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MANAGING SEA DEFENCES – FROM PAPER BASE TO ELECTRONIC

Abstract: Managing sea defences and sea defence related information is a challenging undertaking since there are many types of data that have to be brought together. This includes sea defence cross-sections, photographs, maps and other descriptive data. Sea defence management in Guyana is the responsibility of the Guyana Sea Defences, Project Execution Unit (PEU). The current management system relies mostly on data in paper format with odd bits in computerized form. With the current system managers take an inordinate amount of time just to sort through the information they have. Thus, there is a need for a more efficient means of getting access to and bringing together this diverse information. Support for this project was obtained from the Caribbean Planning for the Adaptation to global Climate Change Project (CPACC) through the many workshops held in the Caribbean region

One means of effectively achieving this efficiency is by using a loosely coupled Geographic Information System (GIS) and Relational Database Management System (RDBMS) approach. This project uses an ESRI ArcView/Microsoft Access system to present both spatial and descriptive data from which managers can make informed decisions related to the management of sea defences. The project focuses on the development of a pilot application to illustrate the usefulness of a Coastal Resource Information System (CRIS) for the island of Leguan in the Essequibo River of Guyana. The system was designed to be highly scalable and flexible. Its scalable characteristic allows it applicability for management of sea defences for the entire coast of Guyana. Flexibility emerges from the fact that it can be easily incorporated into an Internet Map Server (IMS) or packaged for

easy distribution to sector agencies with interests in coastal resources.

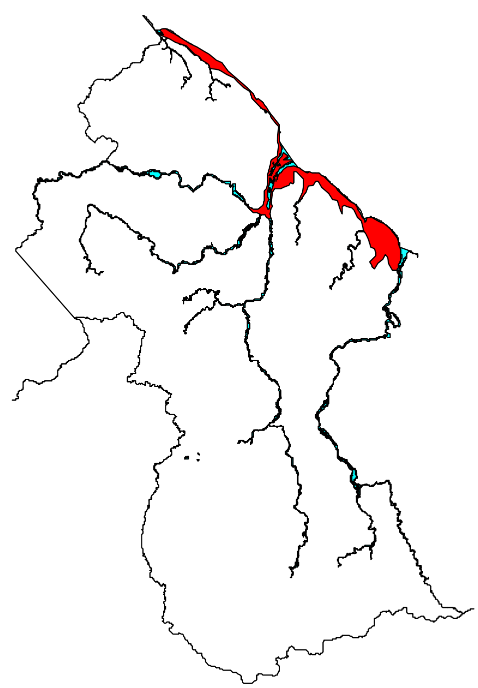
The usefulness of the system lies in its ability to efficiently and effectively capture, present and display information for a cross-section of users but with a bias towards managers. This is achieved through the query and display tools present in a GIS and a RDBMS and also with the ability to communicate with other applications such as Microsoft Word and Excel. Compared with the current system, it takes days to query existing information and updating is virtually non-existent. With the CRIS, these tasks can be accomplished in minutes and the information visually highlighted in a GIS. This will assist the PEU, for example, in scheduling maintenance activities and addressing critical areas in a timely manner using the most up to date information.

INTRODUCTION

The coast of Guyana (about 7% of total area of the country) is unique in that the entire stretch is below sea level (Figure 1), about 90 % of the population as well as economic and administrative activities are concentrated there (EPA, Guyana, 2000, pp. 1). The coast and everything that is located on it is therefore at the mercy of the ocean. However, stretches of sea defences, both man-made and natural, offer protection. The management of these sea defences is therefore important to the country as a whole. The Government of Guyana has recognized this and created the Guyana Sea Defences Project Execution Unit (PEU) under the Ministry of Public Works. The primary mandate of this unit is the management of Guyana's sea defences. This it has done since its inception and much data on sea defences along the coast have been collected. These data are stored as reports in binders, photographs and cross-sections and outlines of sea defences on maps. All of this is mostly in paper format with small bits in computerized form. Analyzing and

FIGURE 1
AREAS LIKELY TO BE AFFECTED BY A 1M SEA LEVEL RISE

DERIVED FROM USGS 1 KM DEM



updating this diverse data in its current form for making informed decisions is time consuming, costly and tedious. A need therefore exists for a more efficient and cost effective means of analyzing and managing these data.

OBJECTIVES

In order to satisfy the need mentioned above, a pilot area was used to develop a system that is flexible, scalable, compatible and user friendly – that can later be adapted to the entire coast. The prototype should improve the efficiency of the current system with respect to updating and performing analyses and also be cost effective. In addition, the system must fit in with the Caribbean Planning for Adaptation to global Climate Change (CPACC) initiative in establishing a Coastal Resource Information System (CRIS) in the CPACC participating countries.

