem transition in the states of São Paulo, Santa Catarina, and Espírito Santo, suggesting local conditions that might be causing particular deforestation and ecosystem transition rates. The result has been to provide a information-based argument for the establishment of laws at the state and national level that aim to protect critical remaining forest ecosystems.

This form of information-based environmental advocacy has been replicated through the many action programs that SOS has subsequently developed including Núcleo União Pró-Tietê, Respira São Paulo, and Mãos à Obra!. In each program, there is a heavy reliance on gathering and using social and environmental information to forward basic goals of public participation in building environmental awareness and monitoring capacity. The Núcleo União Pró-Tietê project illustrates the progression from information-based advocacy to public involvement, albeit organized through SOS, in the management of the information.

### GIS Development by Núcleo União Pró-Tietê

In the late 1980s, SOS embarked on an effort to discover the nature and strength of grass roots citizen interest in water quality monitoring for the city of São Paulo's major water supply, the Tietê River Basin. After 1,200,000 signatures were gathered demonstrating support for the initiative, Núcleo União Pró-Tietê, a citizen water watch organization was created. The Núcleo União Pró-Tietê approach to water quality monitoring is to demonstrate on site the use of mobile water quality test kits, to create a water quality database for the Tietê River Basin from data

collected by citizen volunteers, and to provide resources for community environmental education and organizing. Now 5000 citizen monitors strong, Núcleo União Pró-Tietê has been constructing a water quality database for the Tietê River while simultaneously educating citizens throughout the basin region on water quality issues.

Among the many strategies for educating citizens that Núcleo União Pró-Tietê employed is the development of a GIS approach for representing citizen and key decision maker perceptions about environmental problems (Barreto, 1995; Núcleo União Pró-Tietê, 1994). Relying primarily upon volunteer collected water quality data and interviews of local environmental managers to determine at-risk local environments, Núcleo União Pró-Tietê sought to accomplish two objectives in its system's development. One objective was to develop a working map of environmental quality in the whole basin; a second objective was to use map outputs to raise awareness among citizens about where the most at-risk locations were. This GIS system also showed perceived problems throughout the basin by various water and key environmental decision makers. By involving citizens in ownership of the actual environmental risk map, Núcleo União Pró-Tietê hoped to further stimulate grass roots organizing around locally defined water quality problems.

The use of data from volunteers to develop GIS tools shows a conceptualization of GIS that is not burdened by the concerns of data accuracy, the need to integrate data into other systems through data sharing or the need to use out put maps as a decision making tool. Compared with how mainstream planning and government development of GIS might be expected to proceed, this approach for GIS development leads to unanticipated points of departure for subsequent use of the system. Some of these differences involve developing different kinds of new data bases, new approaches to visualizing data sets, and alternative forms of collaboration around the dissemination of "products" from this GIS with project partners and citizen volunteer groups.

Núcleo União Pró-Tietê's use of GIS output for public education and grassroots organization also contrasts strongly with the internal decision making mechanics that might normally be associated with the use of GIS for environmental assessment. The system developed by Núcleo União Pró-Tietê is accessible to the many volunteers who work with the project. Maps are often created to illustrate to the media and policy makers the status water quality within the basin region and to determine priorities for environmental management (for example see Tarrío 1996).

### **Summary of Technology-based Activities at Fundação SOS Mata Atlântica**

Fundação SOS Mata Atlântica's GIS approach is to link scientific results with environmental awareness campaigns. This style of information handling contrasts sharply with

approaches in other types of institutions. Governments, for instance, often develop databases as archives or records of transactions of business and the public. Because much government GIS development is centered on these objectives, a primary objective of GIS use is often to manage large data sets. Research driven GIS activities, when independent from overtly social objectives, are alternatively focused on providing accuracy in the location of interrelated phenomenon for specified purposes.

GIS technology, however, can be used to map phenomenon which are not actually geographically referenced, as in the Núcleo União Pró-Tietê project. This model called for the identification of critically degraded highly localized environments, relying only on perceptions of interviewed environmental managers and activists at local levels throughout the Tietê basin. The result was a GIS system that illustrated at risk locations based on the perceptions and local knowledge of interviewed environmentalists. The significance of this approach is that such results were later used in efforts to raise public awareness about local problems, and to garner additional donor support for such campaigns. This actual use and conceptualization of GIS is significant because the focus is on communication of the idea of a critical area as opposed to precisely knowing where it is and what factors contribute to its degraded quality (as might be the case in a conventional planning GIS). Moreover, the participatory approach to developing this awareness of critical areas of concern transforms technology into a tool for educating citizens.

### **Implications of Alternative Development of GIS Technology**

A more in-depth examination of alternative scenarios for technology use is an important effort as GIS and information technology become increasingly ubiquitous, used for purposes not yet conceived of. Many developing countries and regions find limited resources for accessing GIS technologies. For example, limiting factors in Brazil include high relative cost of computers and applications, lack of Portuguese language manuals for widely used GIS applications, high relative cost of Internet access, and management modes that often limit use of computers to specific applications and access to specific times. These constraints mean that often, research and NGO settings in Brazil have more restricted access to e-mail, Internet, FTP and other protocols for information sharing and transfer, and limited resources for the purchase of computers and software and development of databases relative to otherwise equivalent settings in North America and Western Europe.

