Comparing Experiences in the British and United States Virgin Islands in Implementing GIS for Environmental Problem Solving

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The British and U.S. Virgin Islands: Comparisons and Contrasts

BVI:

Three miles to the north and east of the US Virgin Islands is the British Virgin Islands (BVI), a group of 36 islands and cays with a total area of 60 square miles. The four largest are Tortola (24 square miles), Anegada (14), Virgin Gorda (8.5), and Jost Van Dyke (4.5).

Geologically the BVI belong to the Greater Antilles, and together with the USVI and Puerto Rico rise from the Puerto Rican Shelf. Rocks of the BVI, with the exception of Anegada, consist of thick, steeply inclined metamorphosed volcanic and sedimentary stratified series of Cretaceous age, with dioritic and pegamitic intrusions. Anegada is a 30-foot high emergent coral limestone platform, apparently from the Pleistocene age.

The BVI is a Crown Colony of the United Kingdom (UK) with a total population (1991 census) of 16,108. Most of the population is on Tortola (13,225 inhabitants); between 1980 and 1991, population increased 46.6%. The BVI has internal self government, with an elected Council headed by a Chief Minister. The UK appoints a Governor who in addition to being the Queen's representative is responsible for defense, internal security, external affairs, the Civil Service and Administration of the Courts.

The BVI economy is based mainly on tourism (it is a "high density tourism" area.) and servicing of international business companies. Sailing and diving is the pivotal feature in BVI tourism. The average number of tourists *per capita* in the BVI is 221, compared with 119 for the US Virgin Islands[1]. The BVI 1990 *per capita* income was recorded at $10,125. Prior to the 1970's the BVI economy was based on subsistence agriculture and remittances from British Virgin Islanders who worked in the U.S. Virgin Islands.

USVI:

The United States Virgin Islands (USVI) is an unincorporated territory of the United States, purchased from Denmark in 1917. Total population (1990) is about 101,000, divided among St. Thomas (48,000), St. Croix (50,000), and St. John (3,500). The tourism-dominated economy of the Virgin Islands generates a per capita GTP (Gross Territorial Product in 1990) of approximately $11,000—highest in the Caribbean.[2]

Geographically, geologically and topographically, St. Thomas (28 square miles) and St. John (20 square miles) are similar: largely volcanic, with deeply indented coastlines, on the Virgin Banks (or Puerto Rican Shelf). St. Thomas and St. John are close to the BVI. St. Croix is a relatively large (84 square miles), mostly limestone island on its own submarine ridge which rises more than 4,000 feet from the bottom of the Caribbean. St. Thomas and St. John are about 5 miles apart; St. Croix is 48 miles south.

During the heyday of tourism development (from the late 1950s through the mid-1970s), the USVI experienced average annual compound population growth rates in excess of 6%, combined with a doubling in real incomes: an unprecedented paroxysm of growth which is still being assimilated by a population which has little in common with the 30,000 people who lived in a predominantly agricultural USVI in 1950. In 1990, the USVI received an average daily visitor load of 37 visitors per square kilometer—compared with a load of 23 visitors per day per square kilometer in the British Virgin Islands, which is also a high density tourist destination[3].

Background to GIS Implementation Activities

BVI: The seeds of GIS applications in the British Virgin Islands were planted by a presentation about a proposed project for St. Lucia, made by Dr. Jan Vermeiren of the Organization of American States at a Caribbean Conference of Planners in Kingston, Jamaica, in 1984. The Town and Country Planning Department recognized the utility of GIS's analytical and display properties to the Department's staff operations for presentations to the Chief Minister and the BVI Executive Council. It should be acknowledged that this proposal fell on fertile ground, given a relatively long held tradition of support for the Town and Country Planning Department by the UNDP and the British Development Division, dating back to the early 1970's.

