MAPPING THE KAFUE FLATS OF ZAMBIA
A CASE OF THE MWANACHINGWALA CONSERVATION AREA

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ABSTRACT

The Kafue Flats of Zambia are an open savannah wetland covering about 6,500 square kilometres along the lower reaches of the Kafue River. They are rich in a variety of wildlife, some of it unique to it. It also has various huge industries along it, which have disturbed the ecosystem of the wetlands with their chemical effluent and use of its waters.

A project called WWF – Partners for Wetlands was thus initiated to try to mitigate this disturbance of the Kafue flats ecosystem. But for this project to successfully take off it required production of an up-to-date base map for planning and implementation of the entire project.

The Department of Surveying in the School of Engineering of the University of Zambia was therefore contracted to produce the desired bas map for the conservation area and its environs, a total area of some 1,500 square kilometres in the Mazabuka district of Southern Province of Zambia.

This paper therefore outlines how this mapping project was carried out as a contribution to sustainable use, management and environmental conservation of the Kafue Flats of Zambia.

1. INTRODUCTION

The Kafue Flats of Zambia are an open savannah wetland covering about 6,500 square kilometres along the lower reaches of the Kafue River. They are rich in the best-known Kafue lechwe that is found nowhere else in the world and also support a unique and diverse bird life that includes the largest population of the endangered Wattled crane [WWF2, 2000].

The Kafue River and the wetlands also supply a number of Zambian towns with drinking and industrial water. Huge agricultural establishments, chemical and leather industries and a huge hydroelectric power generating plant are found here. These undertaking have thus disturbed the unique ecosystem of these wetlands by discharging huge amounts of chemical rich effluent into the wetlands.

These activities in the Kafue flats have thus disrupted the natural cycles that existed before upon which the local population, the birds, the fish and the game depended so much for sustainability.

In order to counter this disruption, WWF Zambia launched the WWF – Partners for Wetlands Project in November 1999 [WWF1, 1999] to spearhead and encourage the sustainable use and environmental conservation of these wetlands in an area now called the Mwanachingwala Conservation Area (MCA). This was to be done through a business entity that would take into account the local community's social and economic interests since they are partners in the project.

The activities to make this project workable, such as the socio-economic study, reintroduction of wildlife and design of reed beds for waste purification, hinged so much on a production of an up-to-date base map of the area. This task was under taken by the Department of Surveying of the University of Zambia using both field surveys, aerial photography and existing topographic maps of the area. The entire mapped area on the fringes of Mazabuka town in the Southern Province of Zambia was about 1,500 square kilometres. However, the project focuses on the area contributed by the partners who are Nanga Farms Plc, Ceres Farms Limited, Zambia Sugar Plc and Chief Mwanachingwala, which is an area of about 483 square kilometres in extent [DoS, 2000].

As the name signifies, the area is very flat. It falls by about only 10m for a distance of about 400km from the giant Itezhi-tezhi dam (about 985m asl) to the Kafue Gorge dam (about 975m asl) [WWF3, 2000], which feeds the power station at the gorge. The average height in the area is about 980m above sea level. Hence most of the water that flows through is retained to create huge wetlands in the area.

The mapping project had to start in February of 2000 although this was at the peak of the rain season because of the urgency with which the base map was required. It was envisaged that the other activities involving planning and implementation of the larger project to which mapping of the base map was a component, were to start soon after the rains a which time the base map was to be ready to facilitate these other activities. There was therefore no choice but to go to the wetlands during the rain season.

The methodology followed in the production of the desired base map involved data acquisition using three different methods and cartographic processing and final product output.

2. DATA ACQUISITION

Thus data collection was done through:

(a) Fieldwork - to establish ground control points for photo/model control during photogrammetric operations as well as to establish the conservation area boundary. Fieldwork was also used to acquire map completion data and to validate the draft map.