In such resource-constrained environments, developing databases from observations collected by citizen monitors and based on perceptions of environmental decision makers could be seen as a practical means of providing an assessment of environmental problems that can result in policy changes that may impact future management practices. But such a strategy as was employed by Núcleo União Pró-Tietê can be seen in local monitoring efforts beyond Brazil as well, where resources constrain the possibility of using geographic information technologies to

their most powerful effect (Masucci 1996).

It is also important to recognize that even when using a low technology approach to developing a GIS, attention to training and providing technical assistance to users is an essential component for organizations to develop adequate GIS and mapping resources. Vendors are all too aware that the market for potential low-end GIS users is growing, particularly with the ease of accessing modules through the Internet, yet the challenge to educators and researchers is to master the understanding of the impact of this type of GIS on organizations, so that we can better assess usefulness at the onset of developing the resource.

One approach for overcoming the issues of training and resource limitations as related to developing GIS is the development of inter-institutional participatory programs for increasing access and effectiveness of GIS (Harris and Weiner 1998, Schroeder 1997; Sheppard 1995). The idea of participatory and community information technology programs is to develop and use information technology on behalf of and in conjunction with the public. As agents of citizen and community social action, NGOs present one type of setting in which the basic infrastructure can exist to support the development of inter-institutional collaborative partnerships.

### **Re-examining institutional partnership roles in technology sharing**

Possible dynamics of developing inter-institutional technology sharing is depicted below. Illustrated is how institutions may work together toward improving technology use capacities, while retaining innovations that pertain to specific settings and problems. Among the ways in which different types of institutions can collaborate on technology use are developing technology training programs, developing databases that can be used for multiple purposes, providing technical assistance in system management and application use, and documenting the institutional challenges that they face in fully utilizing technologies. From this mutual vantage point, partner institutions or working settings gain invaluable insight about a wider range of approaches for the use and development of technologies. This can position them to take better advantage of other types of resources in the improvement of technology use as well.

Among the potential impacts of technology sharing in continuing to shape how NGOs construct innovative adoption approaches for the use of GIS are the following:

- GIS technology provides one manner of organizing newly designed and collected data sets. Many organizations, such as Fundação SOS Mata Atlântica, have constructed data from within GIS, orienting up-front, data gathering and processing to fit within systems. This approach means that in Brazil, Fundação SOS Mata Atlântica has one of the most comprehensive collections of satellite imagery and maps available for researchers and policy makers alike.

- The use of technology drives the relationship with researchers. By identifying this direction as an essential component, associated researchers are called upon to help design methods and systems to make functional for institutional aims.

### **Technology Sharing Activities**

### **Impacts on Technology Use**

Conducting extensive interviews to assess approach to development and analysis of databases, use of applications, and general characteristics of GIS development

- Assess best use of existing resources; project future needs based on real knowledge of system characteristics

Developing working partnerships in laboratory settings and among partner institutions

- Mutual development of databases, knowledge of the use of the system, troubleshooting, especially important in low resource contexts

Providing direct assistance in technology training, application use, and data gathering and management

- NGO orients other institutions to its approach; other institutions give insight to directions of technology use

Identifying common approaches and needs for database development, image processing, application use and sharing, and technical support

- More individuals with working knowledge of system, resulting in greater contribution to analysis, troubleshooting, and system management; development of closer link between educational programs and real world GIS practice

Effectively using Internet, FTP, and e-mail to maintain technical support

- Provides access to other institutional resources, such as technical support, data sharing, and program development and participation

Establishing mutually beneficial educational programs, such as internships, service learning programs, student and scholar exchanges, and developing educational curricula

- More rapid innovation, adoption and implementation of new approaches and develops working knowledge of counterpart institutional settings, aims, research approaches; placing GIS use in context

Joint programs and conference development

- Shared aims in professional development strengthens overall knowledge of both institutional settings and research objectives

- GIS results and outcomes are used in ways that contrast with other types of organizations. Results and outcomes from Fundação SOS Mata Atlântica are used in establishing a baseline awareness of the depth of environmental quality problems, the geography of worst case scenarios, and creating a new geography of arbitration and protection.

## **Conclusions**

As Fundação SOS Mata Atlântica and Núcleo União Pró-Tietê develop new ways of using GIS as a tool for making sure that citizens have decision making input into environmental policy development, new challenges arise in understanding real world GIS approaches. In both cases, the role provided by these NGOs in producing needed data for environmental planning and monitoring is critical to the long-term environmental quality for the State of São Paulo and beyond. Moreover, because Fundação SOS Mata Atlântica and Núcleo União Pró-Tietê are structured with more responsiveness to the participant volunteers, the whole conception of GIS as a tool bears little resemblance to the approaches of other types of institutions. At Fundação SOS Mata Atlântica, GIS emerges as one among many tools of representation of the broad based environmental concerns of their organization.

One practical implication of looking at GIS and associated information technology use and development from the perspective of NGOs and other community and citizen based organizations is that understanding these perspectives about the role of technology permits rethinking the collaborative approaches of technology sharing programs. Another implication of understanding NGO perspectives about technology use is that inter-institutional collaboration itself holds the possibilities of collaboration with citizens, industry, government, and other NGOs. Perhaps one reason for such broadly defined parameters of collaboration by NGOs is that the outcomes of activities are measured by different standards in comparison to mainstream organizations. These can include participation, public education, policy impacts, and networking along side of standards related to the information and information management itself. Finally, through looking at the ways in which GIS and information technology are constructed within NGOs, we can gain perspective about some actual barriers to accessing technology that communities and citizens confront as well as the strategies that they use for overcoming these barriers.

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