OKACOM

The Application of Remote Sensing and Geographic Information Systems Technology

Specialist Report prepared by Rob Harris for :

PERMANENT OKAVANGO RIVER BASIN COMMISSION

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1. INTRODUCTION

This report for the Preparatory Assessment Project, OKACOM, was aimed at providing an overview of how Remote Sensing (RS) and Geographic Information Systems (GIS) data and related computer technologies can be effectively utilized in the OKACOM Environmental Assessment project. Specifically the report address the following topics:

i) The essential role of remote sensing in environmental assessment projects, the type of remote sensing data most suitable for the OKACOM project and the form of data that can be derived from Remote Sensing data sets.

ii) The role of a Geographic Information System/s (GIS) in Environmental Assessment.

iii) The importance of effective remote-sensing, to GIS links.

iv) An overview of GIS and image processing (IP) systems (for processing satellite and airborne imagery) currently in operation in the Botswana/Namibia region, including current operator expertise, and limited information on data availability.

v) Guidelines for the implementation of a centralised Remote Sensing data repository and GIS database for the Environmental Assessment Project.

2. REMOTE SENSING AND THE ENVIRONMENTAL ASSESSMENT STUDY

World-wide, remote sensing is recognised as being a significant source of data for environmental analysis and assessment projects. Projects of this nature benefit from the unique advantages of remote sensing, many of which are fundamental to the successful outcome of environmental projects. Some of these advantages, pertinent to the OKACOM Environmental Assessment are:

i) Regional coverage at adequate mapping resolutions. Landsat TM 180 x 180 km per scene at 30m resolution and SPOT Panchromatic imagery at 10m resolution 60 x 60 km per scene are recommended. These data sets provide the lowest cost per square km for base-mapping and for extraction of a multitude of derived data sets.

ii) The multi-spectral nature of remote sensing data such as Landsat TM, Landsat MSS, or Spot XS (20m resolution) permit image processing (IP) applications, allowing extraction of data from singe data sets for multiple applications. Environmental applications that can benefit directly from or obtain evaluation data from these data sets are:

- Land use mapping and planning;
- Vegetation cover mapping and vegetation classification maps;
- Hydrological mapping and planning ;
- Land degradation mapping;
- Infrastructure mapping, to update outdated infrastructural and topocadastral maps;
- Geological mapping and mineral potential identification;
- Agricultural production mapping, resource identification, and planning;
- Human settlement mapping and planning.

The extraction of applications data from remote sensing data for the above mentioned studies is automated via standard IP procedures in IP software packages.

iii) Remote sensing data provides the most current information on an area available, as opposed to aerial and ground-based surveys or existing topocadastral data which is rapidly outdated. This function of remote sensing data has particular importance to the OKACOM project in terms of gathering data about areas where access is denied, or difficult, due to political conflict or instability in certain regions covered by the project.

iv) Continuous collection of remote-sensing data ensures that environmental planning is based on current data. Comparison of data obtained at different dates during the Environmental Assessment permits time domain analysis, enhancing the quality of:

- Vegetation studies;
- Land degradation monitoring projects;
- Infrastructural development assessments;
- Human resettlement/movement studies.

v) Sophisticated IP procedures can be conducted on remote-sensing data, integrated with other environmental data sets (digital rainfall maps, temperature surfaces, topographic maps etc.) to derive information important for environmental planning.

Examples are:

- Biomass estimation (for use in vegetation monitoring, commercial forestry);
- Grazing capacity information (effective use of grassland resources);
- Soil moisture mapping (agricultural planning and monitoring);
- Habitat mapping and species site matching (locating those areas most favourable/suited to specific agricultural or forestry activities, or requiring preservation status);
- Infrastructural routing and human settlement site planning;
- Erosion potential mapping.

Cost effective use of remote sensing data for the above mapping, planning and modelling operations requires integration with other environmental data sets. This necessitates the use of a Geographic Information System (GIS) which is fully integrated with a Remote Sensing and Image Processing System (*see later section*).

