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EVALUATION

Cape Verde Watershed Management Project:

Geographic Information System for

Erosion Assessment and Control

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1. Introduction

The TDY to Cape Verde was planned as a result of an article in the GIS journal, Geo Info Systems, March 1992, that reported on a successful geographic information systems (GIS) application for watershed development. The application was developed under the direction of Charles Rosenfeld of Oregon State University (OSU).

The objective of the project was "to establish the statistical relationship between hydrophysical indices, measure hydrological conditions and sediment yield. This will be accomplished by detailed mapping of the drainage network, channel morphology, erosional characteristics, terrain morphology and control structures within a representative basin. This is to be done with large-scale photographic imagery analysis with ample ground truthing to verify photographic findings" (Modification 01, March 14, 1988). The resulting GIS statistical model was to be transferred to the Ministry for Fisheries, Agriculture and Rural Animation (MFARA) for continued work in watershed erosion assessment and control.

The data for the project was to be derived primarily from aerial photography of Santiago Island, Cape Verde. The photography was to produce color IR and black and white photographs at both medium and large scale. In addition to the aerial photography and interpretation, field surveys and map analysis was used in the project.

OSU was also responsible for: 1) installing computer hardware and software in Cape Verde at MFARA; 2) training of two Cape Verdeans at OSU; and 3) the operation of the GIS installation at MFARA to analyze the dynamics of watersheds in Cape Verde. The results of the effort to use GIS and remote sensing as tools for watershed management in Cape Verde was unsuccessful.

Such lack of success was not surprising. Often research does not achieve desired results. The problem with this research was not so much that it was more complex than anticipated or that the research design was flawed, but the entire effort was carried out in a careless, nonprofessional manner. The result is not the GIS success story reported on in the journal article.

2. Findings

The project was implemented through a contract with Sheladia Assoc., Inc., the prime contractor. Oregon State University was a subcontractor to Sheladia. The scope of work (SOW) for OSU was defined in two documents; 1) an A.I.D. PIO/T, and 2) a modification enlarging on the SOW.

The main objective for the use of an automated information system was to assist in the development, analysis, monitoring, and evaluation of watershed management initiatives for the Watershed Management Project. The system was to have two main objectives: 1) remote sensing data acquisition and interpretation; and 2) development and technology transfer of an automated modelling environment using geographic information systems technology. Clearly, these objectives were not met by the subcontractor, OSU.

2.1. Remote Sensing Component

This component required OSU to provide the aerial photography to be used as the primary data source for the project. It was from this data acquisition stage that the project began its series of failures to meet the contractual obligations.

OSU clearly failed to deliver usable remote sensing data for any input into a GIS, or for any type of analysis. There were two separate aerial survey

attempts under OSU supervision. The first attempt was completely unusable; flight lines were erratic and in one instance, crossed. A second attempt also produced no results due to: defective film; ineffective mounting of camera using cardboard boxes and elastic cords resulting in non-clarity of the photos; inappropriate flight plans resulting in gaps in coverages and lack of overlap on end and side coverage. A professional evaluation of the result is attached as Appendix A.

2.2. GIS Component

The other contractual obligations of OSU were only partially carried out. OSU was to develop the criteria appropriate for evaluating watershed erosion assessment and control practices and to develop a model for this evaluation. The model was developed through six stream-reach inventory controls, or transects, gathering data on soils, slope, and landuse in each. The data from these inventories were to be the basis for modelling watershed erosion potentials using remote sensing as the primary data source for future modelling.

OSU did develop a watershed erosion model, but it is not an implementable GIS erosion hazards model that could presently be used by MFARA in the context of the watershed development project. Possibly because the primary data source, aerial photos, were unusable, the project objective was revised. The final report states: "The purpose of this [final report] has been to project a skeletal outline of the collection and analysis procedures for watershed physical environment data. The GIS section, in particular, merely outlines the data capture procedures and provides examples of

layered data. Actual GIS analytical products are not addressed".[1]

2.3. Technology Transfer

If there was one overriding implicit objective of this project, it was the development of local capacity to carry-on future watershed erosion analysis using automated technologies. This also was clearly unsuccessful.

