



**OKACOM**

*The Permanent Okavango River Basin Water Commission*

**Transboundary Diagnostic Analysis of  
the Botswana Portion of the Okavango  
River Basin  
Output 10: Database and GIS design for  
an expanded Okavango Basin  
Information System (OBIS)**

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*Environmental protection and sustainable management  
of the Okavango River Basin*

**EPSMO**

# TRANSBOUNDARY DIAGNOSTIC ANALYSIS OF THE BOTSWANA PORTION OF THE OKAVANGO RIVER BASIN.

**Output 10: Database and GIS design for an expanded Okavango Basin Information System (OBIS)**



Final Draft

**OKAVANGO BASIN INFORMATION SYSTEM (OBIS) Design Parameters**

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## **OBIS Design Parameters**

### **Introduction**

This report contributes to the objectives of the EPSMO Project, which aims to achieve global environmental benefits through concerted management of the naturally integrated land and water resources of the Okavango River Basin. This report supports the following specific objectives of the project:

- a. Enhance the depth, accuracy, and accessibility of the existing knowledge base of basin characteristics and conditions;
- b. Assist the three riparian nations (Angola, Botswana and Namibia) in their efforts to improve their capacity to collectively manage the basin.

Specifically, this component addressed Output 10 of the EPSMO project: Database and GIS design for an expanded Okavango Basin Information System (OBIS). The following aspects of the design are discussed below:

1. DATABASE
2. COORDINATE SYSTEM
3. METADATA
4. FILE NAMING/GROUPING
5. DATA SERVING
6. SERVING DATA WITH ARCGIS SERVER
7. DATABASE DESIGN MODEL FOR OBIS

## 1. DATABASE: File Geodatabase (ESRI) at HOORC

The Pdf document entitled “GIS DATABASE FOR THE ENVIRONMENT PROTECTION AND SUSTAINABLE MANAGEMENT OF THE OKAVANGO RIVER BASIN PROJECT” was compiled by a consultant associated with the project and is attached separately. It describes aspects of available data for the Okavango basin.

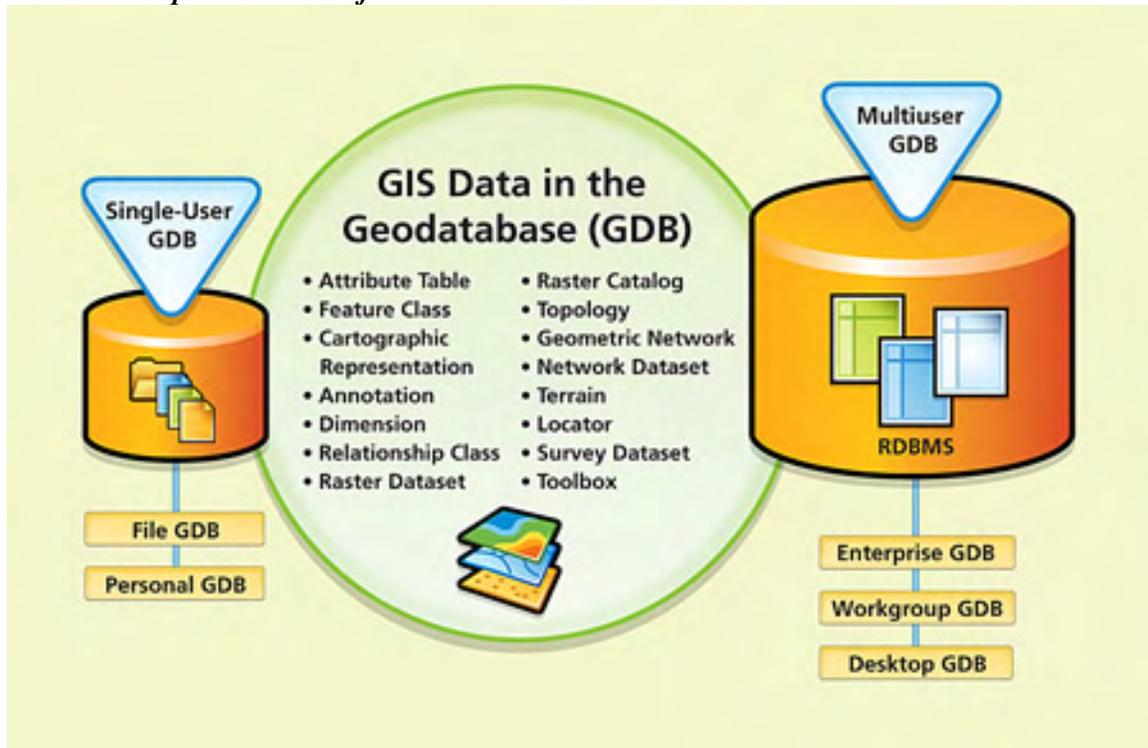
The OBIS database will initially be stored at HOORC, but the possibility exists to replicate the database to other locations. The ESRI file geodatabase is recommended for OBIS. It is ideal for working with file-based datasets for GIS projects, and for use in small workgroups. It has strong performance and scales well to hold extremely large data volumes without requiring the use of a Database Management System (DBMS). Plus, it is portable across operating systems. The file geodatabase is a new geodatabase type released in ArcGis version 9.2. Its goals are to :

