"The governments of the Caribbean are challenged to deliver improved services at low cost. GIS is just one of a variety of tools that we can use to help us succeed."

Cecille Blake

National GIS Coordinator, Kingston, Jamaica

GIS in the Caribbean

"It is paramount that policy standards be established at the national level ..."

Need for National GIS Standards

Building the geographic information system (GIS) infrastructure at the national level requires both foresight and collaboration. In the Caribbean, cooperation among government agencies, private enterprise, and international influences must be developed to ensure a system that is accessible at a variety of levels. Standardizations of land measures and GIS in the Caribbean have become the vision of Mrs. Jacqueline daCosta, director general, Office of the Deputy Prime Minister and Ministry of Land and Environment, and chairperson for the Land Information Council of Jamaica. She describes both her concerns and hopes for national policy in mapping the islands.

Mrs. daCosta would like the executives in government and politics to become fully aware of GIS and how it can be used for a variety of purposes. By establishing a uniform manner of gathering data, GIS can be used to streamline programs in the Caribbean. She explains, "It is paramount that policy standards be established at the national level rather than introduced into the country on a sector-by-sector basis through outside influences."

Mrs. daCosta points out that when various mapping systems are introduced into different sectors on a project-by-project basis, it can lead to segmentation. To establish conformity of land measurement, data collection, and map production, GIS policy needs to be promoted nationwide.

Governments are not yet taking a proactive position in requiring standardization. They tend to accept whatever system is attached to the projects that are offered to them. Assistance programs, known as true projects, are introduced to the nation through outside agencies and organizations whose services are accompanied by foreign information technology. When the United Nations, for example, introduced its health project to the area, the program came with its own software. These piecemeal introductions of software variants into the region not only make integration difficult but also circumvent the establishment of national standards. Because the implementations are project focused rather than nationally focused, the integration of data on a large scale becomes complicated.

"When choosing a system in 1992, the Land Information Council of Jamaica had the foresight to build its GIS using ESRI® software," claims daCosta. "Because of ESRI's strength, it was not hard to make that organizational decision." However, numerous other agencies adopted a variety of software applications. People were unwilling to cooperate with sharing data at that time.

"If you don't determine your standards," says daCosta, "it creates obvious problems. For example, when creating metadata, does the region go with the Federal Geographic Data Committee (FGDC) standard or some other? GIS expertise is needed in the islands at the government level so that decisions can be made rationally for the good of the country. Standards need to be made at the national level so that everyone is in sync."

Last year Space Imaging offered a huge discount to Jamaica for their services to map the entire country. Because it was the middle of the fiscal year, the payment of loans and salaries had first priority for the government. But because Jamaican maps are more than 30 years old, the opportunity could not be passed up. Thus, funding was sought elsewhere. Fortunately, daCosta was able to obtain a contribution from another agency for the project. Space Imaging mapped the country at 1:4,000,000 using raster data format.

The hope is to expand that program. St. Lucia and the other small islands have a cadastral as does Jamaica. However, the cadastral data precludes data stored in digital format. The cadastral index is inaccurate. The Land and Environment Department is proposing to update it through the IDP and the local land agency. Officially, there are 650,000 parcels of land, but this is not the total. Through reconnaissance, the GIS team expects to find a million parcels because people have illegally divided their land.

GIS expertise has been another challenge. Island governments simply do not have enough people with GIS expertise to develop effective systems. Staff salaries are low, thus unattractive to GIS experts. "You get what you pay for," says daCosta. Thus, she and her team set out on a mission to create GIS awareness among government officials.

Mrs. daCosta and a GIS team that included ESRI representatives were invited to explain GIS to officials at a Jamaican cabinet meeting. The Cabinet agreed to allow them just one hour to make their presentation. However, once the members saw the potential of GIS, they had many questions and extended the meeting to three hours. "This is the type of education that is needed in order for officials to realize how important and advantageous a GIS is to a country."

Since then, executives of national ministries and departments have participated in training and information sessions about the opportunities GIS can afford them. By the end of 2001, the heads of all ministries will attend sessions to gain knowledge of GIS. The directors of planning, statistical records, and the commissioner of police will all be able to see for themselves what can be done in their ministries with GIS and how GIS can help them better manage their assets.

Job openings for GIS experts are beginning to appear. Training in GIS has been going on in the islands for a while, with ESRI supporting labs in Jamaica. GIS courses are also offered at the University of Technology.

GIS courses are attached to various geography classes as well. The University of the West Indies is attempting to establish postgraduate training in Trinidad with a program of accredited GIS classes. It is not only Jamaicans who are benefiting from these programs, but also many students from around the islands are enrolling.

Mrs. daCosta believes that the time has come for the small islands to set up a national council for GIS. This is because GIS is a developed technology that has become affordable. "It may have been a good thing that we did not have much money when GIS was first proposed. Since that time, there have been significant improvements in the technology such as in network capabilities." GIS costs have become more affordable, while the GIS software has become more advanced.