Subsequent to this inspiration, the Town and Country Planning Department requested budget authority to develop a land use data base. This data base would include buildings, property boundaries, and man-made and natural features of importance. The Finance Department saw in this project a means to combat growing competition to the Postal Services posed by independent package delivery services. The Finance Department renamed the project the "National Addressing System," and the Legislature provided $200,000 to provide a physical address for each property in the Territory.

The Town and Country Planning Department conducted a pilot project, focusing on the Road Town (the capital). The pilot project demonstrated that the hard copy Land Ownership or Cadastral maps then being used by the Survey Department were inadequate for accurately accounting for properties—even in the urban parts of the most developed of the British Virgin Islands. Therefore, the land use data base (National Addressing System) project was increased in scope to identify options for increasing the accuracy of property ownership records, including maps.

Because the Town and Country Planning Department had little experience with computerized land information systems, departmental

managers sought support from the United Nations Development Programme (UNDP) office in Barbados. The UNDP had previously assisted with the Department's Development Control Applications data base. This mode of operation, in which the BVI would purchase services which would be provided through the UNDP as a "vetting agent" for consultants and other technical assistance, continues to this day. The first such consultancy was provided by an expert from the United Nations Community and Housing Services (UNCHS) Nairobi office, who explored how a GIS might be implemented in the BVI. Over the next few years, three other experts provided input which the Town and Country Planning Department gradually integrated into a picture of how a GIS could be used within the technical and financial limitations of a small island government.

In the meantime, external conditions were also improving the chances for the success of the BVI program. On the one hand, British Virgin Islanders were receiving formal and informal training in computer applications in general, and specifically in AutoCAD drafting systems, which are being used by increasing numbers of local architects and engineers. On the other hand, the power of rugged microcomputer systems which could withstand the harsh operating conditions of the Virgin Islands was also improving, and local dealers were increasing their skills in support of such systems.

USVI: A proposal to develop a locally-supported GIS was being discussed in the USVI in detail in 1988[4]. This project resulted in a formal application from the Government of the United States Virgin Islands for financial assistance from technical assistance funds provided by the Office of Territorial and Insular Affairs of the U.S. Department of Interior. The grant was awarded in March of 1991. The proposed project included combining existing information from several USVI government agencies to produce "Geographic Information System Overlays," as shown in the table below[5]:

Agency	GIS Overlays
DPNR	Zoning
	Flood Plain
	Subdivision
WAPA	Water Distribution
	Acquifer Profiles
	Electrical Distribution
VITEMA	Critical Routes
& Emergency Services	Critical Facilities
DPW	Sewer line Network
	Transportation
	Flood Plain

DPNR=Department of Planning and Natural Resources
WAPA=[Virgin Islands] Water and Power Authority
VITEMA=Virgin Islands Emergency Management Agency
DPW=Department of Public Works

In addition, according to the grant application (which was written by the VI Government and which may not have represented U.S. Geological Survey's intentions), the National Mapping Division (NMD) of the USGS

agreed to digitize the eight USGS 1:24,000-scale quad sheets ("quadrangles") which cover the USVI, including the following "categories:"[6]

Roads and trails
  Power Transmission Lines
Hydrography
  Stream networks
  Shorelines
  Wetlands
  Mangroves
  Reefs
Topographic contours
Political boundaries

The underlying notion was that the whole would be bigger than the parts—each actor would bring his own corporate data and maps and all would share in the digitized product.

The five objectives identified for the project included:

- Provide USGS in St. Thomas with a complete microcomputer [GIS] work station,
- Develop digitized data base from USGS topographic maps,
- Contract for digitizing,
- Acquire digital data to load into GIS,
- Enter data not in digital format.

The proposal included a requirement for 50% local cost contribution to the project, including a matching suite of hardware for data maintenance, backup and analysis—the application states that itemized costs of $305,000 "...will be provided by WAPA and the Office of Territorial and International Affairs." The project application does *not* identify acquisition and support of GIS systems for the local agencies as one of the objectives of the Phase One GIS project.