3. EXAMPLES OF THE USE OF REMOTE SENSING IN THE ENVIRONMENTAL ASSESSMENT PHASE.

i) Use of Spot Panchromatic Images (10m x 10m resolution) on an annual (minimal) basis to map:

- Infrastructural changes - Road, rail network development / degradation;
- Settlement changes;
- Development / growth of existing areas or abandonment.

ii) Some use can also be made of Spot Images to examine the effects of:

- Human settlement / relocation programs and how these are being executed;
- Early signs of erosional features / effects of erosion control programs;
- River management programs via detection and analysis of sedimentation patterns within river courses / along banks / within floodplains.

iii) Use of Landsat TM images (at least bands 3,4 & 5) acquired annually or bi-annual to study:

- Seasonal vegetation changes (bi-annual images needed);
- Seasonal agricultural activity;
- Comparing same season images to monitor vegetation degradation via change detection algorithms, and to quantify biomass loss. Used in conjunction with Spot Images to seek causes in areas where degradation is detected. i.e.
  - Human settlement;
  - Signs of grazing;
  - Flooding;
  - Harvesting/deforestation by commercial operations;
  - Pest, disease related causes.
- Use these same images to concentrate on areas where management programs have been put in place, or are being tested, to determine whether these are having positive effects, no effect or negative effects and attempt to quantify these.

iv) All of the above require multi-date imagery. Single date imagery can be used for:

- Infrastructure routing (e.g. use image classification combined with ground surveys to map soils / vegetation / geology, and to plan routes for roads / pipes / power lines accordingly);
- To generate reports on areas that will be affected by proposed developments. Digitally mapped development projects can be mapped onto satellite data and/or derivative products (classification maps, vegetation indices) to assess areas of specific values that will be affected by that development;

- Use of images and information derived therefrom for agricultural planning, and allotment of natural resources for commercial exploitation;

- Image data as input to GIS for buffer analysis / definition of ecologically sensitive areas; (*see later discussion on RS / GIS linkages*)
- Site / species matching (need GIS and RS input combined) i.e. identify sites ideally suited for planting of specific crops / plantations. This is an aid to effective commercial development and detection of areas or habitats ideally suited for reallocation;
- Re-introduction of fauna / fish species (specialist input to GIS models required). Imagery provides some of the data on the physical parameters of habitat (geology, soils, vegetation, land use);
- Identification and location of mineral resources to assess mineral resource potential, and planning of environmental control programs related to the exploitation of these resources.

v) Use of images can also be made for promotional materials:

- Promote the OKACOM management program to the scientific community, government agencies and local communities;
- Recreational / Tourist / Conservation area management and promotion.

4. AN OVERVIEW OF THE ROLE OF A GIS IN THE OKACOM STUDY

The implementation of a GIS in any environmental assessment study should be carefully planned with the project objectives dictating the manner in which data are collected, processed and stored from the outset. A goal-driven approach to GIS implementation avoids the problems commonly experienced with many GIS projects such as:

- Unnecessary and expensive duplication of data collection efforts;
- Collection of data in formats unsuitable for, or not convertible into formats suitable for analytical procedures required during the project;
- Collection of superfluous data which does not add value to the project outcome;
- Insufficient data collection resulting in incomplete information at crucial stages of the project, or models based on incomplete, outdated or inaccurate data.

A GIS, from the outset, should be seen as having a multifaceted function in the environmental assessment and management program. The GIS is useful for:

i) Data Collection, preferably into a central repository to which all project specialists are afforded easy access.

ii) Data Transformation and Integration; by this is meant that data from diverse sources can be unified in terms of formats, spatial extents and information content. Data standards need to be specified to meet project requirements and goals. The GIS is a vehicle for upgrading data sets to meet required standards of quality and information content.

iii) Data Generation: The GIS is a vehicle for deriving additional data required by specialists through merging, mathematical or statistical operations on existing data sets. An example of this would be the creation of a soil erosion hazard potential map by derivation (GIS analysis and combination procedures) from soil, geological, topographical, vegetation and rainfall data sets.