(b) Photogrammetry – to produce the desired base map for the initial project area by use of 1991 aerial photography at a scale of 1:30,000 and additional map completion by 1996 aerial photography at scale 1:5,000.

(c) Digitizing – to digitize the photogrammetric plots and existing topographic maps for the extension area to complete the production of the desired up-to-date base map of the project area.

2.1 Fieldwork

Although the time the project started was during the rain season, the job had to be done. However the project area being a wetland it was flooded and/or muddy in most parts, which made these parts inaccessible. But through endurance of the field teams the work was done despite the project vehicles getting stuck in the mud so often.

Initially, the fieldwork was used to acquire ground control points by GPS for photo control. The control points were first identified on aerial photos. However, points near the Kafue River were difficult to choose since the river lays in a natural all year round marsh in this area. It's a wetland such that even if there were identifiable points, they would not be easily occupied because of their inaccessibility. This therefore already posed a challenge on how to orient the upper strip of the aerial photos.

During the initial fieldwork, the field teams also carried out consultations with the partners to ascertain their land contribution to the project, thereby establishing the proposed boundary of the project as well.

In the final stages of the project, additional data for map completion such as place names and other missing features of interest to the project were again collected through fieldwork. This stage also took care of map validation as far as the manuscript was concerned. This was done through consultation with the partners of the project.

2.2 Photogrammetry

The main mapping was to be done through photogrammetry. But later the project area was extended and this was mainly done through digitizing existing maps with new features added through fieldwork. Aerial photos of 1991 at scale 1:30,000 were used to produce a six-sheet manuscript at scale 1:10,000 with a Contour Interval of 2m, since the area is very flat. This process was carried out on an A8 stereoplotter.

Figure 1., *Arrangement of six-sheet manuscript*

However, the photo control was not sufficient for the upper strip. Aerial triangulation using 1:50,000 map scaled coordinates did not produce acceptable accuracies. Discrepancies were too large to be accepted. As earlier explained there were no proper features in the marsh to choose as control points. But it there was also something else wrong with the aerial triangulation results. These aerial triangulation results were thus not acceptable at all.

This therefore, necessitated the use of an alternative method that made use of the river itself and the scant control of the middle sheet (No. 5). Thus by linking features of sheet 5 to same feature continuing into sheet 2, control was extended from sheet 2 to sheet 5. This method proved satisfactory as features on sheet 4 and 6 matched well with those on sheet 1 and 3 upon completion (See figure 2).

Although the maps were contoured, on the upper strip only spot heights were given because of the flatness of the area since height info was still necessary for the placing of infrastructure in the conservation area like roads and "hills" where animals could run to during floods.