The project application is ambiguous about the nature of the hardware and operating systems required to support the GIS. A list of hardware to be used by USGS refers to a "microcomputer workstation," but later references to the use of "ESRI ARC/INFO workstation software" makes clear *to sophisticated users* that the systems required to support these applications are UNIX workstations and UNIX language operating systems. In general, UNIX is not used or supported in the Virgin Islands and some Virgin Island officials associated with the GIS project feel they were not fully informed about the critical matter of the GIS operating environment and long-term support costs for the GIS to which they were committing.

A frustration for USGS in the project seems to have been the somewhat limited role the agency had in providing high quality data conversion services (digitizing). One USGS staff member explained that unfortunately

the agency's mandate only extends to providing data; it "can't get involved in applications."

Ownership of the digitized data was not clear from the initial project proposal, which spoke in general terms: "All available digital data and attributes will be complete, accurate, and up-to-date at the end of the project, and will be available for use and transfer to DPNR."[7]

Within the conditions and environmental constraints which have been discussed above, a number of specific differences developed between the two countries' GIS implementation processes.

Initial System Planning Activities

BVI: Although the BVI had no formal "systems plan," on four different occasions consultants worked with the Town and Country Planning Department to provide insight into some aspect of GIS applications. Sometimes the benefits from the consultancies were neither the type nor the quality originally expected, but in general each provided some additional perspective on the possible benefits and perils of implementing a GIS.

USVI: For the US Virgin Islands, there seems to have been few initial system planning efforts, either formally or informally, although the U.S. Department of Interior and USGS have wide experience in the Territory[8]. It can be argued that this very familiarity led to a series of unexamined assumptions and diminished communications about the exact terms of the assistance and services being exchanged between the several agencies of the VI Government and the USGS.

An indicator of the lack of system planning activities in the Virgin Islands is a proposal circulated by the Virgin Islands Emergency Management Agency (VITEMA) for a "Geographical Information Systems: Technical Operators Meeting." This proposal, from an agency which has always been identified as one of the most important participants in GIS activities, calls for a "Technical Working Group" to examine existing DBMS in the territory to develop a "planning strategy" for how to implement GIS[9]. This proposal is dated September 28, 1992—ten days before USGS announced a demonstration of the *completed products* of Phase I of the "comprehensive geographic information system ... being developed for the U.S. Virgin Islands."[10]

Software Selected and Rationale

BVI: In part because of the extended time frame for the BVI planning and initiation of the GIS system, the Town and Country Planning Department never fixed on a specific system configuration until the last stages of the planning process.

This process of "creative procrastination" had three synergistic results:

- PC power increased (and prices decreased) to the point where reasonably priced systems could perform many of the compute- and data-intensive operations demanded by graphics software for mapping.
- ARC/INFO released the ARC/CAD version of its GIS software which worked on PCs, inside of the well-known AUTO CAD drafting software. Computer Aided Drafting (CAD) software was known and used in architect and engineering offices in the BVI, so "upgrading" to include GIS functionality was a relatively easy upgrade path.
- The fourth GIS consultant to work in the BVI happened to be experienced in the problems of implementing systems in the Caribbean, and he had special knowledge and access to early versions of both ARC/CAD, and version 1.0 of ARC/VIEW. These two tools , based on a last minute proposal by IDAS (International Development Advisory Services, of Miami, FL), became the basis for the BVI GIS.

USVI: "Workstation ARC/INFO 6.1" was selected as the basic software for the USVI GIS project because it is the USGS standard software. In the environment surrounding the USVI project, this seemed to be a sufficient explanation although there may have been other reasons. The result of this decision is that WAPA and the DPNR lack any means of updating map or attribute data files, except as that service might be performed by outside providers, including USGS's National Mapping Division. It has been noted by USGS that the only reason WAPA and DPNR lack these capabilities is because they [WAPA and DPNR] failed to provide the matching suite of hardware and software specified in the grant application.