iv) Modelling: The GIS should permit the use of data sets to model outcome scenarios. Given the available input data, if certain parameters are changed, what is the effect going to be on certain outputs? An example pertinent to the OKACOM study - if a dam were built at a certain locality what would the effects be on environmental parameters above and below the dam. The GIS should, in this case, be capable of providing information on:

  - The dam's capacity;
  - Given certain rainfall scenarios the total water budget for the dam's catchment area and downstream expected water availability;
  - Model impacts of changed water budget in the catchment area below dam wall;

  amongst other questions.

Thus, just as a spreadsheet is used by financial analysts, environmental specialists should be able to formulate models using the GIS in terms of the spatially collated environmental data stored in the GIS, and be able to test their models.

v) In the longer term the GIS is an archive of Spatial Data. With time a carefully archived and well-maintained GIS provides a digital historical record against which the results of management plans and environmental policies implemented can be compared in order to evaluate results and guide further environmental management.

5. THE IMPORTANCE OF EFFECTIVE REMOTE SENSING TO GIS LINKS

Historically, Geographic Information Systems technologies, and Image Processing systems designed for Remote Sensing applications, have evolved into separate specialist fields and software technologies. Specialist personnel qualify as either GIS practitioners or Remote Sensing / Image Processing specialists. Recently there has been recognition of the important contribution of Remote Sensing to GIS in that:

- Data from satellite sensors provide unique input into a GIS system. The infra-red and thermal data from multispectral sensors allow for detection and mapping of features that no other method can provide data on. Examples are the early detection and mapping of crop diseases, or mapping of soil moisture content.

- Remote Sensing is the only cost-effective method of mapping large areas in a reasonable time frame. The data obtained from remote sensing for regional studies need to be incorporated into a GIS database if the GIS project is of a regional scale.

- Time domain analysis or change mapping is best effected on large areas by utilisation of remote sensing data. The costs of collecting multi-date data over anything but the smallest area (a single site), using any other method, is prohibitive. GIS, on the other hand, is the only effective technology for objective comparison and statistical analysis of multi-temporal data, given the huge volumes of data involved. Standard GIS procedures can be applied to multi-temporal remote sensing data to quantify change and analyse the direction of change and rate of change.

With this in mind, efforts at merging the technologies have increased in recent years, to the extent that most GIS practitioners now make routine use of digital satellite or aircraft acquired data in their projects, and software products designed for GIS applications incorporate methods of acquiring and utilising remote sensing data.

The effective link between the two technologies cannot be over-emphasised. Effective linking of GIS and Remote Sensing encompasses three important considerations.

i) Software considerations. Traditionally, powerful GIS systems have tended to be Vector-based systems, especially those developed for urban and engineering applications. Image Processing systems are by nature image or Raster oriented systems. Two approaches have been adopted by software vendors in order to provide 'effective links' between GIS and Remote Sensing.

   a) A partnership between a Raster-based product (IP/RS) and a Vector-based product (GIS). Two separate software products are used in parallel with a data link between, used mainly to pass Vectorised interpretations from the IP system to the GIS system.

   b) Single product solutions, in which one software product handles both image and Vector data, provides functions for changing from Raster to Vector formats and vice versa, and has both IP and GIS functionality built into a single product.

   In terms of cost, reliability, ease of data maintenance and most effective linking of GIS and Remote Sensing technology, option (b) is the most desirable.

ii) **Data Analysis Considerations**. Environmental data collected for an environmental assessment project such as the OKACOM project will typically be of two forms:

a) *Continuous data* - maps of variables that change in continuous fashion over the region, have intermediate values between sampled locations, which values can be interpolated from known data values. These data sets are best stored as Raster data sets, and analysed with Raster GIS tools. Examples are:

- Satellite data sets;
- Digital topographic models (DEMs, Slope, Aspect models);
- Climatic data sets (Rainfall surfaces, temperature surfaces).

b) *Categorical or discontinuous data* - Data sets (maps or theme coverages) of discrete areas or lines that have a single property or attribute assigned to them. Examples are:

- Soil maps (polygons of discrete soil type & properties);
- Vegetation maps;
- River maps (lines with discrete attributes of names, flow volumes and other chosen attributes);
- Point Sample maps (hydrological monitoring stations, soil samples);
- Land use maps.

