

# **DEVELOPING GIS FOR CITIZEN ENVIRONMENTAL MONITORING AND HAZARDS MITIGATION IN ALABAMA AND SAO PAULO, BRAZIL**

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## **ABSTRACT:**

This paper will describe the development and evolution of GIS to support environmental quality monitoring and hazards mitigation activities in two citizen-based water watch movements: Alabama Water Watch and Nucleo Pro Tiete in Sao Paulo, Brazil. In both cases, citizen volunteers concerned with creating baseline databases for local watershed areas formed as a result of severe problems in local water quality and because of the lack of baseline data from which to assess these problems. Both view GIS as an important tool in improving their respective organizational capacities to respond to environmental quality problems once detected by citizen-volunteer monitoring and in contributing to environmental policy formation.

One aspect of how GIS is being conceived of at Alabama Water Watch and Nucleo Pro Tiete is that the data used in both instances are obtained by citizen volunteers. In both cases, GIS is seen as a tool for organizing recently obtained water quality records from collection points in local watershed areas and integrating these records with other environmental factors. However, Nucleo Pro Tiete and Alabama Water Watch diverge in that the Brazilian GIS model incorporates perceived information about environmental quality objectives, whereas Alabama Water Watch seeks to develop GIS to augment the state's existing institutional water quality research and assessment efforts. By considering both examples, we find that GIS development from an NGO institutional setting differs in some significant ways from governmental approaches, with important implications for the development of GIS as a tool for responding to local environmental problems in developing settings.

## **BACKGROUND**

In the non-governmental organization (NGO) settings of Alabama Water Watch and Nucleo Pro Tiete, GIS has been an important tool for enhancing capacities to aid in local environmental quality monitoring and hazards mitigation. The experiences of these NGOs provide valuable insights for identifying effective uses of GIS technology and anticipating NGO needs in the areas of technology sharing and transfer in developing regions. The impetus for this effort to learn which methods of technology transfer can be effectively implemented for NGOs is based on a new research project sponsored by USIA (United States Information Agency) entitled "Creating University-NGO Partnerships for Assessing Environmental Quality in Watersheds," and it is administrated through Auburn University and the State University of Sao Paulo, Rio Claro (UNESP-Rio Claro). This project establishes research linkages between local NGOs and universities in the states of Alabama and Sao Paulo and between Auburn University and UNESP-Rio Claro. In addition, the project has forged NGO-to-NGO partnerships, particularly to evaluate alternative technologies in GIS development and to gain insights about culturally and locally specific frameworks that condition how GIS is implemented in each case.

## **Assessing GIS Use in Non governmental Organizations**

The research partnerships formed between Auburn University and UNESP-Rio Claro and between both universities and Nucleo Pro Tiete and Alabama Water Watch have sought to understand the dynamics of effective technology transfer approaches, particularly in the development of low-technology GIS capabilities. Low-technology GIS may be described as appropriate technology in settings with limited human, financial and database resources from which to initiate GIS activities. Typically, this would consist of low-cost, easy to use desktop mapping and GIS applications in association with existing organizational databases and archival database sources (Masucci, 1995a and 1995b). Other characteristics of low-technology

GIS approaches include: developing GIS for single purposes and relying on archival databases prepared by other organizations, shareware applications, data sharing arrangements with other institutions, and technical support from arrangements with other institutions.

Much like with GIS development in general, an important factor in realizing the full potential of low-technology systems is how an organization relates staff development to technology use. An approach that values development of human resources could link utilizing and managing low-technology GIS to enhancing the capabilities of the staff to assess and participate in decisions regarding development of future GIS resources. A primary feature of developing low-technology GIS, then, is to provide adequate training in the use of PC based mapping applications and spatial databases. Compared to working with more advanced GIS applications, this involves a shorter learning curve in the use of GIS, and can result in positioning these GIS users to more quickly plan for future GIS development. Finally, in a low-technology approach for NGOs, it is especially important to maintain the relationship among GIS-trained staff and decision making needs because doing so helps NGOs to retain strong input in local environmental policy issues and monitoring efforts.