- Provide a widely available, simple, and scalable geodatabase solution for all users.
- Provide a portable geodatabase that works across operating systems.
- Scale up to handle very large datasets.
- Provide excellent performance and scalability, for example, to support individual datasets containing well over 300 million features and datasets that can scale beyond 500 GB per file with very fast performance.
- Use an efficient data structure that is optimized for performance and storage. File geodatabases use about one third of the feature geometry storage required by shapefiles and personal geodatabases. File geodatabases also allow users to compress vector data to a read-only format to reduce storage requirements even further.
- Out perform shapefiles for operations involving attributes and scale the data size limits way beyond shapefile limits.

File and personal geodatabases are designed to be edited by a single user and do not support geodatabase versioning. With a file geodatabase, it is possible to have more than one editor at the same time providing they are editing in different feature datasets, standalone feature classes or tables. The file geodatabase is recommended over personal geodatabases. The diagram below shows the structure of a geodatabase.

There will be no need for geodatabase versioning as the number of direct data editors at HOORC will be limited. Therefore, ArcSDE (Spatial Data Engine) will not be deployed at this time. However, this may change if the number of concurrent gis-data editors grows.

*Schematic representation of Geodatabase structure.*



## 2. COORDINATE SYSTEM

All data will be stored in Geographic coordinates (Lat/Long) using the GC-WGS84 system. Where needed, conversion routines will be employed to convert data with other coordinates to the database coordinate parameters.

### 3. METADATA

The international Metadata standard ISO 19115 (*Geographic Information—Metadata*) will be used. Individual metadata will initially be stored as HTML files or text files for easy distribution and access.

The ISO standard 19115, *Geographic Information—Metadata*, was designed for international use and attempts to satisfy the requirements of all existing metadata standards. It allows for either general or detailed descriptions of data sources, makes some allowances for describing resources other than data, and has a small number of mandatory elements.

#### **4. FILE-NAMING and FILE-GROUPING**

To improve data storage and data identification efficiency, standard file grouping and file naming conventions will be employed for OBIS. The data structure for thematic layers will follow the standardised definitions of ISO 19115 (see below). For the naming of individual files, the structure of the SDSFIE (Spatial Data Standard for Facilities, Infrastructure and Environment) file naming conventions will be used, whereby data layers are named according to the following convention:

topic\_category\_featurename\_featuretype.

The country naming convention will follow the ISO 3166 country codes of Angola AO, Botswana BW and Namibia NA.

## 5. DATA SERVING

Data from the database will be served using ArcGIS Server through a WEBPAGE connected to the HOORC website. Through the interface provided it will be possible to:

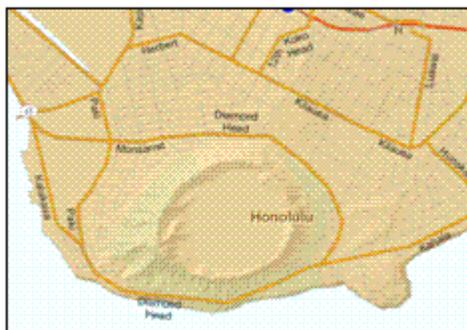
- obtain an overview of available data
- search for data
- access simple metadata about the data
- access predefined maps in PDF and/or JPEG format
- access interactive maps via cached map services

ArcGIS Server is a comprehensive, Web-based GIS that provides a range of out-of-the-box applications and services for mapping, analysis, data collection, editing, and management of spatial information. The use of a map cache is recommended.