An example of the extra costs which such a condition creates is provided by the digitized water supply system. USGS built an ARC/INFO coverage by converting mapped data from AutoCAD source files, which was then linked to detailed attribute information about each element (pipe, valve, elbow, etc.) in the system. USGS then used ARC/INFO Network software, purchased with project funds, to build a NETWORK model which analyzes and displays the operation of the entire water distribution system—but there is no software in the Virgin Islands which can run the network model.

Hardware Platforms

BVI: The BVI GIS was originally installed on a Compaq 486-50, with a 21-inch screen. Town and Country Planning soon learned, however, that data input would be more efficient if it was split up among two or three smaller machines, with the Compaq available for analysis and data quality checking. Existing in-house office computers Town and Country Planning Department were upgraded to handle the data entry. Town and Country Planning staff who use these systems already feel the need for networked applications to share data more quickly. Plans for GIS expansion to other offices, such as the Electricity Corporation, increase the pressure for an extended local area network (LAN).

USVI: The USGS system which was used to build the USVI GIS data base was a Data General UNIX workstation with one large digitizing tablet and one pen plotter. There is no matching or comparable hardware installed anywhere in the USVI, as foreseen in the original project proposal. Observers tend to agree, however, that the failure to provide a specific hardware configuration is less significant than the lack of committed, senior, full-time technical staff. This staff is required to man the level of GIS facility which USGS envisioned for the operating phases of the USVI GIS.

Base Map Priorities and Layers Constructed

BVI: Building a map data base is proving to be a long process for the Town and Country Planning Department, complicated by the failure of a key digitizing contractor in Texas to provide property lines in a format which could be used to construct accurate property polygons. Data entry efficiencies for operators in the Town and Country Planning Department have increased, however, and most properties on the most densely inhabited islands have now been digitized.

A significant part of the cost of developing data bases for the early phases of the BVI GIS implementation has been producing demonstration data displays to illustrate possible new application areas for other agencies and departments of the BVI which have an interest in cooperating and sharing costs of additional system development. Examples include the Electricity Corporation and the National Disaster Preparedness agency to map emergency services.

Doing data conversion (i.e., digitizing) in-house in the British Virgin Islands has had costs and benefits. The costs revolve around the steep learning curve for data entry procedures, and the constant distractions of responding on short notice to "outsiders" who may be important long-term supporters of the GIS. The benefits include the advantages of increasing staff skills, and the ability to build constituencies for the program, based on prompt responses to real needs.

Coverage priorities for the BVI GIS include a national addressing system, completion of the territorial land use mapping, and accurate cadastral mapping (which has major environmental planning and management implications, as seen in the US Virgin Islands case described previously).

USVI: The USGS produced a total of 44 coverages for the Virgin Islands, from a variety of sources. The table below shows the major coverages and scales, by island:

St. Croix	St. John	St. Thomas
STC Water Distribution 1:2400	STJ Water Distribution 1:2400	STT Water Distribution 1:2400
STC Roads 1:2400	STJ Roads 1:2400	STT Roads 1:2400
STC Building Footprints 1:2400	STJ Building Footprints 1:2400	STT Building Footprints 1:2400
STC Shorelines 1:2400	STJ Shorelines 1:2400	STT Shorelines 1:2400
STC DLG Boundaries 1:24,000	STJ DLG Boundaries 1:24,000	STT DLG Boundaries 1:24,000
STC DLG Roads 1:24,000	STJ DLG Roads 1:24,000	STT DLG Roads 1:24,000
STC DLG Hydrography 1:24,000	STJ DLG Hydrography 1:24,000	STT DLG Hydrography 1:24,000
STC DLG Hypsography 1:24,000	STJ DLG Hypsography 1:24,000	STT DLG Hypsography 1:24,000

In addition, the following National Park Service data were converted and added to the data set, but were not produced by USGS.