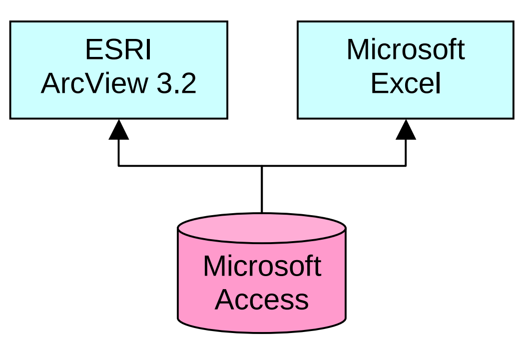
METHODOLOGY

Conceptual Design

The first step in developing the system was conducting a data and user needs assessment. The assessment revealed that much data exist for the island of Leguan in the Essequibo River and on this premise Leguan was chosen as the pilot area. The users wanted a similar interface to the data as used in the current system and the presentation of reports and charts should be as close as possible to the ones currently available. Data for the sea defences around Leguan were stored in a binder as reports, charts, photographs and cross-sections and a map at a scale of 1:10,000 showed the sea defence outline.

The CPACC's CRIS is based on a loosely coupled Geographic Information System (GIS) and Relational Database Management System (RDBMS) approach. It uses an ESRI's ArcView/Microsoft (MS) Access system to present both spatial and descriptive data. It is flexible, scalable, compatible, user friendly and also cost effective – most institutions in Guyana use MS Access and most that are involved in GIS use ESRI's ArcView. Since the CPACC's CRIS meets many of the objectives described above, the system was developed using a similar approach. The CPACC's CRIS is very comprehensive (ESSA Technologies Ltd., 2001) in that it was designed to store very diverse data. The system described in this paper focuses specifically on the management of sea defences and thus fits neatly within the framework of CPACC's CRIS. A model of it is shown in Figure 2. The applications using data from the database maintained live links with it, so that changes made to

FIGURE 2
SYSTEM MODEL



these data would be reflected immediately in the outputs of the applications, that is, a two-tier system.

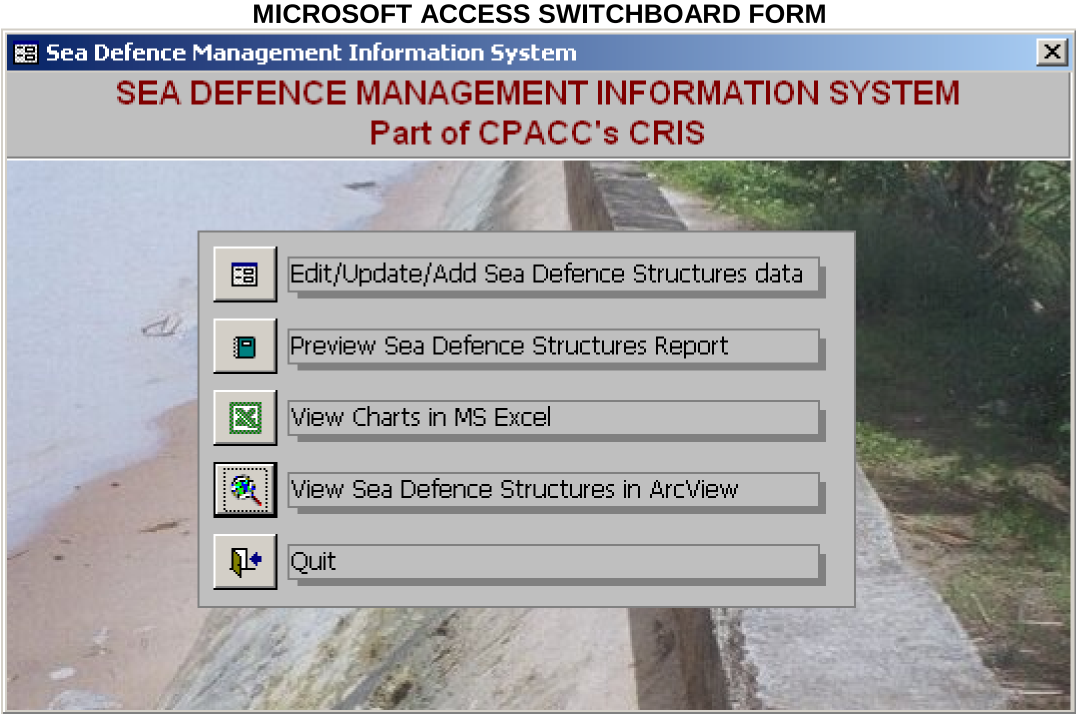
MS Excel was used for advanced presentation of the data to match those currently used by the PEU. This was achieved through the use of pivot tables and charts. ESRI's ArcView was used for spatially displaying the data. Some of the features users would benefit from and thus implemented are:

- The ability to view photographs and cross-sections of each sea defence segment by clicking on it. This was accomplished by dynamically segmenting the sea defence outline using data from the database.
- The ability to view attributes for each segment.
- The querying of the database and displaying these visually.
- The viewing of metadata for each dataset.