Equipment and software were supplied to MFARA. Two officers were trained in GIS, albeit, digitizing and data entry being the primary component for one of the officers, Mr. Joao Lima. Mr. Lima still is employed by MFARA and remains enthusiastic about continuing GIS related activities. The equipment that was supplied by OSU, however, has been down for over a year and not much has been accomplished.

The other officer, Joao Mendez, received a MSc from OSU and is no longer with MFARA. He has since been with INIDA as a computer analyst and is associated with the new AGRHYMET project. He still remains in contact with Mr. Lima and has supplied AGRHYMET GIS digital data in IDRISI format in the hope of continuing the project. Together they have been exploring ways of using this newly acquired data, but for the lack of appropriate equipment and training, they have moved slowly.

It is in our opinion that there has been a clear lack of development of local capacities. Although the officers remain enthusiastic, the overall GIS institutionalization and implementing design was

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[1] Rosenfeld, Charles L., et al. 27 March 1989. Final Report- Cape Verde Watershed Management Project: Geographic Information System for Erosion Assessment and Control. Office of International Research and Development, Oregon State University: 90.

ineffective for the MFARA to carry-on any automated watershed modelling.

3. Recommendations

3.1 Why GIS

The combination of a fragile environment with current agricultural practices has resulted in deteriorating environmental conditions in Cape Verde. Given this, Cape Verde could benefit from an automated geographic information and analysis system for environmental planning and monitoring of development interventions. Such a system could provide the data and analysis to assist in promoting sustainable agricultural development.

3.2 GIS in Cape Verde

Cape Verde has two GIS installations, the center established as part of the Watershed Development Project by OSU at the MFARA and the AGRHYMET center at INIDA. Neither center is serving to produce any type of GIS analysis or other GIS related work. It is not even clear if there is any work expected of them, but it is clear that if such work exists, the personnel do not have the training that will enable them to function to produce it.

It is an indictment of the OSU training that Joao Mendes has only limited knowledge of the IDRISI GIS and Joao Lima, who spent three months of training at OSU, has no IDRISI training, although IDRISI had been identified as the software that would be used for the Cape Verde watershed modelling activity. Both are interested in GIS and both Mr. Lima and Mr. Mendes have been characterized by Rosenfeld as good students.

The two GIS installations can work together sharing data that is of common interest. Both the installation at MFARA and at AGRHYMET use the latest IDRISI GIS software. AGRHYMET has, in addition, the PC ARC/INFO software. Since both software packages readily exchange information, the data produced at either center can be exchanged.

It is not clear whether there is a significant role for GIS centers in Cape Verde and it would be difficult to support the substantial investment necessary to develop the centers were they not already established. But they are established and AGRHYMET will continue with or without USAID/CV support. The significant question this stage is whether there can be an effective use both centers and whether the marginal investment to make the centers a useful part of the Mission program is warranted.

The decision on the usefulness of the centers is one that only those in the Mission can assess. They are certainly not useful as a tool for assessing the hazard potential of Cape Verde watersheds, the use proposed by OSU. There may be a potentially important use in developing a spatial database to document past interventions.

There have been a substantial number of interventions funded by A.I.D. and others designed to protect the natural resource base. GIS, as a powerful automated analysis and monitoring tool, could provide a substantial research database that locates and describes the interventions carried out in the past under the Watershed Management Project. Using such a database, an analysis of the results of these interventions, their success or failure and the reasons why, could serve to guide future interventions to be carried out under the new Watershed Applied Research and Development Project.

3.3. Ensuring GIS Sustainability

If the decision is to use the centers, it is clear that they use will have to be institutionalized within their host agencies. Currently, each of the two centers exists without significant purpose. This is not surprising, since neither has any direction nor are producing any products.

To ensure that the centers are sustainable requires that the technology be recognized as an integral part of their host institution. This institutionalization requires that the value of the technology be recognized. Decision makers and mid-level and senior management officers of the organization must be aware of the uses of the GIS center and both request and use the resources of the center.