STJ NPS Boundaries 1:24,000
STJ NPS Roads 1:24,000
STJ NPS Hydrography 1:24,000
STJ NPS Hypsography 1:24,000
STJ NPS Benthic Communities 1:24,000
STJ NPS Historic Sites 1:24,000
STJ NPS Vegetative Cover 1:24,000

There are a total of 10 coverages identified for St. Thomas, St. John, and St. Croix, based on information from the USGS 7.5' topographic quadrangles ("Quad sheets"—specifically demarking political boundaries, shorelines and streams, topography, and roads), and higher precision WAPA mapping, based on 1986 aerial photogrammetry, including left and right road boundaries, building footprints, shorelines, and water supply system data. The WAPA data is at 1:2,400 scale—an order of magnitude more precise than the USGS base map. St. John mapping includes ten added layers based on data provided by the Virgin Islands National Park.

The original USVI project proposal referred to a two-phase process of data base development, shown below:

PHASE	***TASKS***
I. Base System Development	Water Distribution Network Power Distribution Network Flood plain Maps
II. Agency Extensions (i.e., by USVI agencies)	Land Use Maps Transportation Networks Emergency Facility Networks Tax Parcel/Land Value[11]

USGS announced that Phase I had been completed in October, 1992.[12]

Ownership, access to and terms of reference governing the use of this digital data is confused. USGS says it is unable to provide an authoritative catalogue of the coverages because "one has not been produced." WAPA says it has several diskettes of data which are kept in the safe, and which WAPA has no equipment to manipulate. The Virgin Islands National Park (VINP) has been told that it can use its own data as well as WAPA data converted and attributed by USGS, but the Park does not possess or use USGS digital line graph data. To personnel in U.S. Virgin Islands agencies, the question of access to the GIS information seems to have been clouded by USGS statements that the USGS Water Management Division, for example, cannot make the digitized data available to VI government agencies.

The Department of Planning and Natural Resources apparently has no means of making direct use of the digital data, both because DPNR has no hardware or software which can use the data, and because it has no operators who can build the GIS systems to actually apply the data to decision-making needs[13].

In operational terms, it seems that the data belongs to WAPA, which contributed major financial support and map resources to the project. WAPA has been helpful in providing copies of the digital data to other groups and agencies.

Environmental Problem Solving in Local Decision Making

BVI: In the BVI, the first priority for use of the GIS facilities is to extend the Addressing System nationwide, together with improvements to the property ownership system. This will both improve postal services, as originally proposed, and will provide better information for important revenue and financial analyses. Land use mapping and environmental impact assessments are important second priorities for GIS applications. Among features already developed for interim studies and analyses have been mapping of "Significant Coastal and Wildlife Features" and "Environmentally Sensitive Areas," from the Anegada Development Plan, and mapping of important submarine habitats adjacent to Virgin Gorda.

The BVI have concentrated on developing GIS applications to address strategically important issues in the Territory. Marine and coastal resources are vitally important to the tourism economy of the British Virgin Islands. These resources embody important historic and cultural values. In addition, the BVI need to maintain a high quality environment to support diving and charter yacht-based tourism which is important to the British Virgin Islands economy. The Conservation and Fisheries Department is working with the Town and Country Planning Department to convert the country's *Coastal Atlas* to digital form (see section on Principal Users), as has been done on a demonstration basis for the Anegada and Virgin Gorda mapping described above.

USVI: In the U.S. Virgin Islands environmental decision making generally follows an adversarial, rather than a problem-solving format. For a combination of historical and cultural reasons, it is generally assumed that the development process creates winners and losers. In this environment, information is seen as an important tactical weapon, and it is difficult to muster support for activities or programs which seem directed at making information more widely accessible. Technology is more acceptable—and more likely to receive leadership support—if it is justified on technical, less "political" terms.