The GIS task force realized that they need not reinvent the wheel when setting a course of action regarding GIS for Jamaica's land policy. The team looked to other countries that had already established a GIS. Working closely with New Zealand and Australia, the team considered both the problems and obstacles these countries had to contend with and also the strategies that had worked well for them. The Netherlands, Sweden, Norway, and Canada also provided strong models of what could be done with GIS at the national level. These countries offered their expertise in developing general decisions, national decisions on policy, and technical decisions. "Their experiences really worked to our benefit," says daCosta.

"It is very helpful for us," she explains, "when Jack Dangermond, president of ESRI, lends GIS expertise and insight to national governments considering GIS. This helps them to make more rational and informed decisions when establishing policy."

People of the Caribbean are adopting GIS into their services. Mrs. daCosta states, "People in Forestry and Water Resources are getting the idea and are already putting their data in digital format. Nongovernment agencies, such as Cable & Wireless of Jamaica, have a strong GIS in operation. But so much more is left to be done."

Fortunately, more and more true projects assisting the area are realizing the advantages of GIS and, therefore, are using GIS in their projects. GIS is used, for example, in social services and in hiring projects. Although multilateral institutions are beginning to see the advantages of using a GIS, GIS software is still not procured in an organized and rational manner but rather on a project-by-project basis.

"I wish that there was more coordination by banks and organizations at the national level," says daCosta. "This would support the broader scope of national policy of standardization and coordination that would ultimately lend itself to sharing geographical information. It would be wonderful to have a network GIS throughout the country for agencies and the national government."

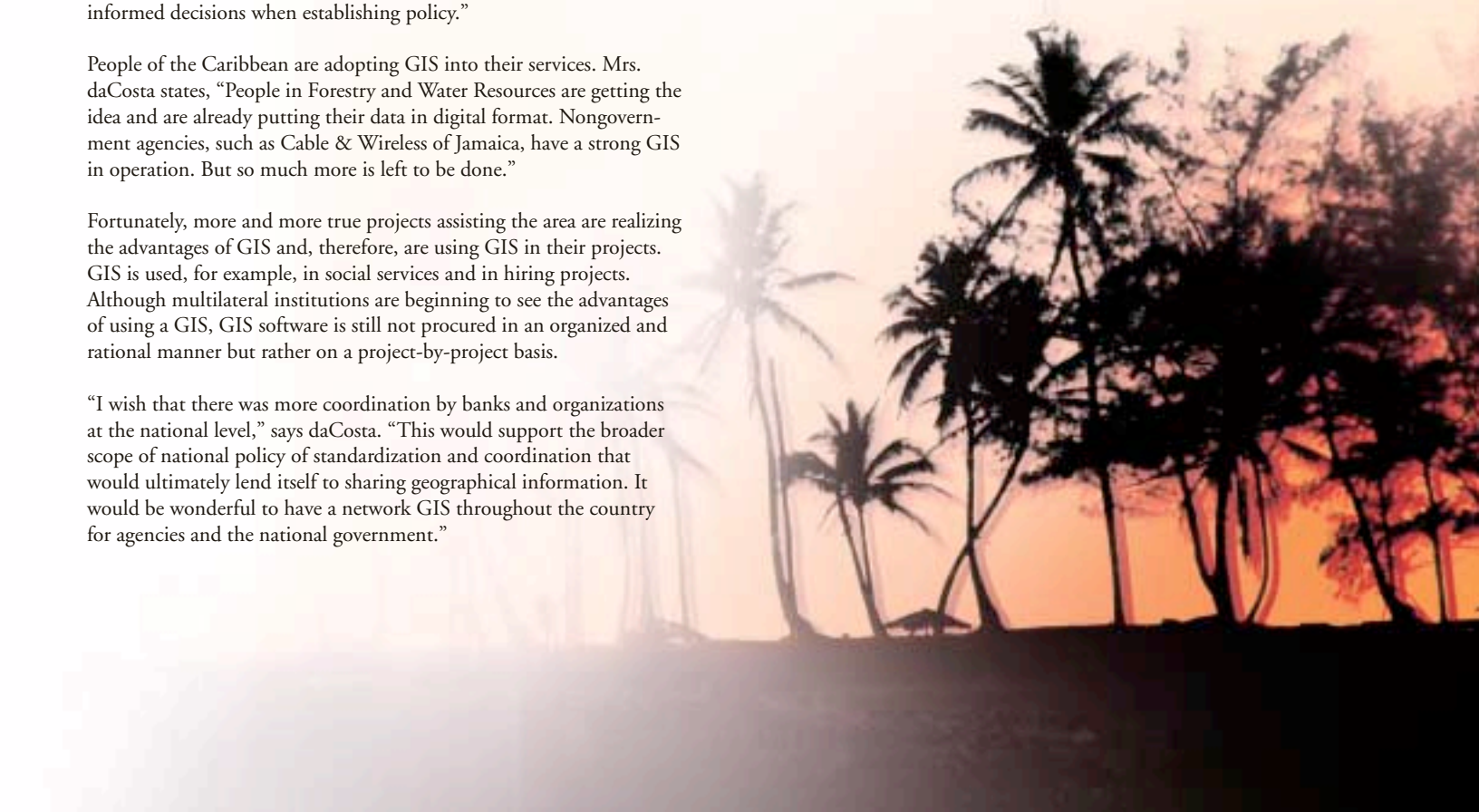
GIS Data Bank
Department of Forestry—Jamaica

Jamaica's Department of Forestry is being recognized for establishing a land use GIS data bank. The data bank provides accurate and accessible information about Jamaica's forests to its personnel, other agencies, and the public. The data bank is supported by a complete set of documentation including a metadata dictionary and user information to ensure its sustainable use.