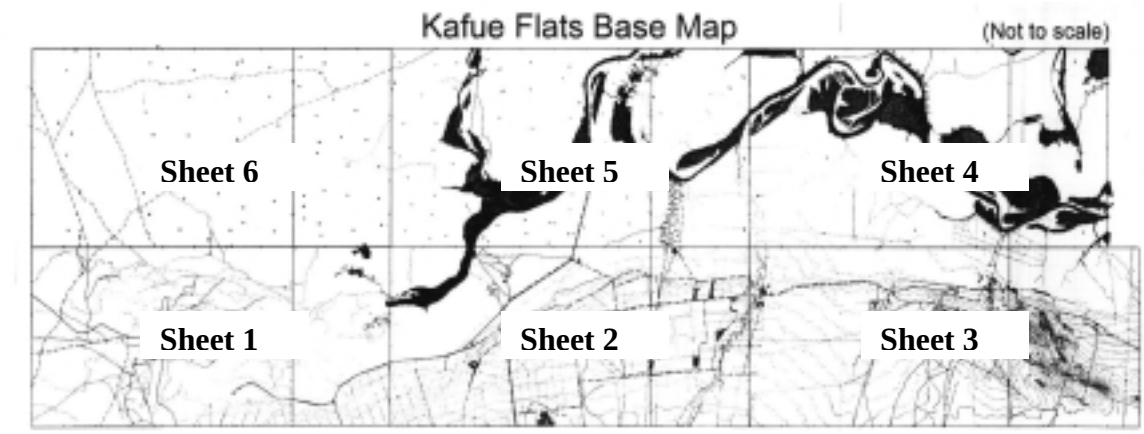

Figure 2. *Digitised photogrammetric plots as imported into Freehand 8*

Further update of the photogrammetric manuscript was done by the use of 1996 aerial photography from Zambia Sugar Estates at a scale of 1: 5000. This aerial photograph was very useful as it had a lot of latest information such as the existence of sugar cane fields irrigated by centre pivots in the area.

The photogrammetric plots (as diazo prints) were also submitted to the client for planning of various other infrastructures such reed beds for sugar estates waste purification and electric fencing of the conservation area. However, the final map was to be at the scale of 1:30,000 and in colour.

2.3 Digitizing

Apart from the hard copy map the end product was also to be submitted in soft copy. This entailed that all the photogrammetric plots had to be digitized. This was done with ILWIS

1.4 software. When the project area was extended further into traditional lands, digitizing became another major exercise as most of the data now had to be collected from existing topographic maps at 1:50,000 scale of the area of interest. Some additional data was also collected from the Kafue flood map at the scale of 1:250,000. Digitizing was also used to integrate additional data into the project map.

Digitizing of the maps was done in parts, which were later integrated or mosaiced during cartographic processing into one seamless map at a scale of 1:30,000 (See the small partitions in figure 2). Each of the six photogrammetric plots was digitized in two parts because the active area on the digitizer was limited by the digitizing software capability.

ILWIS 1.4 was used in digitizing because it has long be used in the department for this purpose and so has been found to be flexible as it is resident on a dedicated PC which is hooked onto the digitizer in the department's lab.

3. THE MAKING OF THE BASE MAP

3.1 Importation of digitized data

The digital files of the digitized maps were converted to dxf format in ILWIS and imported into Freehand 8 graphical software from Macromedia Inc. employing a GIS plug in called MAPublisher 3.5 from Avenza Software Marketing Inc.

Since the map was digitized in UTM coordinates, importing the files that constituted it was done one after another. These separate parts of the map automatically snapped onto their correct position in the map with all the features falling in their respective layers in Freehand (See the fitting of features across sheets in figure 2).

3.2 Cartographic rendering

This map was compiled and rendered using mostly the specifications of the Zambian Basic Map. But also took into account the special requirements of the client. Thus after satisfying these specifications the entire map was cartographically rendered in Freehand 8. Symbols for use in the map were created on and in Freehand as it has various flexible tools for doing so.

When the whole map was ready, 6 sheets were compiled at a scale of 1:30,000 from this seamless map to fit on A1 size paper, all in Freehand. Figure 3 shows the layout of the final six map sheets. Figure 4 shows all the six map sheets framed as one map sheet giving the overview of the whole project area. A sheet showing the whole area was also compiled as the client wanted to have an overall overview of the whole area too at scale 1:80,000.

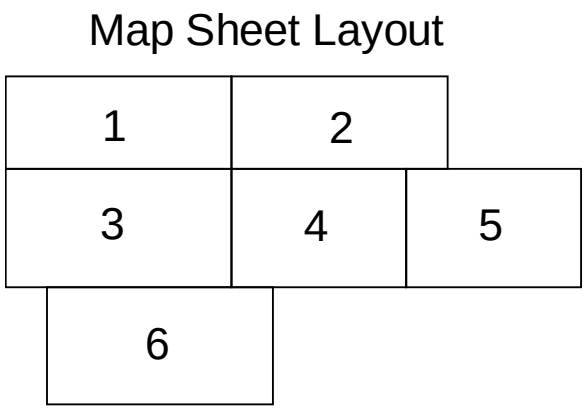

Figure 3. *Layout of the Final six map sheets for the project area*.