An ArcGIS Server map cache is an effective way to build high performance, scalable server-based mapping solutions that can work for hundreds and even thousands of users. A cache can increase the performance of ArcGIS Server applications and enable delivery of very high quality maps that take advantage of the rich cartographic capabilities that are part of ArcMap and ArcGIS.

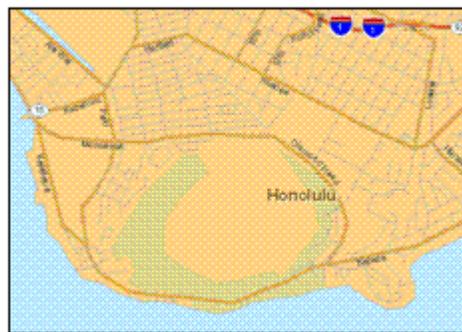
An ArcGIS Server map cache consists of a collection of pre-rendered map tiles that can be used for high performance map display and use. Cached map services as opposed to dynamic map services display quickly because the map image does not have to be rendered on the fly at the time the user requests it. Instead, the rendering of the map image is precomputed when the map cache is created. Map caches are useful for serving map content that changes only periodically.

### Cached Map Service



1.5 Seconds

### Dynamic Map Service



4 Seconds

GIS maps can contain two types of map layers:

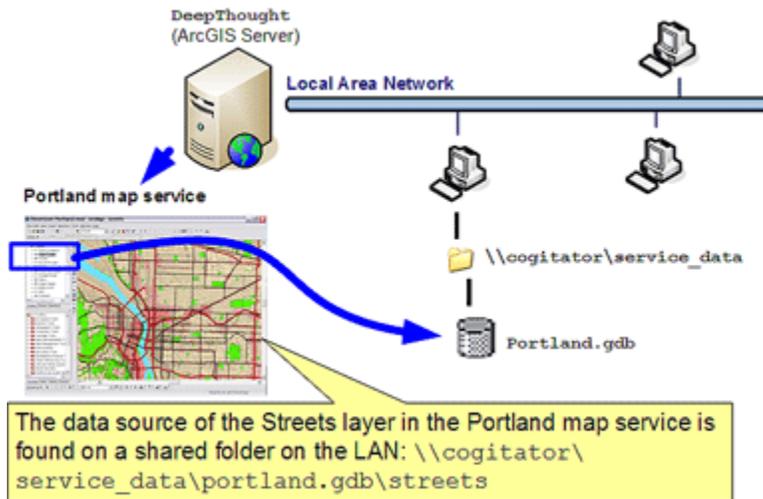
- Base map layers. A GIS base map is a group of overlays that work together to provide a harmonious view on which users perform tasks and visualization of other information. Each base map provides a framework on which other operational map layers can be used. Base map layers typically contain a simple

set of tools for map navigation, map query, scale dependent display, feature identification and selection, address geocoding, and so forth.

- Operational layers. These map layers are used to conduct work tasks within your GIS map application. Operational layers are used to display dynamic map information such as representations of ever-changing sensor observations, status layers, layers used to perform editing tasks, and layers used to perform focused tasks. Tools associated with operational layers tend to be based on work tasks and workflows.

## 6. SERVING DATA WITH ARCGIS SERVER

The data will be served through a shared folder on the HOORC local area network (LAN), using a database connection as illustrated below.



## 7. DATABASE DESIGN MODEL FOR OBIS

There are two options as shown in the diagrams below: to serve the data as basin-wide data or to serve the data by country. Due to the nature and state of the currently available data (some data available basin-wide and other data by country only) it is necessary to combine both options for OBIS. This is achieved by maintaining basin-wide data folders for available basin-wide data (e.g. for digital-elevation data) and country-folders for country-specific datasets. The latter may involve datasets that are available only for a specific country or country datasets that are not entirely compatible between countries.