**Developing appropriate use of GIS in NGO settings.** Perritt and Masucci (1996), Perritt and Drennen (1995), and Leitman et al. (1995) show that NGOs have very different frameworks for approaching environmental monitoring and hazards mitigation compared to governmental approaches. NGOs often seek to fill in the gaps of government environmental monitoring and hazard mitigation activities by providing information about geographic areas not covered, constituencies not represented, and environmental quality problems not yet identified. Technology use approaches follow from the organizational perspective of NGOs, as factors ranging from financial organization, heavy reliance on volunteer members, the need to be responsive to volunteer members, and the shortened time-line for achieving policy results strongly influence NGO technology choices and priorities. In addition, NGOs often work without prior commitment to a particular mode of technology use, unlike governmental organizations, which for example in the case of GIS development may view future needs from the constraints of previous technology investments, continued use of previous versions of specific applications with which staff members are accustomed to working, or legislative mandates to develop GIS in particular ways.

In further contrast to NGOs, governmental settings can be characterized by longer standing commitment to developing databases, with a less direct impact of the new technology on the overall mission. The NGOs considered here are concerned with optimal use of specific GIS tools, with changing technological capabilities having profound implications for the direction of new environmental monitoring activities. In the case of Nucleo Pro Tiete, GIS outputs have been not only instrumental in identifying and documenting water quality for the Tiete River Basin throughout the state of Sao Paulo, they have generated enormous public awareness in the overall water quality of the basin region. One map even recently appeared in Terra, a widely read popular nature magazine in Brazil, as part of an article which highlighted the environmental quality efforts of a citizen volunteer group affiliated with Nucleo Pro Tiete. Alabama Water Watch has taken its GIS approach back to its membership of citizen monitors and to Alabama's Department of Environmental Management to illustrate the role citizens can play in documenting environmental quality.

Current trends in the development of PC-based applications may reduce the risk of suboptimal GIS development in low-resource settings. One example is the rapidly improving processing capabilities, multi functioning, and ease of use through Windows OS applications that many desktop GIS applications have developed. These changes in the ease of use of GIS applications are particularly advantageous for organizations with limited resources, where purchasing new equipment and training and hiring personnel can be relatively expensive options. Another trend which can impact on low-resource settings is the increased availability of geographic databases on-line through Internet resources. This can be advantageous for users who do not already have extensive digital geographic databases, such as in Alabama and Sao Paulo. Finally, improved linkages between remote sites through technologies such as computer video linkages can be useful for technology training by overcoming geographic barriers to educating users on particular applications and systems for specific purposes.

**Potential impacts of GIS in low-resource settings, such as Alabama Water Watch and Nucleo Pro Tiete.** Adoption of GIS technology to support environmental monitoring has been shown to have far reaching impacts on how monitoring and planning is accomplished (Obermeyer and Pinto, 1994; Calkins, 1991; Campbell, 1991). Among the impacts that may result from developing GIS capabilities are adjustments in responsibilities of the staff, increase in mapping activities, increase in demand for maps, surpassing allocated resources, high turnover of personnel, and communication gaps between technical GIS staff and other planners and resource managers (Masucci, 1994). Developing appropriate GIS technology for low-resource

settings involves minimizing costs, selecting easy to use applications, selecting applications appropriate to database management needs and hardware limitations, and development of human resources. As low-resource settings continue to adopt and develop GIS capabilities, knowledge of the appropriate tools for the short term, with the goal of developing long term use of GIS is an essential element in effective GIS management (Dymon, 1994; Warrall, 1991 and 1990). Moreover, there is a recognition among many that PC-based systems can be appropriate beginning places for environmental monitoring and planning related GIS activities (Klosterman, 1992 and 1991; Leipnik et al., 1993; Masser and Blakemore, 1991). Knowledge of how to use PC-based applications can be a powerful asset in low resource planning settings, such as Nucleo Pro Tiete and Alabama WaterWatch because of the possibility for short term results not often available when using more complex GIS applications.