The use of GIS within an institution should be directed towards producing the types on analyses that are required by those making decisions. These analyses require the participation of the resource managers to define the problem, the decision makers to indicate the data they need to influence the decision, and the GIS analysts who use the technology to develop the analyses. Successful GIS adoption techniques should fosters this interaction.

Budgetary support is important and there should be a clear understanding on the part of the Mission on the contribution that they are willing to provide. GIS is a complex technology. It requires continuous support for training of personnel and frequent investment in new hardware and software.

3.4. A Role for AGRHYMET

In addition to budgetary support, a training program to produce GIS technicians will have to be instituted. The logical location of the training should be the

AGRHYMET center. AGRHYMET itself, will need a substantial training effort before the GIS installation is functional, but once the center is productive, it should recruit and train interns as GIS technicians as a regular part of its program. Such training will ensure the supply of needed technical GIS staff in a country where computer literate personnel are highly sought after by the private sector.

AGRHYMET is also the logical center for the production of much of the basic data on soils, landuse, transportation, administrative and political districts and other information that is important for many GIS analyses.

Currently, much of the Cape Verde data has been produced in Niamey, the location of the AGRHYMET center. It would be better to have the data on Cape Verde digitized locally. The work of digitizing the local data would serve to train the Cape Verde technicians and would avoid the obvious errors such as those present in the data layer examined during our visit.

3.5. A Final Note

AFR/ARTS/FARA has funded the establishment of the natural Resource Information Consultative Group (NRICG). The group is housed in the World Resources Institute and serves as a coordinating body for development of GIS systems for Africa. To assure that the Mission has competent guidance in developing SOWs for GIS related activities or for advising on any phase of GIS activities, the Mission can buy-in to the NRICG. Such a buy-in can assure the Mission of unbiased expert GIS opinion on a planned course of action. Mission experience has demonstrated the potential value of such advise.

Appendix A

TECHNICAL REPORT ABOUT THE TECHNICAL QUALITIES OF THE AERIAL PHOTOGRAPHS AT THE ALTITUDES OF 10,000 AND 7,000 FEET OF SANTIAGO ISLAND, PERFORMED IN MAY/1988 BY OREGON STATE UNIVERSITY TEAM

INTRODUCTION

This is a very condensed summary report concerned mostly in explaining the reason for the lack of longitudinal and lateral overlap of the stereo pairs and sharpness of the pictures (shadow zones), as well as the deformation of the images and the quality of the camera and its adaptation to the aircraft.

1. Aerophotographical Camera

The type of aerophotographical camera used to perform the mission on Santiago Island was manual (Hassalbad); operations such as installation, aiming and shooting, for example, are carried out by the camera operator. For technical reasons whose details are unnecessary to be pointed out, this type of camera is not recommended for a mountainous country like Cape Verde.

2. Installation and adaptation of the Camera to the Aircraft

When adapting any type of camera to an aircraft, an ideal spot should be selected for its placement considering that the camera will have to be oriented so that the edges of the photographs are parallel to the axis of the flight line.

First of all, the camera should be protected with a cushion pad, technically called suspension, to absorb the trembling shocks (vibrations) caused by the aircraft engine and moving air.

Also, the shutter mecanism should be of a good quality and semi-automatic. Otherwise, due to the inertia of the system, the velocity of the shots will not be uniform causing then an increase in the number of photographs during the flight.

The technitians from the Oregon State University did not take these technical details in consideration, what caused the overlaps to, in some cases, exceed or fall short and the center of the images of each photograph to be distorted in relation to the flight path.

3. Photographs at 10,000 ft = 3,048 m of altitude

a) - LONGITUDINAL OVERLAP

The longitudinal overlaps go from flight line 1 to 13. Between the flight lines 6 and 7 there is a gap (flaw) within which three more flight lines should have existed.

The common points are only repeated in two consecutive photographs instead of being repeated in three consecutive photographs, as they should have been.

The distortion of the image of each photograph is an evidence that the flight was not rectilinear.

According to the technical requirements of the flight survey plan, the percentages of the longitudinal overlaps were not achieved.