Diagram Option 1: Serve basin-wide data: Seamless, continuous basin-wide data

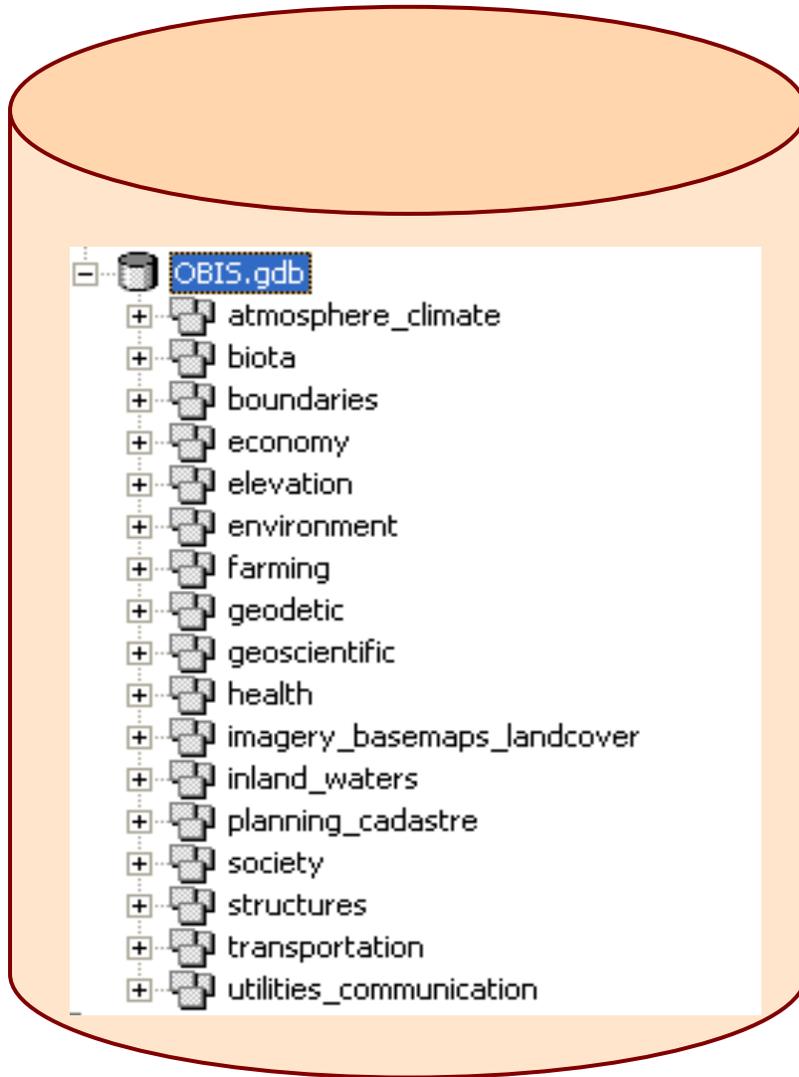
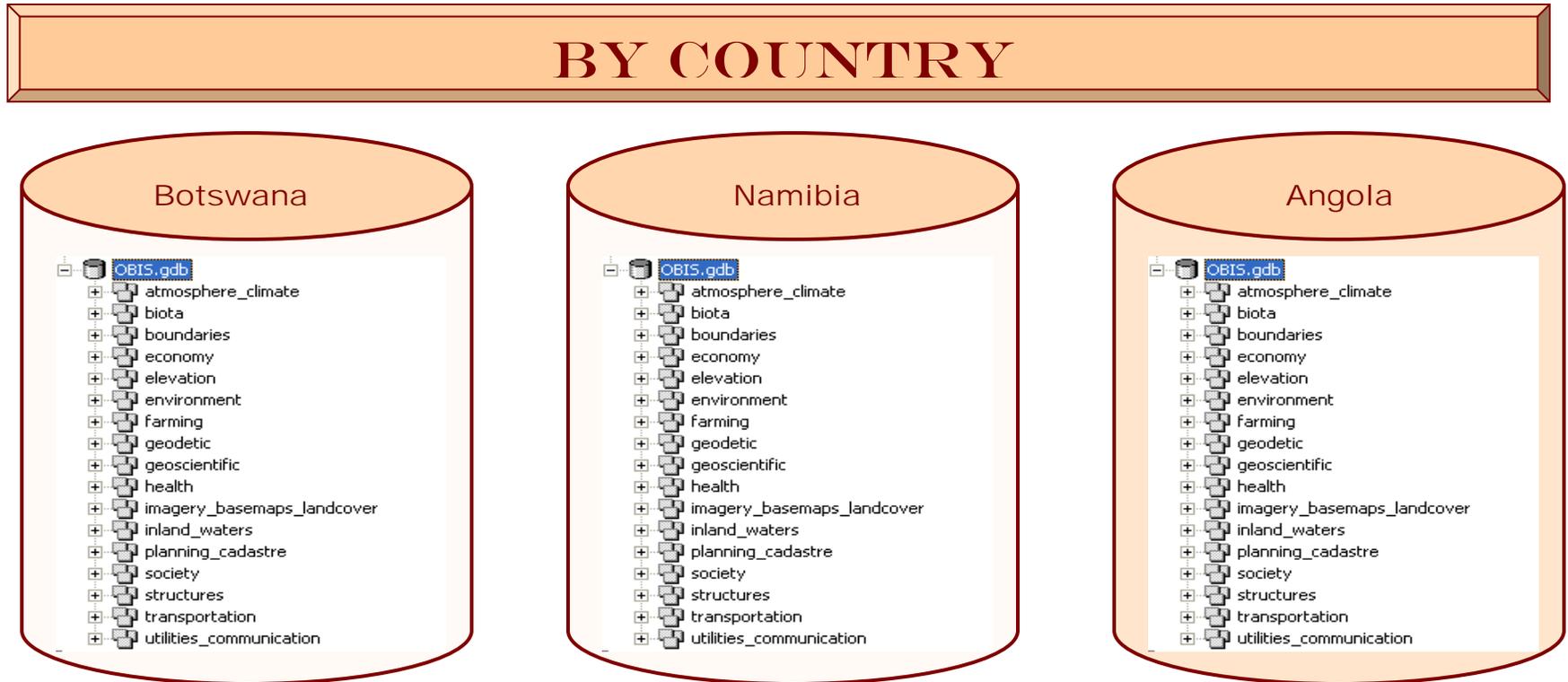