Initiating GIS support for environmental management in any organizational setting is often justified on the basis of improving efficiency in the use of human and scarce financial resources. However, this assumption presupposes a level of readiness to operationalize GIS. Without readiness, or assistance with technology transfer, settings which are already resource poor can experience the dubious effect of exaggerated constraints on the use of these limited resources once the impetus for using GIS emerges. This can produce the opposite effect that these organizations hope to achieve when they use GIS technologies to support decision making activities. Instead of technology positioning the organization to pursue activities that will lead to improved conditions in local environmental quality and responsiveness to potential hazards, technology can effectively widen the gap between effective and ineffective settings.

Many recent case studies provide additional lessons about the impacts of developing GIS capabilities on overall organizational evolution. Investigations about how GIS technology is managed within institutional settings to learn how adoption is best accomplished and which adoption models are best suited for each setting have centered more on planning organizations. These have some important similarities to NGOs in that they too are charged with providing information for community based environmental decision making. The fact that GIS staff have developed their own style of maintaining currency with technology and with supporting the general planning staff is consistent with the observations of several recent case studies (for a review, see Campbell, 1991) and underscores that a remaining difficulty in achieving GIS objectives is the gap between technology and education. This can lead to poor communication between GIS users and other staff members, and it can prevent an adequate projection of system costs in the long run. Cowen and Shirley (1991) note that this leads many institutions to rely on project, rather than database, driven GIS development. Leipnik et al. (1993) also note the importance and difficulty of assessing costs and benefits of GIS development, due to the uncertainties of rapidly changing technology, regulatory demands, and availability of funding. There are many reasons why this communication has not improved, often embedded in the geography of available resources for developing GIS technology.

As in governmental settings, environmental managers in NGOs will increasingly rely on spatial data for decision making on a daily basis. Well developed and managed geographic information systems can help to save time and effort in assessing local environmental quality concerns and problems, but the nature of local problems and the how NGOs approach them suggests new concerns for GIS research. Several issues have been raised by planners that pertain to the NGO problem of using GIS technology, including system cost and design considerations, implementation schedules, and data quality and accuracy (see Somers, 1987; Prisley and Mead, 1987; and Hewitt and Koglin, 1987).

While many NGO professionals, like other potential GIS users *believe* that GIS will be a useful tool for spatial analysis of data, they often base this on a notion that the benefits of electronic storage of large spatial data sets and the ability to compute spatial analysis with one or two commands are easily derived once GIS has been adopted. But these beliefs, as with governmental users, must be measured through a realistic decision-making framework for initiating and continuing to develop GIS that evaluates systems in terms of costs like purchasing data, computers, and software and learning to use applications.

## **ESTABLISHING UNIVERSITY-NGO PARTNERSHIPS IN ALABAMA AND SAO PAULO**

In both Alabama and Sao Paulo, NGOs have emerged as active partners in environmental planning and assessment in recent years, based on histories of under institutionalized local planning and environmental monitoring efforts, and desire on the part of local citizens to become more actively involved in environmental quality issues. The cases of Alabama Water Watch and

Nucleo Pro Tiete parallel each other in significant ways. Both are citizen-volunteer driven water quality testing programs in which citizen volunteers have taken on the local task of testing water quality using mobile test kits throughout their local watershed areas. Both Alabama Water Watch and Nucleo Pro Tiete are structured with numerous local chapters covering a larger state jurisdiction, with citizen volunteers in local communities often serving as active members in other environmental grass roots organizations as well (Barreto, 1995). And most importantly, in both NGOs participation in water quality monitoring has enabled citizens to be better positioned to advocate water quality needs and to respond to hazards, including pollution and pollution-related problems associated with flooding and drought. Citizens have been enabled, through participation in these organizations, to develop a critical stakeholder voice within governmental institutional environmental planning and policy making efforts, providing needed community-based input about local environmental problems in the watershed areas that can be considered as a part of comprehensive water management programs in both regions.