3.3 Printing

The finished map was printed in colour on a Calcomp Techjet 24 GT plotter on A1 size paper. However as first a problem was encountered in that the map would not be printed from Freehand. But this was later overcome.

4. PROBLEMS ENCOUNTERED

4.1 Fieldwork

The first handle in the project was the Marshlands themselves. The project area is largely a wetland and so fieldwork was carried out under very trying conditions. This was aggravated by the fact that this work started at the pick of the rain season. This problem resulted in the upper strip not having enough ground control points.

Aerial triangulation that was carried out did not help matters at all as its results were way off the mark. Although the results showed a good accuracy in planimetry, leveling of the photo models was not possible; distance comparisons could not tie up and to condemn it all the mapped features could not fit to the ends of the same features in the other plots already done. The differences in height were up to 8m.

However a study of the project area shows that the opposite of this aerial triangulation results should have been true as the area is very flat as it only falls for 10m in a distance of 400km over the whole stretch of the Kafue flats and in this area differences of less than 2m are true. In fact if there was to be a problem then it should have been in planimetry for failure to locate a point exactly in its position and not in height where a mislocation of about 10m or even 50m would have no consequence in height. Leveling and scaling of models also failed using aerial triangulation results. So the aerial triangulation coordinates were discarded altogether.

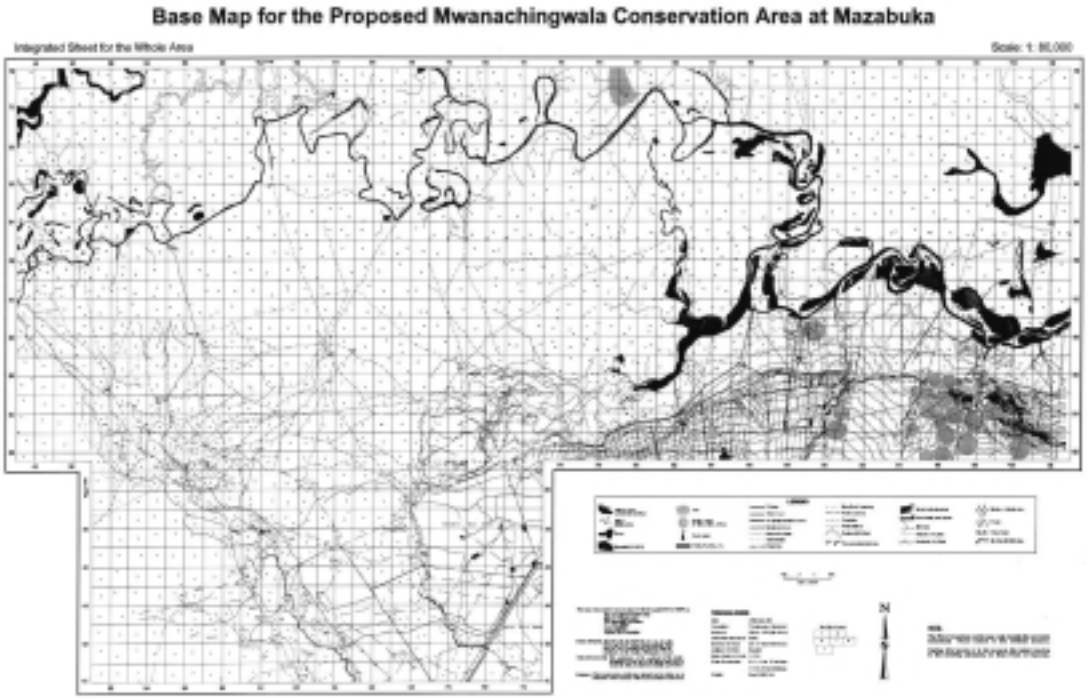

Figure 4. *All the six map sheets frame into one map showing the whole project area*

Therefore, this problem of insufficient ground control points was solved by extrapolation of coordinates from the 1:50,000 topographic maps for features such as river junctions and using nearby spot heights. This did not introduce problems at all as the project area is very flat. In addition there were enough scaling parameters that were used on the middle sheet to ascertain the correctness of the extrapolated control. This also took into account the assumption that the topographic maps used were compiled with sufficient pre-marked ground photo control, as is usually the case to guarantee correctness of the extrapolated coordinates.