Such data sets can only be stored efficiently as Vector data sets with attached attributes in a linked database.

The need for effective GIS - IP links becomes apparent when data stored in formats a) and b) above need to be integrated for essential management functions. An example, pertinent to the OKACOM project, would be an implementation of the UNIVERSAL SOIL LOSS equation, to evaluate potential soil loss at any position within the catchment area.

The equation:

$$A = R * K * LS * C * P$$

where A = soil loss / erosion potential
R = rainfall (Raster)
K = soil erodability factor (Vector attribute attached to soil map)
LS = Slope length factor (derived from Raster-digital topographic model & stored in Vectorized format)
C = Management factor (land or catchment management factor - either Vector or Raster data set)
P = Conservation factor (either Raster or Vector map)

Implementation of this equation requires the derivation of several parameters from satellite data via a Raster based IP analysis, followed by Raster to Vector conversion. Thus Management (*C*) and Conservation (*P*) factors would be derived by IP methods applied to satellite images and designed to assess the "state" of various land surface areas, which areas would be mapped as Raster data containing a management/conservation ranking at each image cell position. Calculation of the soil loss factor will require an integration of Raster & Vector data sets that is not possible in a Raster only (IP dedicated) or Vector only (GIS dedicated) system. The two technologies would be required to work together to solve this problem, preferably again, within one system. Data exchange across separate systems (IP & GIS) to solve this problem is inefficient in that potential for errors on conversion is increased, data conversion problems may occur in the process, and the time/cost related to solving the problem in two systems is increased.

Other applications related to effective IP and GIS links within the OKACOM project are:

- The production of cartographic quality (Vector) maps from satellite or aerial photograph interpretation. This requires that IP methods applied to digital image data, have outputs in quality Vector format.

Example: use of classification methods on multispectral satellite data to produce Vector maps of Land use.

- Application of Raster data sets to Vector data sets to solve / answer certain key questions.

Example: What vegetation occurs in this catchment area on slopes greater than 30º? This requires information from a Raster data set (SLOPE) to determine an area (>30º slopes) which can be used to extract the required information from a Vegetation map (Vector).

- Application of a Vector data-set to extract information from a Raster data-set.

  Example: Vegetation mapping identifies an area of rare vegetation community requiring preservation status within the catchment. Specialists wish to obtain information on the variables (rainfall, temperature, soil moisture, aspect, slope, altitude etc.) that favour this vegetation community in order to identify other potential preservation sites. Answering such a question requires application of the rare vegetation species polygon / polygons to the Raster data sets listed above, in order to extract information on the environmental factors in the area covered by that vegetation community, followed by a search of the combined Raster data sets in order to identify sites with a similar range of values of these environmental parameters.

The above routine GIS tasks are highly likely to be encountered during the OKACOM environmental assessment study, and effective IP (Raster and Remote Sensing) to GIS (Vector database) links will be essential for these assessments. A GIS strategy incorporating seamless integration of Raster and Vector data sets is essential to the successful outcome of the Assessment study.

iii) Data storage and Maintenance Considerations. The third aspect of efficient Remote Sensing / IP to GIS linkages relates to effective data storage and retrieval, and ease of maintenance of the OKACOM database. Particularly if it is desired that a central data repository ultimately be set up for OKACOM managers and specialists to access as needed, consideration needs to be given to the following aspects:

- Will Raster and Vector data sets be stored entirely separately from each other and in different system formats, or together within one portable and accessible file structure?