The data bank is also fully integrated with the framework for spatial information developed by the Land Information Council of Jamaica. This framework was set up to ensure that data gathering and loading efforts are not duplicated among the numerous organizations collecting similar types of geographic data in Jamaica. The framework also specifies that data be gathered and assembled to a published standard that makes it accessible to other users.

Jamaica's Department of Forestry's GIS data bank will allow its users to extract vital environmental information such as broad-based national land use and resource inventory data, land suitability information, forested areas with high values at risk, and rates of deforestation on the island.

"It would be wonderful to have a network GIS throughout the country."



Environmental Geochemical Database

Chemistry and geochemistry have contributed enormously to our understanding of the natural environment. This has been due, in no small part, to remarkable advances in chemical analysis and to the increasing power and availability of computers housing large databases connected to GIS software. Such systems have a myriad of applications pertinent to agriculture and forestry; biodiversity; environmental assessment and protection; epidemiology; natural resource identification and management; waste disposal; plant, animal, and human health; and land use.

The International Centre for Environmental and Nuclear Sciences (ICENS) is a research center located on the Mona Campus of the University of the West Indies. The institution has a three-campus ESRI University Site License allowing for full access to all of ESRI's software line (ArcInfo™, ArcView®, MapObjects®, and ArcPad™).

The ICENS studies the interrelationship in Jamaica between the chemistry of the land and that of the water and air. These studies span a variety of geological, botanical, and biological matrices including soil, rock, water, suspended particulate matter, plants, and human blood. Information that is compiled includes physical characteristics, sampling details, and analytical results. The database contains information from more than 14,000 samples.

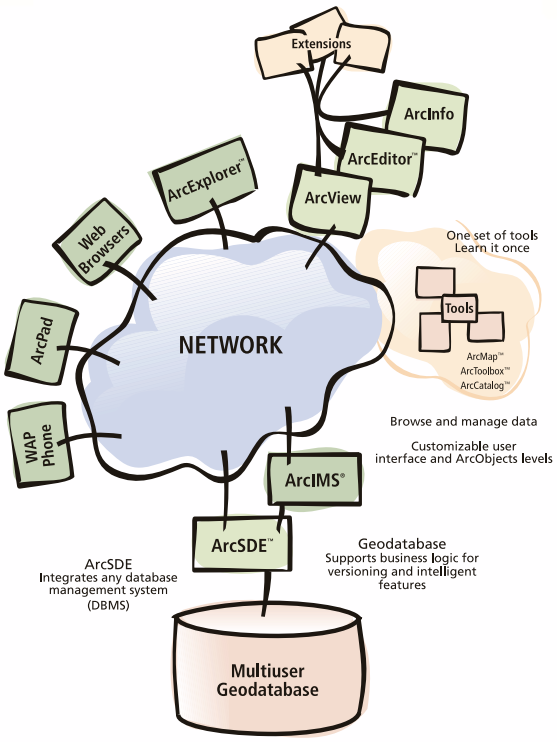
GIS provides the necessary tools in the display and analysis of the data collected. In one particular case, GIS was used to identify the occurrence of lead in a residential community near ICENS. A study of the lead distribution for Jamaica showed several areas with quite high lead concentrations. The old Hope Mine in the hills on the east bank of the Hope River stands out.

Although mining ceased at that location more than a century ago, the soils in the now residential area reflect both the natural mineralization and severe contamination from the waste products of the mining and ore beneficiation. ICENS used their GIS to produce maps for public awareness and action. An educational program is in place to assist the community in coping with their high soil lead environment.

A better understanding of natural physical and chemical fluctuations influencing the environment is essential. High-quality geochemical databases are now pertinent to a wide range of investigations in the earth and life sciences and have become an essential component of environmental knowledge and resource management. In this effort, GIS is a critical tool.

Monitoring Global Warming
CPACC—Barbados

The goal of the Caribbean Planning for Adaptation to Global Climate Change (CPACC) project is to prepare other countries and institutions to cope with the effects of global warming. CPACC is using GIS technology to monitor coral reefs and assess the vulnerability of coastlines, as well as make an accurate economic appraisal of coastal resources. The project will enable countries to make more informed decisions regarding adaptation to sea level rise and integrated coastal zone management.



This system has made geographical and environmental information more accurate, accessible, and comprehendible for the 12 countries they serve. They are Antigua and Barbuda, the Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, and Trinidad and Tobago.

CPACC has proven to be a valuable asset in anticipating and preparing for environmental changes that are potentially disastrous. CPACC is being recognized for implementing GIS in their Coastal Resources Inventory System.