The presentation made on the "Virgin Islands GIS," in October, 1992, by the USGS team which had just completed the digital coverages for Phase I of the GIS project, tended to emphasize the ease of access issues[14].

As discussed in the section below on Principal Users, it was originally assumed that the Territory's three Coastal Zone Commissions would be primary beneficiaries of the GIS effort, for the assessment of environmental effects of major development proposals. The ground water protection program of the Division of Environmental Protection of the VI Department of Planning and Natural Resources is using GIS analyses produced by the Water Resources Division of USGS, employing the USVI GIS coverages, with added data (e.g., wells) being digitized by the Water Resources Division.

GIS Support Factors

The GIS support contractor for the British Virgin Islands says a successful GIS requires three key support elements: GIS Policy Leadership, GIS Technical Leadership, and competent outside expert assistance. The comparative experience of the two programs for these three key implementation support factors can be summarized:

SUPPORT FACTORS:	BVI	USVI
GIS Policy	Town & Country Planning Director led project from Chief Minister's Office	No GIS Manager in Government
GIS Technician	BVI Technician trained in US	No GIS Specialist in Government (draftsman at WAPA)
Outside Support	UNDP and IDAS (private contractor)	USGS technical support and US Interior Dept. Financial Support

Principal Users: Planned and Actual

BVI: The BVI Department of Finance is the first user of data products from the GIS, based on the initial funding for the addressing system. This system is based on detailed parcel maps of the BVI, so that the effective base map resolution of the BVI system is 1:2,500—considerably finer than the 1:24,000 scale of the USVI maps.

The Town and Country Planning unit, however, is also working to recruit other users to the system, including:

- Public Works;
- Water and Sewerage Department for a system-wide map (which may eventually spin off as a separate system, given its long-term interest in engineering-quality facilities management information);
- Conservation and Fisheries are actively considering GIS applications;
- the British Overseas Development Administration funded a *Coastal Atlas* for the British Virgin Islands.[15] At the suggestion of the Town and Country Planning Department, this mapping was developed in ArcINFO. There is a proposal to convert the *Coastal Atlas* to digital form for natural resource management applications, with a demonstration already having been developed showing the distribution of sensitive marine communities around the island of Virgin Gorda; and
- the GIS group is starting to experiment with the use of remote sensing products in GIS production, which would encourage the use of GIS for natural resource change detection.

The Town and Country Department's GIS specialist, Mikey Farara, is being moved to a position to provide networking support (including GIS distribution over the network) for a number of government agencies, while the GIS operation is being augmented with the addition of a cartographer to assist in tailoring GIS products to users' needs.

As enthusiasm for the GIS has blossomed in the BVI, the problem of managing for realistic expectations, and stressing the investment costs which participating agencies can expect, has become a management problem for the Town and Country Planning Department.

USVI: Because of the complex evaluation issues which face the US Virgin Islands' three Coastal Zone Commissions (one on each island), land use planning in general and coastal zone permitting specifically were assumed to be important first users of the GIS. There was, however, no process implemented by the Department of Planning and Natural Resources to prepare the Division of Comprehensive and Coastal Zone Planning to implement this system. In addition, the scale of permitting decisions may be too fine for the GIS base map. (See discussion of scale, below.)

WAPA is not using the GIS data. One senior manager characterized their experience with the GIS project as "paying a lot of money for a diskette of data that we keep locked in the safe."[16]

The Virgin Islands National Park (part of the U.S. National Park Service) and Biosphere Reserve has purchased a pc-based GIS system, and has employed an analyst to implement it for the Park and adjacent areas on St. John and the surrounding seas. This system plans to enter the USGS-developed data into the data base. In addition, through the vehicle of the Virgin Islands Resource Management Cooperative (a collaboration of research and resource management organizations), the VINP GIS data and analytical capabilities are available to members, including the Virgin Islands Government members.