- Will specialists require one software product to access and **analyse** Raster data sets (including satellite data), and another software product to access **and analyse** the Vector data sets? The **and analyse** underlined is important here as some GIS software may allow access to, but **not** analysis of, a format for which it is not specifically designed. An example are desktop mapping systems ("Vector"-based) which allow Raster images or data sets to be accessed as "backdrops" but not to be manipulated or analysed to any useful extent.

- Particularly if remote access of the central data repository is required, how many files, file formats, file locations (directories) and file linkages will have to be managed in order for database integrity to be maintained?

- How easy will it be for specialists to obtain the data they require? Issues of data format, data locality and correct data linkages also need to be considered here.

- How will updating of data sets be accomplished? If specialists use the latest satellite data (Raster IP) to update the land-use map (Vector GIS), how efficiently will this process be in terms of number of file formats used, and software products used, and how easy will it be to ensure adherence to data standards in such a process?

Clearly, in relation to the above points, the fewer software products used and the fewer the number of file formats used the more manageable the above tasks become. This is not to suggest that specialists involved in the OKACOM project all be required to use one standardised file format and/or software product. At the specialists site they should be free to use the product they are most familiar with. At the central database location, however, a single file / database format is recommended, one which is carefully selected to be compatible with all formats submitted / required by various specialists. This single format central database is then efficiently maintained, and requests for data, or submissions of data from specialists, are translated into and out of this central data structure via efficient export / import procedures.

6. OVERVIEW OF GIS AND IP SYSTEMS CURRENTLY IN OPERATION IN BOTSWANA AND NAMIBIA, AND DATA AVAILABILITY

A survey of persons / agencies engaged in GIS / IP work of relevance to the OKACOM study was conducted. Limited responses to the questionnaire (*Appendix I*) were received and more detailed follow-up on this aspect is required. Those responses that were received give some insight into the systems in use, data sharing philosophies and data availability. Following is a summary of the returns received.

A) Directorate of Environmental Affairs, Ministry of Environment and Tourism

(Fax : +264 61 249015; Tel : +264 61 240339)

Respondent	:	Dr J.M. Mendelsohn (consultant)
GIS Software	:	ILWIS
IP Software	:	None
IP Experience/capability	:	None
GIS Experience/capability	:	Advanced; 1 Person
GIS Usage	:	Vegetation mapping Soil mapping Water resource mapping & analysis Human geography & demographics
Satellite Data Usage	:	Vegetation mapping Soil mapping Agricultural studies
Data Available	:	See Appendix II
Format	:	As ArcView shape files (Vector maps)
Data Sharing	:	Freely available with permission (see Appendix II for details)

B) Inter-Consult, Namibia, P.O. Box 20690, Windhoek

(Fax : +264 61 220400;Tel : +264 61 230934)

Respondent	:	Sophie Simmonds
GIS Software	:	None
IP Software	:	None
IP Experience/capability	:	Not stated / Outsource
GIS Experience/capability	:	Not stated / Outsource
GIS Usage	:	Not stated
Satellite Data Usage	:	Not stated
Data Available	:	None stated

GIS and IP work is sourced out on a project by project basis. Presumably they would contract to do work related to the OKACOM project. Their philosophy / procedure related to data acquisition / sharing would also need to be negotiated.

C) Windhoek Consulting Engineers, P .O. Box 2484, Windhoek
(Fax : +264 61 238880;Tel : +264 61 237728); E-mail : wce@iwwn.com.na)

Respondent : S.E. Crerar
GIS Software : TNT Mips
IP Software : TNT Mips
IP Experience/capability : Intermediate; 2 persond
GIS Experience/capability : Limited
GIS Usage : Limited
Satellite Data Usage : Environmental studies
Water and transport Studies
Feasibility and planning Studies
Data Available : Limited Landsat TM and MSS coverage of Northern Namibia

D) Ministry of Agriculture Water and Rural Development (Namibia)
(Fax : +264 61 249247; Tel : +264 61 2022082; E-mail : agricaez@nam.lia.na)