Logical Design and Implementation

The next step was the design of the database. This was done so that it matches the nature of the data and can be used by external applications such as ArcView and other Microsoft's Office applications. At the same time it followed, as closely as possible, the relevant parts of the CRIS database (ESSA Technologies Ltd., 2001) – for easy integration later on. The design of the database was implemented in MS Access 2000. Among other things it comprised of a switchboard from which the user can select various options (see Figure 3). The first option presents a form from which users can edit, add or update data. The second option allows

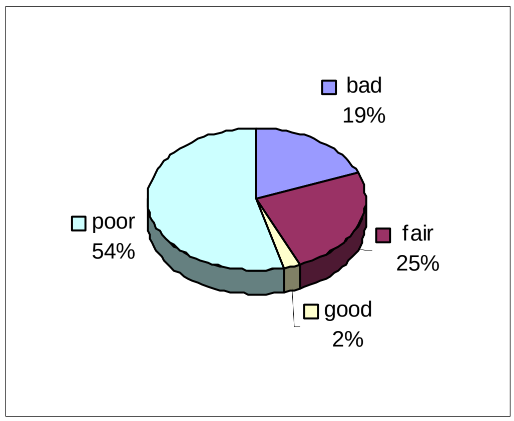
FIGURE 3
MICROSOFT ACCESS SWITCHBOARD FORM



users to view or print reports that are almost identical to the ones currently used by the PEU. The data entry form and report were designed in MS Access. It is not very easy to prepare pivot charts based on pivot tables in MS Access 2000, so MS Excel 2000 was used for this and called from the MS Access switchboard (the third option). The MS Excel workbook contains a live link to the MS Access data as outlined in Figure 2. Again, the pivot tables and charts were prepared to be as identical as possible to the ones currently used by the PEU. An example is illustrated in Figure 4. The fourth option allows users to view, query and perform other operations on the spatial data (more about this later). And the fifth option quits the application.

FIGURE 4
SAMPLE PIVOT TABLE AND CHART FROM MS EXCEL

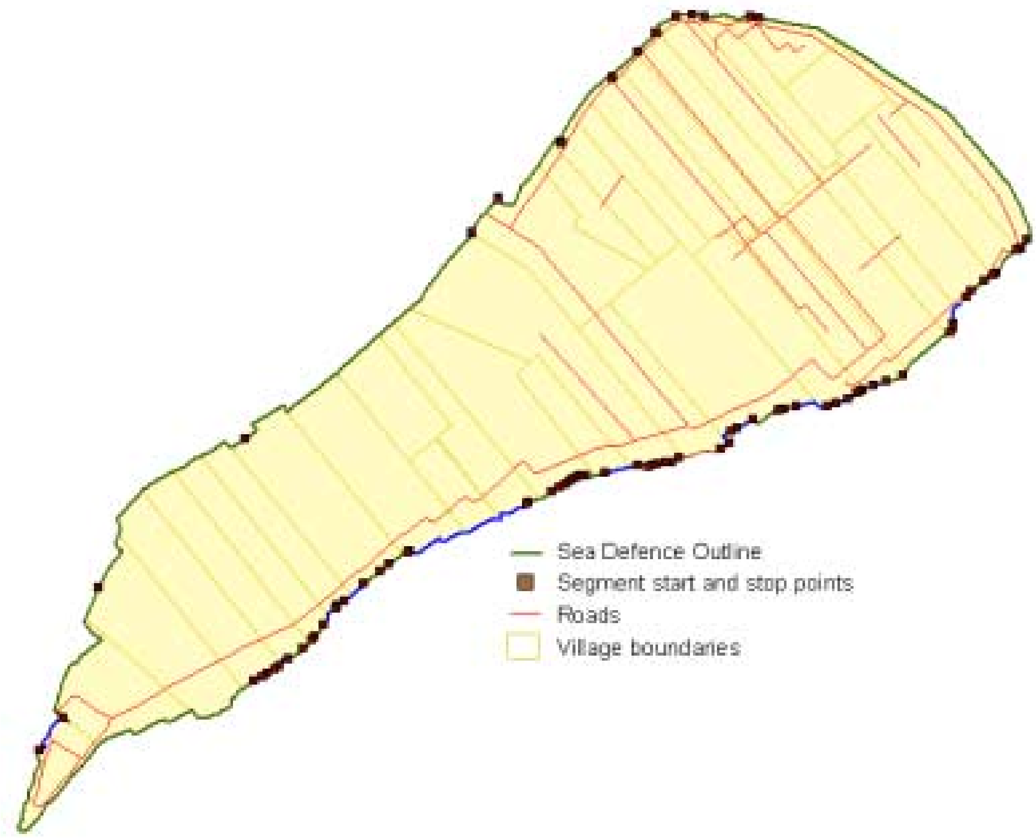
Sum of length (m)		
structure condition	Total	% of total
bad	6695.30	18.7696
fair	8908.80	24.9749
good	774.00	2.16983
poor	19292.90	54.0857
Grand Total	35671.00	