GIS and Satellites over the Caribbean
Spatial Innovision Jamaica

Commercial imaging satellites have become an important resource for digital earth mapping. Space Imaging of Denver, Colorado, develops technology for digital earth information mapping. Spatial Innovision, a New Kingston company from Jamaica, puts the power of the famous IKONOS satellite to work for the Caribbean by deploying this imaging technology. The high-resolution digital space imaging delivers detailed pictures on a scale of 1:5,000 within a few weeks. "The cost of this mapping is more competitive than other aerial mapping systems which we have been using," says Jamaica's Deputy Prime Minister Mullings.

Space imaging combined with a GIS creates a powerful assessment tool. GIS helps farmers to precisely monitor the health of crops and estimate yields. Government officials use GIS to plan and monitor enlightened land use policies. City planners use GIS to further the development of new housing communities. Insurance companies use GIS to measure and map property damage after natural disasters. Space imaging provides definitive and rapid solutions for easy determinations of geography. Combined with GIS it transforms into a powerful decision making tool.

GIS-Based Mine Planning and Operations

Bauxite Mining Operation Leverages GIS

The application of GIS in the mining industry is an exciting avenue for growth and application of geographic and spatial tools to optimize decision making. GIS technology was identified several years ago as one of the emerging key technical tools needed to address unique geographic and spatial requirements associated with mining developments in Jamaica. Therefore, Kaiser Aluminum and Chemical Corporation (KACC) began development of the first GIS data infrastructure for one of the Jamaican operations, Alumina Partners of Jamaica (ALPART), in the south coast.

KACC operations in Jamaica include the two largest bauxite mines as well as the most successful alumina refinery. Seven years later, after the company had installed its original GIS, an aggressive GIS program was adopted for the bauxite mining operations of Kaiser Jamaica Bauxite Company (KJBC) in the north coast. It was then that ESRI was invited to assess GIS needs and to help define a preliminary scope of GIS-based mine planning and operations applications.

KJBC sought to improve decision strategies utilization of current bauxite reserves as well as integration of future reserves. Air photography, ground surveys, and photo controls provided the necessary inputs for comprehensive digital mapping of the entire mining lease and its environs. The KJBC project set out to create the information infrastructure required for integrated mine planning and operations applications.

Key GIS-related issues identified included

- Current data management and future data development
- Effective communication with Jamaica's regulatory agencies
- Cadastral (landownership) systems
- Terrain and ore body modeling (tons/grade)
- Exploration, ore definition, and drilling
- Land acquisition and land lease management
- Mine planning, modeling, and operations
- Mine environment management
- Bauxite quality management and control
- Reclamation and rehabilitation planning
- Resettlement and postmining activities

The GIS Project Implementation Plan detailed the strategies and actions for KJBC in data modeling, application development, data conversion and data application access, and distribution. Communications between KJBC and ALPART were maintained to promote a common integration framework for both facilities to streamline efficiencies and reduce operating costs.

The digital mapping project was completed by Aero-Data Corporation of Baton Rouge, Louisiana. Deliverables included a turnkey hardware/software system (Windows® 95 and Windows NT® ready) installed at KJBC.

ESRI's ArcView GIS 3.1, ArcView Spatial Analyst, and ArcView 3D Analyst™ were provided for the project by Spatial Innovision, ESRI's business partner in Jamaica. System hardware included desktop computers (450 MHz Pentium® II PCs) as well as a multiple-bay storage chassis with 9 GB hard drives, high-quality HP plotters, and other ancillary equipment.

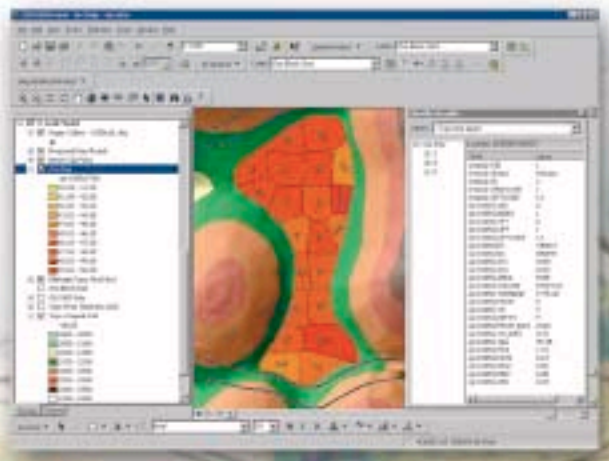
User education and training for KJBC personnel followed system installation in Jamaica. Within three months, KJBC mine planning personnel were using system resources to prepare future mine plans and development applications for implementation for the upcoming year.

Integrated mine planning systems are available from a number of vendors for large-scale surface and underground mines. Most systems are built around a given database management architecture and include design and optimization capabilities, ore blending and control, operations scheduling, haul road design, and terrain modeling, among others. However, these systems are quite expensive, complex to use, and require ongoing maintenance and support.

Mine planning and development in Jamaica are unique because of the complexities associated with scattered deposits and landownership issues. GIS provides an ideal building block approach to KJBC and ALPART, as well as any mining operation in constrained environments. The backbone of the system is the information infrastructure provided by spatial data obtained from air photography and ground surveys, properly available in an integrated database environment. Application-specific modules are then appended to this environment to support planning, development, and operations.