Diagram Option 2: Serve country-specific data: not seamless across country borders





**ISO 19115 Code list**

Name	Domain code	Definition
MD_TopicCategoryCode	TopicCatCd	high-level geographic data thematic classification to assist in the grouping and search of available geographic data sets. Listed examples are not exhaustive. NOTE It is understood there are overlaps between general categories and the user is encouraged to select the one most appropriate.
farming	001	rearing of animals and/or cultivation of plants. Examples: agriculture, irrigation, aquaculture, plantations, herding, pests and diseases affecting crops and livestock
biota	002	flora and/or fauna in natural environment. Examples: wildlife, vegetation, biological sciences, ecology, wilderness, sealife, wetlands, habitat
boundaries	003	legal land descriptions. Examples: political and administrative boundaries
climatologyMeteorologyAtmosphere	004	processes and phenomena of the atmosphere. Examples: cloud cover, weather, climate, atmospheric conditions, climate change, precipitation
economy	005	economic activities, conditions and employment. Examples: production, labour, revenue, commerce, industry, tourism and ecotourism, forestry, fisheries, commercial or subsistence hunting, exploration and exploitation of resources such as minerals, oil and gas
elevation	006	height above or below sea level. Examples: altitude, bathymetry, digital elevation models, slope, derived products, monitoring environmental risk, nature reserves, landscape
environment	007	environmental resources, protection and conservation. Examples: environmental pollution, waste storage and treatment, environmental impact assessment
geoscientificInformation	008	information pertaining to earth sciences. Examples: geophysical features and processes, geology, minerals, sciences dealing with the composition, structure and origin of the earth's rocks, risks of earthquakes, volcanic activity, landslides, gravity information, soils, permafrost, hydrogeology, erosion
health	009	health, health services, human ecology, and safety. Examples: disease and illness, factors affecting health, hygiene, substance abuse, mental and physical health, health services
imageryBaseMapsEarthCover	010	base maps. Examples: land cover, topographic maps, imagery, unclassified images, annotations
intelligenceMilitary	011	military bases, structures, activities. Examples: barracks, training grounds, military transportation, information collection
inlandWaters	012	inland water features, drainage systems and their characteristics. Examples: rivers and glaciers, salt lakes, water utilization plans, dams, currents, floods, water quality, hydrographic charts
location	013	positional information and services. Examples: addresses, geodetic networks, control points, postal zones and services, place names
oceans	014	features and characteristics of salt water bodies (excluding inland waters). Examples: tides, tidal waves, coastal information, reefs
planningCadastre	015	information used for appropriate actions for future use of the land. Examples: land use maps, zoning maps, cadastral surveys, land ownership
society	016	characteristics of society and cultures. Examples: settlements, anthropology, archaeology, education, traditional