The next task was getting the spatial data into the GIS and implementing the features mentioned above. The spatial data (sea defence outline) was available as either distances and bearings values or as a 1:10,000 map with a user defined reference grid. Distances and bearings are scale independent, therefore, this was initially used but it was found that the starting and ending points did not meet and since they differ significantly 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 use a Global Positioning System (GPS) receiver to find the position of these objects on the ground. This was done with a Garmin GPS 12CX unit. These points were then used to georeference the map during the digitization process. Digitizing was done in ESRI's ArcMap and the end product was a shapefile representing the entire outline of the sea defences. Metadata (that is, descriptions of the datasets) were then created for each datasets using ESRI's ArcCatalog. An ODBC (Open Database Connectivity) connection was made to the MS Access database and this was used in the SQL (Structured Query Language) connect from ArcView. Values from the resulting query were used to dynamically segment the sea defence 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 are 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 populate fields in the main database table with relative paths to the photographs and cross-sections. They showed up in the table resulting from the SQL connect 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 perform with the query tool that comes with ArcView, the Advanced Queries & Formulas v2.0 ArcView extension was used instead. This allowed queries to be stored and reused later. A query showing ‘structures whose condition are bad and structures whose priority are critical’ is highlighted in blue in Figure 5.

FIGURE 5
RESULTS FROM QUERYING THE DATABASE



RESOURCES USED

Software

- Microsoft Access 2000
- Microsoft Excel 2000
- ESRI ArcView 3.2
- ESRI ArcMap
- ESRI ArcCatalog
- ArcView Extensions
    - ✓ MetaScan
    - ✓ Advanced Queries and Formula 2.0
    - ✓ HotLinkAPI 1.1
    - ✓ WinSizer
- IrfanView (graphic file viewer).

Hardware

- Pentium III 866 MHz PC
- Garmin GPS 12CX
- Summagraphics SummagridV (36” X 48” digitizer)
- HP Scanjet 6200C Scanner

PROJECT EVALUATION AND THE NEXT STEPS

The application is currently under the first evaluation by the PEU. This process involves members of the PEU interacting with the system, assessing how easier it has made their jobs and how easy it is to use. So far it has received great reviews but it is still too early to decide if all the objectives were met. Certainly, it fits in with the CPACC’s CRIS; it is flexible, scalable, compatible, user-friendly and cost effective. More so, it shows the flexibility of the CRIS. The feedback from the evaluation process and future users’ needs will obviously drive the future development of it. This may involve enhancement of the current features and addition of new ones. Future list of features that are planned include:

- Inclusion of bathymetric data from which profiles can be automatically generated.
- Internet enabling as much of the application as possible so that many more persons have access to it.
- Acquisition of satellite image or georeferenced aerial photo mosaic 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 these would be used for other analyses.

This project is the first to showcase the usefulness of a CRIS in Guyana. By doing this, it is hoped that many projects of this type would follow. The key, I believe, in getting organizations with interests in coastal resources to adopt a CRIS and the concept behind it, is by showing how it can help them. Implementation would require investing in the necessary hardware and software but most importantly the human resources needed to manage and sustain it. This would require the necessary training and institutional change to support it.

Recently coastal zone management has received great attention in Guyana due to the potential effects of global climate change and the fact that much of Guyana's population and development is located there (EPA, Guyana, 2000, pp. 1). One outcome from this was the Integrated Coastal Zone Management (ICZM) Action Plan. This was developed to address coastal issues especially the management of coastal resources. The CRIS could therefore streamline much of this process by giving coastal managers an advance tool with which to manage these resources.

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