KJBC and ALPART immediately benefited from the ability to produce layered maps of specific attributes peculiar to their operations. For example, land purchasing is guided by a consolidation strategy driven by visual knowledge of terrain and infrastructure present. Mine planning proceeds in orderly fashion under an integrated model of ore/grade management, transportation, reclamation, and resettlement. Internal communications and legal compliance with the government of Jamaica and its regulatory agency, the Jamaica Bauxite Institute (JBI), are greatly aided by the commonality of data available under the enterprisewide GIS.

ESRI business partners for this project were Spatial Innovisions, Condor Earth Technologies, and MapTek.



Planning Education
Montego Bay, Jamaica

The Ministry of Education and Culture (MOEC) is using GIS to support education planning. The MOEC is currently conducting studies for the Greater Montego Bay Development Project to determine projected student populations and facility needs. The study area spans Sandy Bay in Hanover to Falmouth in Trelawny.

In general, schools within the Greater Montego Bay area are overcrowded because of the rural–urban drift that has taken place over the last 10 years. This drift has resulted in the development of many settlements in and around the area. With government policy thrust focused on early childhood, the MOEC has sought to alleviate the problem of overcrowding by focusing on basic schools that are not recognized in the education planning process.

Without a record of the total number of students leaving basic schools, the MOEC is unable to make provisions for every child at the primary level. The government is now making greater effort to incorporate these "unrecognized" schools and also account for their numbers in the planning process. Administrators needed a spatial and textual manager and outlined the following as information that would be needed for the database.

- The number of school places available within each category of school (i.e., basic, primary, and secondary levels)
- The location, names, and total number of basic schools and primary schools
- Enrollment in basic schools
- Number of children who will move from basic schools to the primary level
- Capacity of primary schools to accept incoming basic schoolchildren

Because of the flexibility that digital maps provide and the ease with which global positioning systems (GPSs) can record locations, combining the GIS and GPS was an obvious solution.

With the assistance of West Indies Home Contractor personnel and equipment, Mrs. Dwyer, the GIS project manager, was able to capture the locations of basic, primary, and secondary schools within the study area. She did this using a GeoExplorer® 3 GPS unit. The locations of the schools were captured over a five-day period and the *x* and *y* coordinates of the schools downloaded in ArcView GIS 3.2 to create a point shapefile. The schools were then mapped according to type on the 1:50,000 metric map of the area (see inset).

The locations of housing developments built over the last five years were also captured. This information will serve to assist the MOEC in identifying population centers to see where future needs will arise. Population projections from the Statistical Institute of Jamaica (STATIN) are used to project how many places will be needed in the future. With this database the MOEC can more efficiently plan for student allocation and the placement of new schools.

Combining the GIS and GPS was an obvious solution.

In the future, Mrs. Dwyer plans to add teachers, training, and other relevant attributes to the data layers. This will certainly aid assessment, planning, and goal setting for the school district.

Managing Water Systems
Jamaica

The use of GIS to support water utilities in commercial and operational management is fast becoming the norm around the world. The National Water Commission (NWC) has recognized that to improve efficiency and enhance planning necessitates an improvement in documentation of the company's water and sewerage facilities. This need can be met by a comprehensive GIS. In a renewed thrust toward developing its GIS, the NWC considered program elements of basic hardware and software as well as training when developing its GIS plan.

The NWC turned to ESRI for its GIS software. This includes ArcView, ArcPad, and various extensions. The NWC also uses Trimble™ products for data collection exercises. Trimble's GeoExplorer 3.0 and GPS Pro XR™ are valuable for wide-scale data collection. GPS Pathfinder® Office software seamlessly integrates the geographic data captured in the field into the company's GIS.

Implementing a training program has also been taken seriously. Spatial Innovision Ltd. provided GIS/GPS training to both executive and operational staff. Staff members have participated in GIS/GPS hands-on training. They understood the potential of GeoExplorer 3.0, GPS Pro XR, and GPS Pathfinder Pocket for data collection. They also saw how ArcView provides the platform for executing data editing, manipulation, analysis, and display of the spatially referenced information. A positive effect of the training program has been that administrators have come to appreciate and accept GIS and GPS as integral to doing business.

Gathering data was the next step. The NWC has procured a number of data sets from various organizations and agencies for use in its GIS. Moreover, data about the company's facilities and assets has been captured to suit specific requirements and needs. The NWC, in conjunction with consulting agencies, has captured a large quantity of data for the Greater Spanish Town area, which is to be utilized for hydraulic modeling and systems planning. This information is represented by a comprehensive water supply map of the Old Capital. System operators can obtain maps of specific water supply characteristics even on the fly.

In addition, the NWC has embarked on a water supply systems mapping project for the entire island. Data gathered from this exercise will form the basis for creating water supply system development plans. GIS aids decision making to establish new systems, rehabilitate or replace existing system components, and extend existing water supply systems to areas of need. In the future, data will be served across the NWC's corporate Intranet using ArcIMS technologies. The system will enable staff to access and manipulate data for their own purposes.

The NWC found its GIS well able to develop preliminary parish plans built on demand analysis and forecasting techniques. Using data from electoral district boundaries and population counts, water demand center maps were constructed reflecting population density and forecasting techniques. Maps of the existing water system provided information on water production and system extent. This aids the calculation of shortfalls or surpluses for demand centers. This information is useful for planning the provision of potable water to various communities.