Respondent : A.J. Calitz
GIS Software : Regis (Vector CAD based); TNTmips
IP Software : TNTmips (Vector, Raster, CAD)
IP Experience/capability : Not stated
GIS Experience/capability : Intermediate; 2 Persons
GIS Usage : Vegetation mapping
Soil mapping
Climatological studies
Terrain analysis and modelling
Agricultural studies
Satellite Data Usage : Vegetation mapping
Soil mapping
Agricultural studies
Geological mapping
Climate studies
Terrain modelling
Data Available : Agro-Ecological Zones for Namibia:
- captured from maps, field surveys and satellite data
- scale 1 : 2 000 000
- a Vector data-set with information on soils, summary Landform information and Lerngth of Growing Period zones.

Format : Not stated
Data Sharing : Not stated

E) National Remote Sensing Centre (Namibia)

(Fax : +264 61 222830; Tel : +264 61 221511; E-mail: Harold@forestry.met.gov.na)

Respondent	:	Harold Kisting
GIS Software	:	ArcInfo (Vector); ArcView (Vector CAD view only)
IP Software	:	Erdas (Raster IP) Idrisi (also Raster GIS)
IP Experience/capability	:	Process Landsat, Spot & Spot X S; 3 persons
GIS Experience/capability	:	5 Persons (2 advanced & 3 intermediate level experience)
GIS Usage	:	Vegetation mapping Human geography / demographics
Satellite Data Usage	:	Vegetation mapping Human geography / demographics
Data Available	:	None stated
Format	:	Not stated
Data Sharing	:	Not stated

F) EcoSurv (PTY) Ltd - Botswana

(Fax : +267 313610; Tel : +267 350048; E-mail : ECOSURV@info.bw)

Respondent	:	M. Murray-Hudson
GIS Software	:	Idrisi (Vector / CAD GIS view only)
IP Software	:	Erdas; Idrisi
IP Experience/capability	:	Processing of NOAA AVHRR data. 2 Persons - 1 intermediate & 1 beginning level of experience
GIS Experience/capability	:	2 Persons - intermediate experience
GIS Usage	:	Vegetation mapping Water resource mapping & analysis Terrain modelling and analysis Wildlife habitat mapping
Satellite Data Usage	:	Vegetation mapping Terrain modelling Wildlife habitat mapping
Data Available	:	None stated

Summary

- Sufficient expertise exists in the region to undertake satellite data processing and GIS tasks related to natural resource mapping (vegetation, agricultural, habitat, water resource mapping), though most of this capability is within private consultancies who would need to be contracted to assist with management of OKACOM GIS data sets.
- Little experience in the use of GIS/IP for interpretation and mapping of infrastructural networks was reported, though consultancies such as Windhoek Consulting Engineers are known to have this capability.

- A wide range of software systems are in use within the region, ranging from powerful integrated GIS/IP systems (TNTmips and to a lesser degree IDRISI) through combination or linked GIS/IP systems (ArcInfo and ERDAS) to specialised, more limited systems (REGIS - a system most suited to urban applications and ILWIS a powerful, but difficult to use GIS system). Several respondents make use of Desktop Mapping Systems (not GIS senso stricto) such as ArcView.

- Few respondents gave information about available data sets, which may indicate that either there is a lack of data available **or** that data is proprietary and there may be some reluctance to make these data available for the OKACOM project. Further investigation is required on this aspect.

7. GUIDELINES FOR THE IMPLEMENTATION OF A CENTRALISED REMOTE SENSING DATA REPOSITORY AND GIS DATABASE FOR THE OKACOM STUDY

Implementation of a centralised GIS/IP database would require the following steps:

i) If not already decided on, a clear definition of the data required by the Assessment project in order to attain the goals of the Environmental Assessment phase. This requires input from project specialists on the data sets they would require to have access to from the GIS database in order to successfully implement their respective assessments.

iv) This needs to the followed up by negotiations with contributors to the OKACOM project Consultants and Government agencies, in order to obtain actual data sets as determined in i). above, in whatever format they are available.