		beliefs, manners and customs, demographic data, recreational areas and activities, social impact assessments, crime and justice, census information
structure	017	man-made construction. Examples: buildings, museums, churches, factories, housing, monuments, shops, towers
transportation	018	means and aids for conveying persons and/or goods. Examples: roads, airports/airstrips, shipping routes, tunnels, nautical charts, vehicle or vessel location, aeronautical charts, railways
utilitiesCommunication	019	energy, water and waste systems and communications infrastructure and services. Examples: hydroelectricity, geothermal, solar and nuclear sources of energy, water purification and distribution, sewage collection and disposal, electricity and gas distribution, data communication, telecommunication, radio, communication networks

## The Okavango River Basin Transboundary Diagnostic Analysis Technical Reports

In 1994, the three riparian countries of the Okavango River Basin – Angola, Botswana and Namibia – agreed to plan for collaborative management of the natural resources of the Okavango, forming the Permanent Okavango River Basin Water Commission (OKACOM). In 2003, with funding from the Global Environment Facility, OKACOM launched the Environmental Protection and Sustainable Management of the Okavango River Basin (EPSMO) Project to coordinate development and to anticipate and address threats to the river and the associated communities and environment. Implemented by the United Nations Development Program and executed by the United Nations Food and Agriculture Organization, the project produced the Transboundary Diagnostic Analysis to

establish a base of available scientific evidence to guide future decision making. The study, created from inputs from multi-disciplinary teams in each country, with specialists in hydrology, hydraulics, channel form, water quality, vegetation, aquatic invertebrates, fish, birds, river-dependent terrestrial wildlife, resource economics and socio-cultural issues, was coordinated and managed by a group of specialists from the southern African region in 2008 and 2009.

The following specialist technical reports were produced as part of this process and form substantive background content for the Okavango River Basin Transboundary Diagnostic Analysis.

<i>Final Study Reports</i>	<i>Reports integrating findings from all country and background reports, and covering the entire basin.</i>		
		<i>Aylward, B.</i>	<i>Economic Valuation of Basin Resources: Final Report to EPSMO Project of the UN Food &amp; Agriculture Organization as an Input to the Okavango River Basin Transboundary Diagnostic Analysis</i>
		<i>Barnes, J. et al.</i>	<i>Okavango River Basin Transboundary Diagnostic Analysis: Socio-Economic Assessment Final Report</i>
		<i>King, J.M. and Brown, C.A.</i>	<i>Okavango River Basin Environmental Flow Assessment Project Initiation Report (Report No: 01/2009)</i>
		<i>King, J.M. and Brown, C.A.</i>	<i>Okavango River Basin Environmental Flow Assessment EFA Process Report (Report No: 02/2009)</i>
		<i>King, J.M. and Brown, C.A.</i>	<i>Okavango River Basin Environmental Flow Assessment Guidelines for Data Collection, Analysis and Scenario Creation (Report No: 03/2009)</i>
		<i>Bethune, S. Mazvimavi, D. and Quintino, M.</i>	<i>Okavango River Basin Environmental Flow Assessment Delineation Report (Report No: 04/2009)</i>
		<i>Beuster, H.</i>	<i>Okavango River Basin Environmental Flow Assessment Hydrology Report: Data And Models (Report No: 05/2009)</i>
		<i>Beuster, H.</i>	<i>Okavango River Basin Environmental Flow Assessment Scenario Report : Hydrology (Report No: 06/2009)</i>
		<i>Jones, M.J.</i>	<i>The Groundwater Hydrology of The Okavango Basin (FAO Internal Report, April 2010)</i>
		<i>King, J.M. and Brown, C.A.</i>	<i>Okavango River Basin Environmental Flow Assessment Scenario Report: Ecological and Social Predictions (Volume 1 of 4)(Report No. 07/2009)</i>
		<i>King, J.M. and Brown, C.A.</i>	<i>Okavango River Basin Environmental Flow Assessment Scenario Report: Ecological and Social Predictions (Volume 2 of 4: Indicator results) (Report No. 07/2009)</i>
		<i>King, J.M. and Brown, C.A.</i>	<i>Okavango River Basin Environmental Flow Assessment Scenario Report: Ecological and Social Predictions: Climate Change Scenarios (Volume 3 of 4) (Report No. 07/2009)</i>
		<i>King, J., Brown, C.A., Joubert, A.R. and Barnes, J.</i>	<i>Okavango River Basin Environmental Flow Assessment Scenario Report: Biophysical Predictions (Volume 4 of 4: Climate Change Indicator Results) (Report No: 07/2009)</i>
		<i>King, J., Brown, C.A. and Barnes, J.</i>	<i>Okavango River Basin Environmental Flow Assessment Project Final Report (Report No: 08/2009)</i>
		<i>Malzbender, D.</i>	<i>Environmental Protection And Sustainable Management Of The Okavango River Basin (EPSMO): Governance Review</i>