Telecommunication Company Transforms Traditional Mapping into GIS

Cable & Wireless in St. Lucia

In St. Lucia, landmarks serve as the traditional means of island navigation. With an escalating demand for telephone service, Cable & Wireless made use of the islanders' landmark navigation integrating it with a unique method of address matching upon which it has built its GIS basemap.

Cable & Wireless sent out data capturers to digitally photograph each residence on the island, providing the new customer with an easy method of identifying his/her home and the service representative with a reference point by which the nearest telephone distribution point could be located. They also collected the unique number associated with the home's electrical meter and established the location of the nearest outside distribution point.

Timely telephone installation enabled by accurate mapping "has saved the company a significant amount of money," says John Wood, regional GIS manager of Cable & Wireless. Wood recognizes the potential of GIS for the community. "We have held meetings with the government disaster awareness agencies, the police and fire departments, and the electric and water utility companies of St. Lucia. They are all very interested in the possibilities of developing a national GIS. This will become more feasible in our next stage when we have collected, with GPS equipment, the *x,y* coordinates of our residential and commercial users and our company assets such as distribution terminals."

In phase two, Woods indicates that Cable & Wireless plans to implement ESRI's ArcInfo 8 to begin building its AM/FM/GIS. It is envisioned that this system will provide the company with complete asset management capabilities, tracking resource labor rates, material costs, and cable routings, as well as a complete work order system. The company will also consider adding a telephone network extension to its GIS at that time.

Predictive Modeling of Tree Distribution

Guyana, South America

The greenheart tree (chlorocardium rodiei) is Guyana's main timber export. Ecologists have qualitatively stated that the distribution of the greenheart tree is dependent on soil moisture. The greenheart tree is highly valuable for both conservation and utilization purposes. Thus, methods of assessing and predicting greenheart forest distribution are important.

Although ground surveys are the chief means of assessing tree status, these surveys are difficult to conduct in the densely forested wet tropics. On the other hand, optical satellite imagery faces the huge hindrance of heavy cloud cover. Other remote sensing methods, such as radar, still remain at the experimental stage. Therefore, analysts chose a documentation approach based on creating a spatial model to synthesize existing landscape data and preliminary survey data.

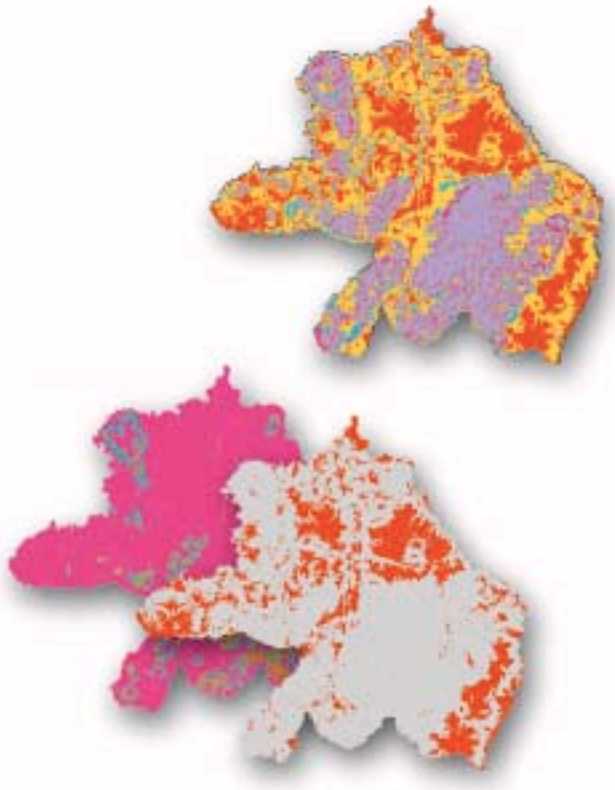
Forestry analysts employed the talents of the Iwokrama International Centre for Rain Forest Conservation and Development. This group is an autonomous international conservation, research, and development organization formed by agreement between the Government of Guyana and the Commonwealth Secretariat. The Iwokrama International Centre manages the 3,700-square-kilometer (1,429-square-mile) Iwokrama Forest area in central Guyana, South America, for the purpose of demonstrating how a tropical forest can be managed in an equitable and sustainable way and its biological diversity conserved.

Because of the diversity of its projects and its need for a sophisticated GIS that can support variety, the Centre uses a GIS based on ESRI software. ArcView Spatial Analyst is used for extracting topographic variables in combination with survey data for the greenheart tree project. A loosely coupled spatial model based on ArcView and SPSS software was constructed.

ArcInfo DEM construction and filling was used to achieve hydrological consistency. Hydrological variables that were known from the literature to influence soil moisture (e.g., slope, contributing upslope area, curvature) were extracted from the DEM of the area. This was combined with the georeferenced present or absent data on greenheart trees from the forest inventory. Slope and contributing upslope areas were found to be statistically significant. The product result was a linear probabilistic equation. This regression equation was then fed back into ArcView using standard map algebra to generate a probability surface for greenheart tree distribution. The result was compared with a new set of georeferenced forest inventory data. The model achieved about a 60 percent classification accuracy, which is comparable to the accuracies reported for other landscape analyses.