## **Nucleo Pro Tiete**

Nucleo Pro Tiete's approach for development of GIS builds on previous work begun in the 1980s at S.O.S. Mata Atlantica, the NGO under which Nucleo Pro Tiete was formed (Barreto, 1995; Nucleo Pro Tiete, 1994; Camara, 1991). The foundation sought to improve citizen environmental awareness in Sao Paulo by documenting for the first time the deforested areas of the Atlantic Rainforest in Sao Paulo, Brazil. Remote sensed images were used as the baseline data from which comparisons to historic maps could be made in order to determine which areas of forest remained and which were at critical risk of being encroached upon by other landuses. One outcome was the protection of many remaining areas of Atlantic Rainforest that were identified through the GIS approach of S.O.S. Mata Atlantica. Similarly, Nucleo Pro Tiete was formed to develop baseline data about the current water quality status of the Tiete River Basin that covers the state of Sao Paulo and forms a significant portion of the City of Sao Paulo's drinking water supply. Formed after 1,200,000 citizens signed a petition to create it, Nucleo Pro Tiete became a new environmental monitoring effort of S.O.S. Mata Atlantica, with a continued reliance on GIS to aid in making the case for environmental protection in areas that have not yet been impacted by severe pollution found in metropolitan Sao Paulo.

As part of their efforts to ensure that citizens have a voice in identifying environmental quality concerns for their communities, Pro Tiete relied on easy to use and develop technologies, including mobile water quality testing kits and personal computer analytical applications to record and manage records. Nucleo Pro Tiete had received funding to develop a PC-based GIS taking its water quality records for the Tiete River Basin gathered over a one-year period and using them to categorize water quality for the basin as a whole into classifications ranging from good to poor. They developed this using REGIS software running on a 486-33mhz system, and the system is now administered by a cartography/staff member.

## **Alabama Water Watch**

In Alabama, the evolution of NGOs like Alabama Water Watch into participatory agents in environmental planning in the Alabama has appeared recently as part of a broader water management issue--conflict over the use of water in the Apalachicola-Chattahoochee Flint and Alabama-Coosa River Basins. A part of resolving conflict over water uses within these basins has been a recently arrived at consensus among participants in a three-year long comprehensive study that a compact agreement among the three states is necessary. The plan calls for the development of an interstate cooperative compact, and many call for GIS development in state planning and environmental institutions in Georgia, Florida and Alabama so that water use priorities can be established and monitored. In fact, one of the most important tasks of the comprehensive study of water use priorities in the two basin regions has been to develop baseline information for many competing water use groups that can be used in newly developed models. For many involved in planning in the region, developing GIS remains a good idea, without proven ability to work as tool to assist in the very complex task of mitigating among various stakeholder interests. From specific stakeholder perspectives such as Alabama Water Watch, GIS is viewed as one of the best tools for integrating databases and assessing internal priorities. While GIS development in Alabama has remained the preview of commercial and governmental organizations, (most notably, Alabama Power has provided the leadership and resources for the state's GIS resource development, often in cooperation with state government and educators - Warnecke et al. 1994), the governmental approach for GIS differs from an NGO approach in significant ways precisely because an NGO objective is typically to add information from different perspectives into the overall decision making arena.

GIS at Alabama Water Watch was developed under different circumstances compared to Pro Tiete. A low-technology approach was used to locate over 300 citizen monitored water quality stations covering local watershed areas across the whole state of Alabama. The system uses MapInfo for Macintosh, building from existing water quality parameter records for the collections points, and integrating those records with spatial data such as stream location, watershed boundaries, and jurisdictional boundaries. Alabama Water Watch's purpose for developing GIS is to be able to provide an analysis of records that compares citizen-collected data with research-collected data to ascertain whether or not citizen-collected data is valid. Preliminary findings suggest that basin wide characteristics are reliably determined by citizen collected data, with important implications for the use of the database and a citizen volunteer approach for state-wide planning efforts (Deutsch, 1995).