## TDA Basin Database and GIS Design

		Vanderpost, C. and Dhlwayo, M.	Database and GIS design for an expanded Okavango Basin Information System (OBIS)
		Veríssimo, Luis	GIS Database for the Environment Protection and Sustainable Management of the Okavango River Basin Project
		Wolski, P.	Assessment of hydrological effects of climate change in the Okavango Basin
<b>Country Reports Biophysical Series</b>	<b>Angola</b>	Andrade e Sousa, Helder André de	Análise Diagnóstica Transfronteiriça da Bacia do Rio Okavango: Módulo do Caudal Ambiental: Relatório do Especialista: País: Angola: Disciplina: Sedimentologia & Geomorfologia
		Gomes, Amândio	Análise Diagnóstica Transfronteiriça da Bacia do Rio Okavango: Módulo do Caudal Ambiental: Relatório do Especialista: País: Angola: Disciplina: Vegetação
		Gomes, Amândio	Análise Técnica, Biofísica e Socio-Económica do Lado Angolano da Bacia Hidrográfica do Rio Cubango: Relatório Final: Vegetação da Parte Angolana da Bacia Hidrográfica Do Rio Cubango
		Livramento, Filomena	Análise Diagnóstica Transfronteiriça da Bacia do Rio Okavango: Módulo do Caudal Ambiental: Relatório do Especialista: País: Angola: Disciplina: Macroinvertebrados
		Miguel, Gabriel Luís	Análise Técnica, Biofísica E Sócio-Económica do Lado Angolano da Bacia Hidrográfica do Rio Cubango: Subsídio Para o Conhecimento Hidrogeológico Relatório de Hidrogeologia
		Morais, Miguel	Análise Diagnóstica Transfronteiriça da Bacia do Análise Rio Cubango (Okavango): Módulo da Avaliação do Caudal Ambiental: Relatório do Especialista País: Angola Disciplina: Ictiofauna
		Morais, Miguel	Análise Técnica, Biofísica e Sócio-Económica do Lado Angolano da Bacia Hidrográfica do Rio Cubango: Relatório Final: Peixes e Pesca Fluvial da Bacia do Okavango em Angola
		Pereira, Maria João	Qualidade da Água, no Lado Angolano da Bacia Hidrográfica do Rio Cubango
		Santos, Carmen Ivelize Van-Dúnem S. N.	Análise Diagnóstica Transfronteiriça da Bacia do Rio Okavango: Módulo do Caudal Ambiental: Relatório de Especialidade: Angola: Vida Selvagem
		Santos, Carmen Ivelize Van-Dúnem S.N.	Análise Diagnóstica Transfronteiriça da Bacia do Rio Okavango: Módulo Avaliação do Caudal Ambiental: Relatório de Especialidade: Angola: Aves
	<b>Botswana</b>	Bonyongo, M.C.	Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module: Specialist Report: Country: Botswana: Discipline: Wildlife
		Hancock, P.	Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module : Specialist Report: Country: Botswana: Discipline: Birds
		Mosepele, K.	Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module: Specialist Report: Country: Botswana: Discipline: Fish
		Mosepele, B. and Dallas, Helen	Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module: Specialist Report: Country: Botswana: Discipline: Aquatic Macro Invertebrates
	<b>Namibia</b>	Collin Christian & Associates CC	Okavango River Basin: Transboundary Diagnostic Analysis Project: Environmental Flow Assessment Module: Geomorphology
		Curtis, B.A.	Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module: Specialist Report Country: Namibia Discipline: Vegetation
		Bethune, S.	Environmental Protection and Sustainable Management of the Okavango River Basin (EPSMO): Transboundary Diagnostic Analysis: Basin Ecosystems Report
		Nakanwe, S.N.	Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module: Specialist Report: Country: Namibia: Discipline: Aquatic Macro Invertebrates
		Paxton, M.	Okavango River Basin Transboundary Diagnostic Analysis: Environmental Flow Module: Specialist Report: Country: Namibia: Discipline: Birds (Avifauna)