At this time, the only major Virgin Islands government user of GIS information is the ground water protection group of the Division of Environmental Protection of the Department of Planning and Natural Resources. Because they lack equipment or software to manipulate the GIS data already available, they use the Water Resources Division of USGS as a GIS contractor, with two problems:

- **High costs.** Except for the fact that USGS "owns" the existing digital data, and the complexities of processing private contracts, DPNR believes it could get similar services at cheaper prices from other vendors.
- **Scale.** Environmental management processes in the Virgin Islands (and in most other small island states) require knowledge of property ownership, which implies maximum map scales of 1:5,000 to 1:10,000. The USGS quad sheet scale of 1:24,000 is too coarse for many management purposes. Costs of remapping areas of concern at the higher resolution are high—in theory, doubling the scale from 1:5,000 to 1:2,500, for example, will quadruple digitizing and maintenance costs—and the problems of maintaining multiple map resolutions and sources are not trivial.

What GIS Will Do

Joseph Berry has proposed seven basic categories of "What GIS Can Do for You."[17] These applications can be related to the GIS products and proposals for the US and British Virgin Islands, with special attention to natural resource and environmental issues. The table shows what can be done by coverages which have been, or are being developed for the two systems:

		USVI		BVI	
Questions:	Analytical Function	Application	Status	Application	Status
Can you map it?	Mapping	USGS & WAPA-based coverages	Done	Land Use Cadastral	Done & Proposed
Where is what?	Natural Resource Management	Digital Line Graph (DLG) Hydrography DLG Hypsography Well Inventory STJ National Park Coverages	Done Done Done Done	Coastal Atlas Sensitive Areas Significant Features Population Data Land Use Sensitive Areas	Proposed and Partial Major Islands done
Where has it changed?	Temporal	DLGs compared with WAPA Boundaries and Roads 1982 to 1989	Done	Land Use Updates Population	Proposed Proposed
What relationships exist?	Spatial			Land Use Population Data Coastal Atlas	Partial Proposed Partial
Where is it best?	Suitability	STJ National Park Coverages (limited application)	Done	Land Use Coastal Atlas Sensitive Areas Significant Features	Partial
What effects what?	System	STJ National Park Coverages (limited application)	Done	Land Use Coastal Atlas Sensitive Areas Significant Features Population Data	Partial and Proposed
What if ...?	Simulation	None Discussed		Speculation, but no plans to implement—yet	

The table above illustrates two contrasting issues separating the two jurisdictions:

The USVI has the *data* available to perform a number of relatively complex analytical processes, especially in St. John; but it has no capability to actually execute any such studies.

The BVI, on the other hand, has proposed—and often developed pilot or demonstration applications for—a number of GIS uses, but it still needs to develop the data resources to support these on a territory-wide basis.

Lessons Learned

The comparative experience of these two very distinct GIS programs reinforces three basic lessons of information system design and implementation:

Plan—don't assume. The prolonged, not to say repetitious, planning process which evolved in the BVI, involving multiple consultants with often conflicting advice, served to educate policy makers and managers in a much broader range of possibilities and avoidable problems than were available to the USVI. A corollary to the need for careful planning is the need to *avoid making decisions* or commitments to specific systems before such decisions are

absolutely necessary. Especially in systems involving high technology, premature decisions often mean early obsolescence.

Implement in Phases with **Early Demonstration Products**. Some issues, such as cadastral mapping and scale, are so subtle to inexperienced users that they need to be tried out in "real life" situations. Spotted at an early stage in the data conversion process, the USGS may have been able to provide a better solution than the "1:24,000: One Size Fits All" attitude which some US Virgin Islands critics now claim characterizes the federal approach.

Identify Critical Success Factors for Each Situation. In some environments (*e.g.*, USVI) GIS is most attractive for its ability to provide enhanced powers of analysis; in others, such as the BVI, it is seen as a data integration tool, and as a way to better inform political leadership and the public.