## **Features of Technology Sharing: Developing Low-technology GIS Use in NGO Settings**

By learning what aspects of organizational development are enhanced with GIS resources and how non-governmental organizations in particular develop GIS to achieve these objectives, many new aspects of technology use can be identified. Building and adapting appropriate technology GIS is an option especially important for getting started in developing settings, with beginning at a level appropriate to existing computer and personnel resources, and to assess which data are most pertinent to the mapping activities they envision the most significant challenge. The following elements of technology sharing form the basis of the USIA program, which hopes to add to frameworks already in place at each organization. These follow from a human-centered model of GIS adaption, an approach that relates new developments in GIS to the readiness of settings and personnel charged with making them work. It provides that use of some existing tools such as cost-benefit assessment of alternative GIS approaches and the assessment of specific organizational constraints can result in more efficient outcomes for low resource settings (Worrall, 1991 and 1992; Somers, 1987).

The USIA project has provided several exchange visits and opportunities for assessing technology use and development in NGO settings. Ongoing data sharing and adaption of GIS development models have been adopted in several participating institutions. Through workshops, training, Internet use, common use of GIS applications, the various participating groups have formed some common-use threads of GIS that allow for sharing approaches. Especially important has been bi-lingual mode of communicating about GIS use, as much documentation is written in either English or Portuguese, and with interpretation has come new opportunity for technology use.

## **Methods for Developing Technology Sharing Programs**

**1. Conducting extensive interviews learning about databases and applications.** Identifying current needs has permitted assessing how these fit with available resources and GIS training.

**2. Developing working partnerships in laboratory settings.** Participating in the hands-on-use of applications for research and environmental assessment problems, this activity is supported through the exchange visits.

**3. Providing direct assistance in technology training.** Conducting workshops, developing new courses, and establishing programs such as internships, that will link decisions to use GIS and associated technologies with knowledge of the limitations and constraints of the technology, appropriate use of technology, and operationalization of the technology that will result in desired outcomes in terms of data management and mapping.

**4. Effectively using Internet, FTP, and e-mail to maintain technical support.** Identifying through project meetings, interviews, and laboratory partnerships how available communications and file transfer technologies can aid in the tasks of technical support, data sharing, and solving problems of application use beyond the month-long visits that establish linkages between the international partner units.

**5. Identifying common approaches and needs for database development, image processing, application use and sharing, and technical support.** Developing shared resources and making these available to partnership units through the use of communications applications and the development of common resources such as home-pages.

**6. Internships and educational curricula.** Providing Supervised experiences to learn systems and work hands-on with databases, applications, and research resources for environmental quality program and developing educational programs to share problems encountered and new techniques.

**7. Field visits.** Visiting many examples of GIS use in settings with similar challenges to the partner NGOs and universities, reviewing all aspects of available technologies in order to identify links between information gathering and application use for handling spatial databases and mapping.

**8. Joint program and conference development.** Assisting and partnering in grant preparation in order to develop common resources, databases, and opportunities to continue advancing GIS training. Jointly planning international conferences that will permit sharing findings of the results from assessing use of technologies in NGO settings and the partnership approach between universities and NGOs.

## **Identification of Capabilities of Existing Staff, and Training or Internship Programs to Assist in Learning to Use Applications and Develop Systems**

The key to operationalizing technologies are adequate training and understanding of the systems, existing databases, and functionality of software. The USIA project approach advocates adopting GIS by assessing the readiness of the user to get started at different levels of GIS use. For non-users with no resources to hire additional GIS skilled personnel, then a technology training approach for existing staff will be an essential element to effectively integrating GIS into decision making. One key to technology training is trainers to participate cooperatively with planners and resource managers to determine how best to plan for the GIS needs of an existing setting. One proposal is that universities can take more active roles in this technology training function. In addition, in developing countries, NGOs often take the lead in providing resources, both human and computer, for initiating and developing GIS capabilities at local levels and for specific purposes.