A predictive map spatially depicts the distribution of an important tropical tree species over a 3,700-square-kilometer study area. The map may be used to guide future surveys by highlighting other suitable candidate sites for fieldwork.

This opens the potential of using spatial models for transforming sparse data sets into information needed by resource planners and managers. The study demonstrates that spatial models can be used as another tool in gathering information on the tropical biodiversity resource and could conceivably play a part in many practical applications such as providing information on the distribution of key indicator species in planning protected areas. A contribution has also been made to the understanding of the ecology of a tropical tree species.



Managing Geographic Sea Defenses

Guyana, South America

Although Guyana is in South America, its Caribbean coastline shares many of the same geographic phenomena as its neighboring island countries. A unique quality of Guyana is that most of it is below sea level. Ninety percent of the population is located in this lowland area. The coast and everything located on it is, therefore, at the mercy of the ocean. Fortunately, stretches of sea defenses, both man-made and natural, offer protection. The management of these sea defenses is primarily the responsibility of the Guyana Sea Defenses Project Execution Unit (PEU), which falls under the Ministry of Public Works. In addition, the Environmental Protection Agency (EPA) of Guyana has a mandate that includes the sustainable management of Guyana's coastal zone.

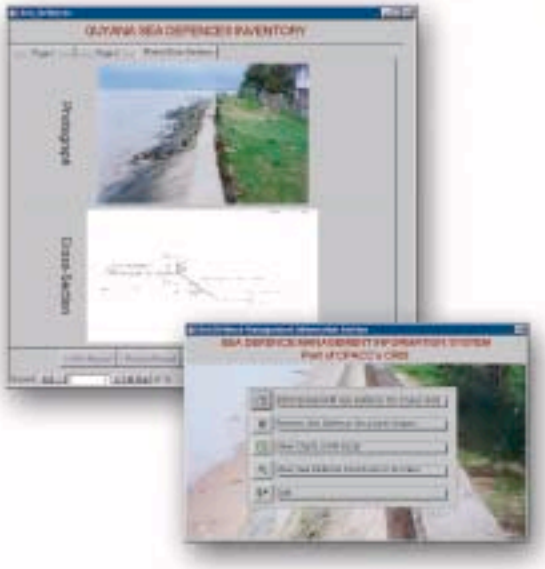
Guyana is implementing a GIS for managing its geographic sea defenses. The system is flexible, scalable, and one that later can be adapted to the entire coast. The users want a similar interface to the data as used in the current system with reports and charts presented as close as possible to the ones previously used.

Since much geographic data already existed for the island of Leguan in the Essequibo River, the island was chosen as the pilot area. Data for the sea defenses around Leguan has been stored in a binder as reports, charts, photographs, and cross sections, and a map at a scale of 1:10,000 showed the sea defense outline.

For this pilot project, the PEU devised an information system that combined ESRI's ArcView software and Microsoft® (MS) Access for presenting both spatial and descriptive data. This combination was chosen since most institutions in Guyana and the Caribbean are already using MS Office. Furthermore, most agencies that are involved with GIS use ESRI's ArcView software. The PEU refers to the data management system as the Sea Defenses Management Information System (SDMIS). The approach they chose allows the applications to use data from the database while maintaining live links with it; thus, changes made to data would be reflected immediately in the outputs of the applications.

The system offers its users such features as the ability to view photographs and cross sections of each sea defense segment by clicking on it. System features allow users to view attributes for each segment, query the database, and visually display outcomes. The system also allows users to view metadata for each data set.

Once the system was in place, the next task was getting the spatial data into the GIS and implementing these features. The spatial data from the sea defense outline is available as distance and bearing values or as a 1:10,000 map with a user-defined reference grid. Distances and bearings are scale independent; therefore, the grid was initially used. However, designers found that the starting and ending points did not meet. Since these points significantly differed, the next option was to digitize the 1:10,000 map.



Because a user-defined reference grid was used, a means was needed to georeference the map. The approach taken was to locate easily identifiable objects on the map, such as kokers and sluices, and to use a global positioning system receiver to find the position of these objects on the ground. This was done with a Garmin GPS 12CX unit. The points were then used to georeference the map during the digitization process. Digitizing was done using ESRI's ArcMap software, and the end product was a shapefile representing the entire outline of the sea defenses.

Metadata (i.e., descriptions of the data sets) was then created for each data set using ESRI's ArcCatalog software. A link was established with the data in the MS Access database through querying by ArcView. Like MS Excel, this link remained live.

Values from the resulting query were used to dynamically segment the sea defense outline. Two types of dynamic segmentation were performed, point events and linear events. Point events were used to show the start and end points of each segment that was documented, and linear events were used to show the segments between those two points. The point events were more for display purposes so that the user could see where each segment begins and ends.