iv) Once data sets have been obtained, to collate these into a single, widely accessible format. During this process, attention must be given to data quality standards, and substandard data rejected or upgraded. Some Vector data may, at this stage, require standardisation in terms of the attribute data attached i.e. standard codes and database table constructs. All Vector data obtained in non-topological formats, should wherever possible, be upgraded to full topological format to facilitate proper GIS neighbourhood and contiguity analysis and minimise spatial data errors. This is particularly true of data received from desktop mapping systems (ArcView and MapInfo) which use a CAD-like, free-form topology system.

iv) At this stage a decision on the system and file structure to be used in the central data repository will have to be made. In the light of the foregoing sections it is recommended that:

- A single, easily maintained and portable file structure be used;
- The file structure should guarantee that project data components remain together and do not become separated, for e.g. the Landsat imagery and Vector maps derived therefrom are always accessible together;
- The file structure / system chosen supports import from and export to ArcInfo, ERDAS, IDRISI, ArcView, ILWIS and REGIS, even if via an intermediate format, so as to allow current users of these systems to contribute and receive data from the central database;
- The central system chosen should support integrated analysis of Vector and Raster (image) data;
- A powerful Vector and Raster editing, and or Raster IP function, must be part of the centralised system to facilitate cleaning, editing and processing of contributed data sets in both these formats;

- The central GIS/IP database software should support links to fully relational databases in the most commonly used formats and/or be able to import from external databases into a proper relational database format. At very least ASCII, DbaseIV and INFO tables should be accommodated by the systems in a two-way data-flow, to and from the GIS.
- The centralised system must have the capability for generating customised reports, including summary statistics, from Vector and Raster data sets, for use by project specialists. These reports need to be, at very least, in digital ASCII format, but preferably in a wide range of database formats;
- The centralised system should have some mechanism for low-cost, platform independent, view-only access or query of the centralised database. This will allow for all users of the OKACOM project data to have at least visual access to the data sets;
- The centralised system should permit network access to the central files/GIS database from remote terminals, even if only for data viewing operations. Preferably it should also permit easy access to a specific data set/s, extraction thereof, and download to a remote site for further processing/analysis;
- As far as possible, the centralised data repository should deploy the fewest number of different software solutions possible in order to minimise maintenance costs, and complex data translation/linking issues.

v) Following selection of a centralised database software, undertake import of the data sets and organisation into a workable and accessible data structure, with procedures put in place for addition of new data as it becomes available during the Environmental Assessment phase. GIS consultants would have to be called in to assist in the implementation of this phase, guided by <u>the project's</u> chosen software requirements, data sets and format, and accessibility requirements. It is essential that the database setup meets the project's data requirements and data exchange needs, and not visa versa, that is, that these are made to fit into any existing software dictated formats.

vi) Simultaneous to the setting up of the centralised database, those involved in the OKACOM project who require access to the central GIS/IP database, and who are not already equipped with software and hardware to do so, be supplied with the necessary system/s most compatible with the central database system. For those equipped with their own systems, mechanisms for data query, data translation to the format of their choice, and data delivery mechanisms should be put in place.

☐

OKACOM PROJECT
GIS and REMOTE SENSING DATA and SOFTWARE SYSTEM QUESTIONNAIRE

As part of the Okavango Basin Preparatory Assessment Project, and analysis of the current status of data availability, and a survey of GIS and image processing (IP) systems in use in the region, is being undertaken. Your co-operation is requested by filling in this questionnaire and faxing the completed form to Dr. R. Harris at +27 461 24365.