## **Fully Utilizing Internet Resources for Communication, Data Sharing and Educational Purposes**

Availability of databases at low cost is enhanced when other support for GIS is available to planners and environmental managers. As with technology training, universities and state and federal agencies can (and do) provide a resource infrastructure that provides these data resources at low or no cost. The critical aspects for this to translate into actual use are knowledge of how to access the databases and to utilize them within GIS applications and having access to the basic computer infrastructure necessary to obtain low-cost data. Given that many of the original sources of spatial data for the drought adjustments project were obtained from resource settings, the assumption that access to on-line support is erroneous. Many low-resource planning and resource management settings simply cannot afford the basic computer hardware that would make even low-technology GIS a viable option for spatial data handling. Given that reality, the task at hand for technology training is to help these planners and resource managers assess appropriate beginning points and realistic objectives given their financial and human resource constraints.

## **Identifying and Using GIS Applications That Are Inexpensive and Easy to Use and Maintain Within a Given Institutional Setting**

The trend to use Windows operating system applications has positive implications for low resource planning and NGO settings. Users in low-resource settings, where purchasing equipment and hiring personnel are limited options, may overcome obstacles of complex command structures in the past with easy to use applications. A second trend which should be

capitalized on is the increasing availability of geographic databases on-line through Internet resources. This can be advantageous for users who do not already have extensive digital geographic databases, which characterizes many potential users in Alabama. Finally, the trend of improving linkages between remote sites through technologies such as computer video linkages can be useful for technology training purposes by eliminating obstacles to learning a given software on a given platform with given local constraints. These individualized problems can more easily be solved through video aids and monitor and hardware sharing technology. The key trend suggested by these technological innovations is that more than ever, technology training can afford access that has been difficult to overcome in the past without large financial and personnel investments.

## **Evaluating Effectiveness of the USIA Technology Sharing and Transfer Program**

Some variables to be considered in evaluating appropriate technologies include but are not limited to: funding sources and amounts for implementing system at the local level, equipment and software purchases, personnel additions and staffing changes, and changes in other local level planning activities and services. In considering local level changes, it is also important to establish the use of data provided by the local level GIS: is system design driven by local concerns, information needs at the regional and state level, or other influences? The following issues characterize the problems of integrating GIS with organization needs: how can benefits and productivity of GIS use be measured in terms of system costs; how can system design best support the level of proficiency and decision support needs in specific settings; how can implementation and development of systems and databases be best scheduled to coordinate with planning policy and, more importantly, the timeline for specific planning decisions; and how can systems help in handling database problems, such as data accuracy, coordination of data at different scales, meeting new data standards, and integrating specialized databases with baseline data. Similar issues are raised by Campbell (1991), who calls for more research on the interpersonal dynamics within institutional settings that adopt GIS in order to understand what factors lead to effective use of GIS for specific decision making purposes.

While the importance of understanding these factors is recognized, especially by GIS users, even the most basic aspects of resource allocation and personnel adjustments are difficult to assess. More complex issues, such as weighing the advantages and disadvantages of technical aspects of system design are closed to the non-GIS user, even though these decisions are critical to adequate support for other planning activities. And while many organizations which need GIS recognize the importance of developing GIS support for decision making, they often rely on inappropriate assessment criteria to determine funding levels, often resulting in under-equipped and under-staffed GIS approaches. All too often, adopting GIS is seen as an independent process from the more difficult task of restructuring planning activities to integrate GIS support. As more policies are used to establish technology-based decision making, often because of a perception of improved efficiency and reduced costs, better understanding of the ensuing restructured decision making process is critical.

**Assessing the advantages and disadvantages of low-technology GIS.** Some benefits of using low-technology GIS include, lower costs relative to workstation or high-end systems; relative ease of use; relative ease of configuring platform; increasingly integrative with digital database and map sources; increasingly integrative with multiple graphic and database management software application; ease of using query capabilities; increasingly including modeling capabilities; increasingly high cost for low resource settings. Some limitations include: requires technical staff for GIS project development; requires dedicated hardware resources; limited querying capabilities compared to high-end systems; limited modeling capabilities compared to high-end systems; limited integration of raster and vector data and relatively long computation and mapping times. These need to be evaluated in terms of the organizational evolution of NGOs.