Apart from the features fitting nicely across sheets (See figure. 2), distances were compared with those measured on photos and maps, and from GPS points, which compared well for the extrapolated points. All in all the fitting of the mapped features across sheets was excellent. Moreover only half of the width of the top strip (where ground control was insufficient) was used and had the river as its main feature only.

4.2 Printing

As earlier stated, printing was a problem, as the printer could not react to commands from the software. This was ascertained since it could print using other software on same PCs. After much hassling and trying this and that and much consulting, it was discovered that Freehand 8 could not print well with windows 95/98 a fact that was confined from the Macromedia Freehand technical issues website. This problem was thus overcome by using an updated version of Freehand, in this case Freehand 8.0.1.

5. DELIVERABLES

At the end of the mapping exercise, a report of the whole process, hard copy maps and a digital GIS copy in ArcView on a CD ROM were delivered to the client. The hard copies were used for planning of various infrastructures as well as implementation of the plans in the project area. They have also been used in the various reports for the project. The digital GIS file delivered in fact has a wider coverage of the environs of the project. This was delivered to facilitate further use of the collected geo data for the benefit of the project and its stakeholders. The project is being encouraged to develop a 'small' GIS for the project. However from time to time the project does request for more and more of the hard copy maps, especially the one giving the overview of the entire area.

6. CONCLUSION

This project was a very good experience in that it was done from scratch to finish; involved new and revision mapping; field collection of additional data through consultations with stake holders and thus exposed the Department to a number of challenges that such projects pose. It was thus another important phase of learning.

The interaction with the local communities involved in this project during the mapping exercise and the successful completion and delivery of the final products is a good point of how local communities can be involved in technical jobs like geo data collection for the good of the community. In such a case the community in fact feels part and parcel of every process that took place, as they were involved in realizing the outcome of the project. In fact the larger project is about WWF partnering with the local communities and the private sector in arresting the degradation of the local environment upon which everyone in the area depends.

This project further shows clearly how environmental and conservation issues depend on Geo-date. All the other works in the conservative area, such as the business plan, depended on the output of the mapping project for planning and implementation. It is thus an eye opener and a good example to all who still think that investing in geo-date is a waste of time and money. Geo data concerns everybody who has anything to do on, under or above the land and better planning very much depend on reliable up-to-date geo data.

Most important of all, though, in this project was that at the end of the mapping exercise both the client and the contractor were happy about the job done.

Finally WWF Partners for Wetlands are being highly commended for their visionary thinking on the importance of geo data.

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BIOGRAPHICAL NOTES

After graduated from the University of Zambia (UNZA) with a Bachelor of Engineering degree in Surveying in 1992, the author worked for the then giant Zambia Consolidated Copper Mines Limited at Nkana Division as a Sectional Surveyor doing underground and surface surveys. In 1995 joined the University of Zambia as a Staff Development Fellow and obtained an MSc in Integrated Map and Geoinformation Production at the International Institute for Aerospace Survey and Earth Sciences (ITC) in the Netherlands. Upon return in 1997 the author has been lecturing, supervising student projects and carrying out consultancy work at UNZA. In 2001 obtained a certificate in Remote Sensing Image Processing from the Indian Institute of Remote Sensing in Dehradun, India.

The author is a member of the Surveyors Institute of Zambia (SIZ) and is currently the vice chairperson of the Zambia Association of Geographic Information Systems (ZAGIS).

In 1999 attended the ICA conference in Ottawa Canada as an ICA Award Winner with a paper entitled **"***Remapping Zambia for Census, Elections and Other Needs."*

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