Name ______________________________

Organisation ______________________________

Position ______________________________

Contact details of person managing GIS/IP in your organisation

Name ______________________________

Phone ______________ Fax ______________ Email ______________

Internet address: Web Site ______________ FTP ______________

GIS Software

The following **GIS SOFTWARE** is used within your organisation (please)

ARCINFO ☐ PC ARCINFO ☐ REGIS ☐ TNTmips ☐ IDRISI ☐

MAPINFO ☐ ARCVIEW ☐ OTHER ______________

IMAGE PROCESSING Software

The following **IMAGE PROCESSING SOFTWARE** is used by your organisation (please)

TNTmips ☐ ERDAS ☐ ERMAPPER ☐ IDRISI ☐

OTHER ______________________________

Image Processing Experience/Capability

Your organisation has experience/capability to process

LANDSAT MSS ☐ LANDSAT TM ☐ SPOT PAN ☐ SPOT XS ☐

SPOT-LANDSAT MERGE ☐ RADAR IMAGES FROM ERSI/2 ☐ RADARSAT ☐

DIGITAL PHOTOGRAPHS ☐ AIRVIDEO ☐ OTHER ______________

Your organisation uses GIS for (please 3)

____

Vegetation mapping/studies

Soil mapping

Geo ical mapping

Water resource mapping/analysis

Climatological studies

Terrain modelling & analysis

Wildlife habitat mapping

Agricultural studies

Human Geography/demographics

Urban studies

Engineering applications

ur organisation utilises satellite data for (please 3)

Vegetation mapping/studies

Soil mapping

Geological mapping

Water resource mapping/analysis

Climatological studies

Terrain modelling & analysis

Wildlife habitat mapping

Agricultural studies

Human geography/demographics

Urban studies

Engineering applications

mber of persons qualified/experienced in GIS

Level of experience (enter number of persons in each experience category):

Advanced Intermediate Beginning

Number of persons qualified/experienced in Remote Sensing/Image Processing

Level of experience (enter number of persons in each experience category):

Advanced Intermediate Beginning

Computer resources available for GIS/IP studies

	Number	**Model / Make**
UNIX Workstations		
Apple Mac		

	Number	**Processor**	**MHZ speed**	**Memory (RAM)**
PC Intel Machines (list advanced machines)				

Operating system used on PC INTEL (tick all used)

DOS ☐ WIN 3.1 ☐ WIN 95 ☐ WIN NT ☐

Other computer systems/operating systems in use

Are your computers networked? Yes ☐ No ☐

Network Software

Number Networked

	Format (A4/A3/A0)	**Number**	**Make/Model**
Digitisers			
1.			
2.			
3.			
Scanners			
1.			
2.			
3.			

	Format (A4/A3/A0)	**Number**	**Make/Model**
Printers			

1.						
2.						
3.						
CD-ROM writer	[redacted]					
Tape Device	Yes		No		Make	Capacity

Data

Please list the digital data you have available on the Okavango River Basin Region within your organisation, and are prepared to make available to the OKACOM study. For each data set the following information would be appreciated.

Name of data set:	e.g. Hydrology
Spatial Information contained in data set:	e.g. River/drainage courses map (lines), hydrographic stations points)
Attribute data attached to map elements:	e.g. River names, stream river order, max silt load etc. (lines) Points: station ID, date, time, water flow (units) i.e. give details of database attached & fields
Extents of Region covered by data:	(lat/long corner co-ordinates)
Source of data:	e.g. digitised from maps, field survey, satellite image interpretation

Scale at which data was captured if from maps or satellite data

Format of data set	i.e. ARCVIEW .SHP file ARCINFO .EOO file etc.

Can supply data on: TAPE CD-ROM FTP

Satellite Data Availability

Please specify processed satellite data sets you have available for use in the OKACOM study. For each dataset specify:

Derived from	e.g. Landsat TM
Data description	e.g. Vegetation map
Processing used	e.g. Supervised classification with field control
Region covered	Lat/Long corner co-ordinates
Available as	e.g. digital dataset/hard copy image/map
Scale of data set	e.g. 1 : 250 000 map sheet/ground cell resolution of image

Please supply information on any other data sets you may have that would be of use in the OKACOM study e.g. digital elevation models, climatological databases etc. including a description of region covered and data formats e.g. Rainfall data, 1960 - present, area extents, Dbase IV file.