**Evaluating specific mapping applications and how they will be used for spatial data handling.** Desktop mapping applications will have strong appeal in low resource settings or in settings that are just beginning with GIS or that are just beginning to see a need for raster based applications. In low-resource planning settings, improving technical knowledge and dedicating enough resources to operationalize the software will be important factors to overcome. University settings provide a contrasting scenario in that access to Internet resources, on-line help, and to other GIS users supports easy adoption and rapid integration of new applications.

Many low-resource settings are characterized by limited equipment, staff, and access to technical support. Yet, the alternative

for such settings is whole-scale adoption of new equipment and software, and extensive personnel training. Even if resources were available for this type of transition in a low-resource setting, the results can be that the original planning mission of the unit may be unrecognizable once that adoption has taken place. This problem is one that many desktop applications have been resolving for many years by providing a software application that keeps such settings from being completely left behind by technology or that keep such settings from being overtaken by new technology aimed at revolutionizing decision making for that area. The emerging challenge as Internet provides data and communications, as graphical capabilities of computers improves, and as output devices handle better output, is to restructure how these settings conceive of their tasks in the face of new technologies.

**Making human-development central to operationalizing GIS technologies.** This model begins adopting GIS by assessing the readiness of the user to get started at different levels of GIS use. For non-users with no resources to hire additional GIS skilled personnel, then a technology training approach for existing staff will be an essential element to effectively integrating GIS into decision making. One key to technology training is to participate cooperatively with technology trainers who can guide without directing how best to plan for the GIS needs of an existing setting. One proposal is that universities can play more active roles in this technology training function, with NCGIA having developed GIS curricula guidelines and many geography departments establishing GIS centers for just such outreach activities. In addition, in developing countries, NGOs often take the lead in providing resources, both human and computer, for initiating and developing GIS capabilities at local levels and for specific purposes.

## CONCLUSIONS

As Alabama Water Watch and Nucleo Pro Tiete develop new ways of using GIS as a tool for making sure that citizens have decision making input into environmental policy development, we must address how to better anticipate the needs and priorities of NGOs with technology use and development. In both of these cases, the role provided by these NGOs in providing needed data for environmental planning and hazards mitigation is critical to the long-term environmental quality of their respective regions. Yet, because the institutions are structured with more responsiveness to the participant volunteers, the whole conception of GIS as a tool bears little resemblance to governmental approaches, which often seek to maintain neutrality through technology use. In the NGO case, GIS becomes a tool of representation, and as such is developed in different ways. One lesson that emerges from both cases is that a much shorter time horizon is employed in assessing the effectiveness of GIS, suggesting that what would be important to governmental agencies is critical to NGOs- short term mapping results. Another lesson that emerges is that because NGOs rely on volunteer and develop staff positions often only at later stages of their organizational development, initial GIS activities are often even more constrained in terms of human resource availability than in governmental settings. This means that university partnerships can play an especially important role in providing technical assistance, training, and support for NGO GIS activities. And because governments will form even stronger linkages with NGOs both in looking to them for representative interests and in relying upon NGO databases to fill in the gaps of government ones, it is critical to the public interest that NGOs have access to appropriate technologies and technology training that will enhance their overall ability to incorporate GIS into organizational treatment of their databases.

It is also important to recognize that even in a low technology approach attention to training and providing technical assistance to users is essential to organizations developing adequate GIS and mapping resources. Vendors are all too aware that a large market of potential GIS users looms on the horizon, 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. Even with low technology, resource investments can be quite large, if a system is to be a viable decision making aid. These factors need to be considered and this option needs to be weighed against other types of decisions, including not to purchase GIS. This represents a public choice approach to GIS development which means that non GIS users and developers must be part of the decision. In NGOs this is quite an iterative process, as many grass roots NGOs work very closely with their members to define mission directions and make decisions about investing in technologies and staff members. Nucleo Pro Tiete and Alabama Water Watch provide examples of the organizational style that is emerging as a new GIS user, and for the purpose of introducing stakeholders into the policy making arena.

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