## TDA Basin Database and GIS Design

		Roberts, K.	Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module: Specialist Report: Country: Namibia: Discipline: Wildlife
		Waal, B.V.	Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module: Specialist Report: Country: Namibia: Discipline: Fish Life
<b>Country Reports Socioeconomic Series</b>	<b>Angola</b>	Gomes, Joaquim Duarte	Análise Técnica dos Aspectos Relacionados com o Potencial de Irrigação no Lado Angolano da Bacia Hidrográfica do Rio Cubango: Relatório Final
		Mendelsohn, J.	Land use in Kavango: Past, Present and Future
		Pereira, Maria João	Análise Diagnóstica Transfronteiriça da Bacia do Rio Okavango: Módulo do Caudal Ambiental: Relatório do Especialista: País: Angola: Disciplina: Qualidade da Água
		Saraiva, Rute et al.	Diagnóstico Transfronteiriço Bacia do Okavango: Análise Socioeconómica Angola
	<b>Botswana</b>	Chimbari, M. and Magole, Lapologang	Okavango River Basin Trans-Boundary Diagnostic Assessment (TDA): Botswana Component: Partial Report: Key Public Health Issues in the Okavango Basin, Botswana
		Magole, Lapologang	Transboundary Diagnostic Analysis of the Botswana Portion of the Okavango River Basin: Land Use Planning
		Magole, Lapologang	Transboundary Diagnostic Analysis (TDA) of the Botswana p Portion of the Okavango River Basin: Stakeholder Involvement in the ODMP and its Relevance to the TDA Process
		Masamba, W.R.	Transboundary Diagnostic Analysis of the Botswana Portion of the Okavango River Basin: Output 4: Water Supply and Sanitation
		Masamba, W.R.	Transboundary Diagnostic Analysis of the Botswana Portion of the Okavango River Basin: Irrigation Development
		Mbaiwa, J.E.	Transboundary Diagnostic Analysis of the Okavango River Basin: the Status of Tourism Development in the Okavango Delta: Botswana
		Mbaiwa, J.E. & Mmopelwa, G.	Assessing the Impact of Climate Change on Tourism Activities and their Economic Benefits in the Okavango Delta
		Mmopelwa, G.	Okavango River Basin Trans-boundary Diagnostic Assessment: Botswana Component: Output 5: Socio-Economic Profile
		Ngwenya, B.N.	Final Report: A Socio-Economic Profile of River Resources and HIV and AIDS in the Okavango Basin: Botswana
		Vanderpost, C.	Assessment of Existing Social Services and Projected Growth in the Context of the Transboundary Diagnostic Analysis of the Botswana Portion of the Okavango River Basin
	<b>Namibia</b>	Barnes, J and Wamunyima, D	Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module: Specialist Report: Country: Namibia: Discipline: Socio-economics
		Collin Christian & Associates CC	Technical Report on Hydro-electric Power Development in the Namibian Section of the Okavango River Basin
		Liebenberg, J.P.	Technical Report on Irrigation Development in the Namibia Section of the Okavango River Basin
		Ortmann, Cynthia L.	Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module : Specialist Report Country: Namibia: discipline: Water Quality
		Nashipili, Ndinomwaameni	Okavango River Basin Technical Diagnostic Analysis: Specialist Report: Country: Namibia: Discipline: Water Supply and Sanitation
		Paxton, C.	Transboundary Diagnostic Analysis: Specialist Report: Discipline: Water Quality Requirements For Human Health in the Okavango River Basin: Country: Namibia

*Environmental protection and sustainable management  
of the Okavango River Basin*

**EPSMO**



*Kavango River at Rundu, Namibia*



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