The next task was linking the photographs and cross sections to each line segment. The photographs and cross sections were first scanned and stored on the PC. An "update query" was used in MS Access to

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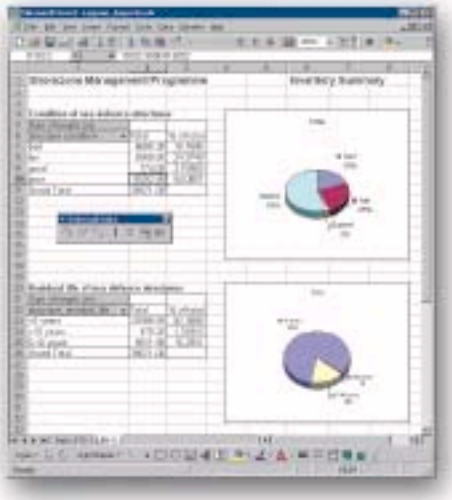

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populate fields in the main database table with relative paths to the photographs and cross sections. They showed up in the linked table resulting from the query in ArcView, and the HotlinkAPI ArcView extension was used to establish the link between the photographs and cross sections with the segments. Viewing of metadata was achieved with the MetaScan ArcView extension. Although querying can be performed with the query tool that comes with ArcView, the Advanced Queries and Formulas 2 ArcView extension was used instead. This allowed queries to be stored and reused later.

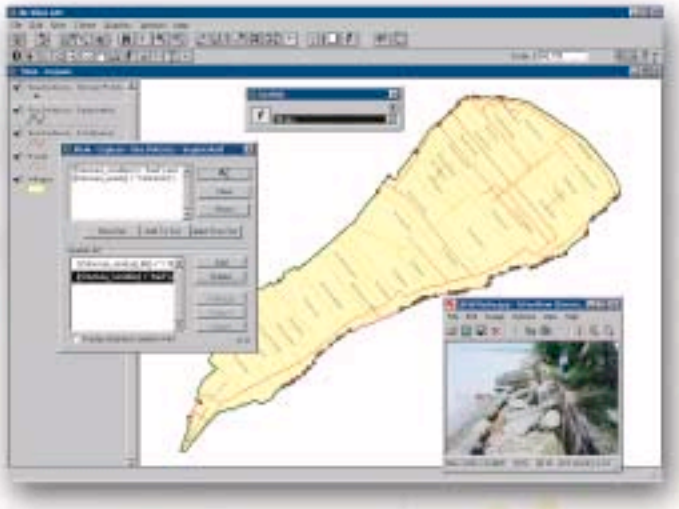
Since the inception of the pilot project, the following features are slated to be added to the application:

- Bathymetric data for generating profiles
- Security level access
- Simulation for predicting shore and sea defense changes
- Satellite image or georeferenced aerial photomosaic or orthophoto

This would be used to verify the accuracy of the current digitized outline. In addition, other data would be extracted from the image and used for other analyses.

The engineers continually kept the end user in mind while they designed the application. Most parts of the user interface (forms, reports) were designed to look like the current paper-based system as closely as possible. This was done to ensure a smooth transition from the paper base to the computerized system. Of course, the next step is expanding the project to support Guyana's entire coastal sea defense.

"The system is flexible, scalable, and one that later can be adapted to the entire coast."



Water and Sewerage Authority Has GIS History

West Indies

The Water and Sewerage Authority (WASA) of Trinidad and Tobago has come a long way since 1988 when the company first decided to begin digital mapping. It realized that a computerized geographic information system would facilitate better management of its more than 5,000 km of underground pipeline assets. In those days, there was no source of digital basemaps; therefore, it hired a survey service to take aerial photographs of parts of the islands.

It was not long until the organization began to derive benefits from its GIS program, then based in AutoCAD. But the limitations of the initial system became apparent, and within five years the company undertook a data conversion to work in the new environment of ESRI's software. ArcView offered the manipulation needed for facility management. The initial focus of the department was that of supporting the delivery of water and wastewater services. Approximately 90 percent of the underground pipeline assets have been captured and are used not only for assisting day-to-day operations but also as the source of data for the network modeling of improvement works and for some aspects of asset management. Customer service initiatives within WASA have resulted in the database being populated with the relative location and the chief occupant or owner of each property on the islands. Data is shared across the local and wide area networks. An integrated framework will eventually be put into place.

Application development has been mainly on the PC platform using MapObjects. Conceptual designs are undertaken in-house. A Caribbean software consultant, Vision Logic, has done the preliminary designs, detailed designs, and programming. The main application created for the project is the Regional Geographic Information System (ReGIS), which is a query tool. The latest ReGIS module is designed to assist in the analysis of the level of service being delivered to WASA's customers.

Today, WASA has a ready market in other island utility agencies and, therefore, offers for sale its base data in part or as a complete set. WASA's growing GIS has not only been invaluable to the company itself but is also an important asset to many agencies throughout the West Indies.

"ArcView offered the manipulation needed for facility management."

For more than 30 years ESRI has been helping people manage and analyze geographic information. ESRI offers a framework for implementing GIS in any organization with a seamless link from personal GIS on the desktop to enterprisewide GIS client/server and data management systems. ESRI GIS solutions are flexible and can be customized to meet the needs of our users. ESRI is a full-service GIS company, ready to help you begin, grow, and build success with GIS.

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