Major GIS implementations need to ensure they have met the three major support requirements: (1) A political/senior management "chief," (2) A technical "chief," and (3) Competent outside technical assistance.

Finally, implementers should recognize that they have a stake in *open information sharing*, and they should seek ways to redefine the decision-making process as a non-zero sum game: more information should provide benefits for all parties. It should also be recognized that such changed attitudes require fundamental value shifts which take a long time to achieve and which may have high short-term costs.

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1 Bureau of Economic Research, Virgin Island Department of Commerce. *Economic Indicators.* St. Thomas, July, 1994.

2 *Ibid.*

3 McElroy, Jerome L. "The Stages of Tourist Development in Small Caribbean and Pacific Islands," for the *International Symposium on the Island Economies:* Policy Models for Planning Development. Lesbos, Greece. November 27–30, 1991.

4 Potter, B., Green, K., Goodwin, M. *Management of Natural Resource Information for the Virgin Islands National Park and Biosphere Reserve: Special Biosphere Reserve Report.* Island Resources Foundation, St. Thomas, 1988.

5 Government of the United States Virgin Islands. Application for Technical Assistance Funds, Office of Territorial and International Affairs, U.S. Department of Interior: "Virgin Islands GIS System." Grant Acceptance signed April 29, 1991.

6 It is understood that the actual categories were subsequently adjusted, based on discussion between USGS, WAPA, and government agencies. Documentation for these new coverages are not available, but the general idea holds, except that no VITEMA data was used, and USGS did not digitize the WAPA power system.

7 Government of the United States Virgin Islands. Application for Technical Assistance Funds, Office of Territorial and International Affairs, U.S. Department of Interior: "Virgin Islands GIS System." Grant Acceptance signed April 29, 1991.

8 An informed source claims there was a grant made, possibly from EPA, for a preceding $50,000 "GIS Project," but no mention of this has been found in the materials available for this article, either as a proposal, or in terms of specific products.

9 Ward, Roy G. to Cyrille Singleton. Memorandum: Geographical Information Systems: Technical Operators Meeting. VITEMA, St. Thomas, September 28, 1992.

10 Parks, John E. "Letter: Invitation to a Demonstration of the Virgin Islands GIS." USGS, St. Thomas, October 8, 1992.

11 Government of the United States Virgin Islands. Application for Technical Assistance Funds. It has been said that the contents of these two phases were subsequently adjusted to reflect

different coverages, but the notion of a "phase II" in which local agencies would assume more operating responsibilities was retained.

12 Parks, John E. "Letter: Invitation to a Demonstration of the Virgin Islands GIS." USGS, St. Thomas, October 8, 1992.

13 The Department is said to be preparing another GIS proposal, however, for training, hardware, and software for a new GIS system. At the level of unconfirmed rumor, it is alleged that this system would be based on *MapGrafix*, a Macintosh mapping system.

14 Parks, John E. "Letter: Invitation to a Demonstration of the Virgin Islands GIS." USGS, St. Thomas, October 8, 1992. "The GIS is intended to provide decision-makers...with easily accessible spatial information..."

15 University of Manchester, British Overseas Development Administration (BODA). *British Virgin Islands Coastal Atlas.* Manchester, 1993. This project was a collaboration between graduate students at Manchester University, the British government, and the Government of the British Virgin Islands. Contrast this with the experience of Professor Joseph Berry of the Yale School of Forestry, recounted in footnote number 18.

16 Private communication.

17 Berry, Joseph K. "What GIS Can Do for You," *GIS World.* Boulder, Colorado. May 1994. While at the Yale School of Forestry in the 1980's, Professor Berry supervised a series of GIS studies by his students of land use and land suitability on the west end of St. Thomas. Copies of both the data and the analytical GIS software (AMAP) were offered to government planners and resource managers, but the Government was unable to respond to the offer because it lacked hardware to run the software, and there was no agency with clear responsibilities for computer mapping or GIS in support of environmental resource management.

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