The causes of these anomalies are many, but the most important ones are the followings:

- Failure to install a suspension for the aerophotographical camera to function as a shock-absorber, to avoid the trembling caused by the vibration of the aircraft engine and air pressure;

- Failure to use an adequated shutter for mountainous areas;

- Failure to program a more elaborated flight plan and select an objective more adequated for mountainous areas;

b) - LATERAL OVERLAP (%)

For the flight at 10,000 ft, in many cases, lateral overlap did not exist, because the required technical recommendations which are of 10% and 35%, were not taken in consideration.

Stereo pairs with and without lateral overlaps:

- Photo 1 with photo 2..... 1% of lateral overlap
- " 2 " " 3.....40% " " "
- " 3 " " 4.....60% " " "
- " 4 " " 5..... No lateral overlap
- " 5 " " 6..... " " "
- " 6 " " 7..... " " "
- " 7 " " 8.....0% to 1% of lateral overlap
- " 8 " " 9.....0%, 1%, 5%, and 15% of lateral overlap
- " 9 " " 10..... No lateral overlap
- " 10 " " 11..... " " "
- " 11 " " 12.....12% of lateral overlap
- " 12 " " 13.....10% to 20% of lateral overlap

Regarding the lateral overlap among the stereo pairs, it can be verified that only three stereo pairs are in good technical conditions to work with, either in the office or on the field. The remaining ones are only good for prompt works.

4. Photographs at 7,000 ft = 2,134 m of altitude

a) - LONGITUDINAL OVERLAP

The overlaps of the longitudinal stereo pairs only exist on flight lines 1 to 8 and flight lines 13 to 20. There is a big flaw from flight lines 9 to 12.

The common points are repeated in three consecutive photographs and in some cases, they are repeated in four consecutive photographs, what technically is not recommended.

The center of the images were very distorted distorted; this means that the flight was not rectilinear.

The percentage for the longitudinal overlaps were not followed as technically is recommended (60%) for an aerial survey.

There are some stereo pairs with longitudinal overlaps of 70%, 80%, and 90%. This caused an excessive number of photographs.

As pointed out on page 2 (3.a) the causes of these technical anomalies are many.

b) - LATERAL OVERLAP (%)

In many cases, lateral overlap did not exist for the flight at 7,000 ft, because the required technical recommendations, which are of 10% and 35%, were not taken in consideration.

Stereo pairs with and without lateral overlaps:

- Photo	1	with	photo	2.....	No lateral overlap
- "	2	"	"	3.....	0.5% e 1% of lateral overlap
- "	3	"	"	4.....	1% of lateral overlap
- "	4	"	"	5.....	1% " " "
- "	5	"	"	6.....	5% " " "
- "	6	"	"	7.....	No lateral overlap
- "	7	"	"	8.....	1% to 8% of lateral overlap
- "	13	"	"	14.....	0.8% of lateral overlap
- "	14	"	"	15.....	No lateral overlap
- "	15	"	"	16.....	60% of lateral overlap
- "	16	"	"	17.....	1%, and 3% of lateral overlap

Among the lateral overlaps of the stereo pairs for the flight at 7,000 ft, it is noticeable the inexistence of stereo pairs with the percentages technically required. There is one stereo pair with 60% of overlap, the exact percentage required for longitudinal overlaps, but this does not help much when doing specific works.

5. SUMMARY:

- The majority of the stereo pairs have image deformations; this is because the camera (objective) selected was not adquated for mountainous areas;

- The photographs lack image sharpness, for the luminosity, the focal distance, and the diameter of the objective were not technically conjugated among them, and also because an inadequated filter was used.

- There are stereo pairs with exceeding overlaps (almost superimposed). This was caused by a bad tuning of the shutter and by the lack of a suspension to function as aerophotographical camera shock absorber during the flight.

- The center of the images were very distorted: the flight line was not rectilinear and there was no cushion for the objective.

- The aerophotographical camera was not properly adapted to the aircraft. This caused non-uniform shootings in relation to the velocity of the aircraft and consequently distorted image center.

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Praia, July 20th, 1990

Appendix B

Persons Consulted

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