2.4. APPLICATION CASE STUDIES

Surface waterbodies inventory

Introduction and objectives

Introduction

Although the AWRD contains multiple surface waterbody (SWB) data layers, extensive work still needs to be undertaken before these data can be utilized to more fully support fisheries and integrated water resources management. With the exception of the point SWB database covering the SADC region of southern Africa (derived from the original WRD), most SWB data layers included with the AWRD lack many of the physical, limnological and environmental attributes that influence each individual waterbody.

Fortunately for Africa, a broadly inclusive baseline of useful attributes can be found within the Source Book for the Inland Fishery Resources of Africa (SIFRA). However, because the SIFRA reports (Vanden Bossche and Bernacsek, 1990a, b, 1991) are themselves based on compilations of data from a number of different sources, there is wide variability of data quality and quantity for SWB listings in each country. It is therefore difficult to summarize the data contained in these reports in a format that can be easily linked back to the original SWB data layers contained in the AWRD.

Objectives

The purpose of this case study is to determine the viability of creating a surface waterbody inventory by integrating the historic data records contained in the SIFRA reports with spatial data layers from within and outside of the AWRD data archive. The premise of the case study is that such integration would result in more harmonized and complete SWB data layers containing a composite of available attributes. This case study demonstrates two approaches to examine the potentials and limitations of integrating the SIFRA report data with spatial SWB feature data.

Approach 1: This approach uses spatial data from both within and outside the AWRD archive to create a consolidated inventory of SWB features for the United Republic of Tanzania. The purpose of this exercise is to determine the viability of creating hot-links from coincident or nearby spatial SWB features to the more detailed fisheries and limnological attributes contained in the SIFRA reports.

Approach 2: This approach looks for SWB features that are found in both the AWRD data layers and the SIFRA report for the Republic of Zimbabwe, in order to generate an attribute table which can be linked directly to spatial features in any standard GIS. This approach additionally estimates the amount of time and effort required to create such a table for other regions.

United Republic of Tanzania

Materials and methods

Data utilized

Detailed lake and reservoir data available from the FAO sponsored Africover Project, http://www.africover.org, are used to simulate a user specific spatial dataset from a hypothetical fisheries institution in the United Republic of Tanzania. The United Republic of Tanzania was chosen for this exercise in order to benefit from the availability of the completed Africover datasets, including a layer of waterbodies, covering the country. The Africover data were derived from 28.5 metres LandSat satellite imagery and are compatible with an approximate minimum spatial scale of 1:150 000. The United Republic of Tanzania is one of nine countries for which Africover datasets were available at the time this case study was prepared.

The attribute data used to simulate the historic reporting of limnological and fisheries statistics for this hypothetical Tanzanian institution are drawn from the SIFRA report for the United Republic of Tanzania.

In addition to the SIFRA data, subsets of data from several sources are used to provide source names for the Africover waterbodies and potential linkages back to the SIFRA information. These additional subsets are drawn from the SADC-SWB data layer and the NIMA GNS gazetteer data layer, and the subsets were extracted based on the Tanzanian boundary from the VMap0 political boundary layer Ad1_Py.shp.

The data utilized for the Tanzanian portion of this case study are presented in Figure 2.30 and Table 2.16.

FIGURE 2.30
Data employed for the Tanzanian analysis

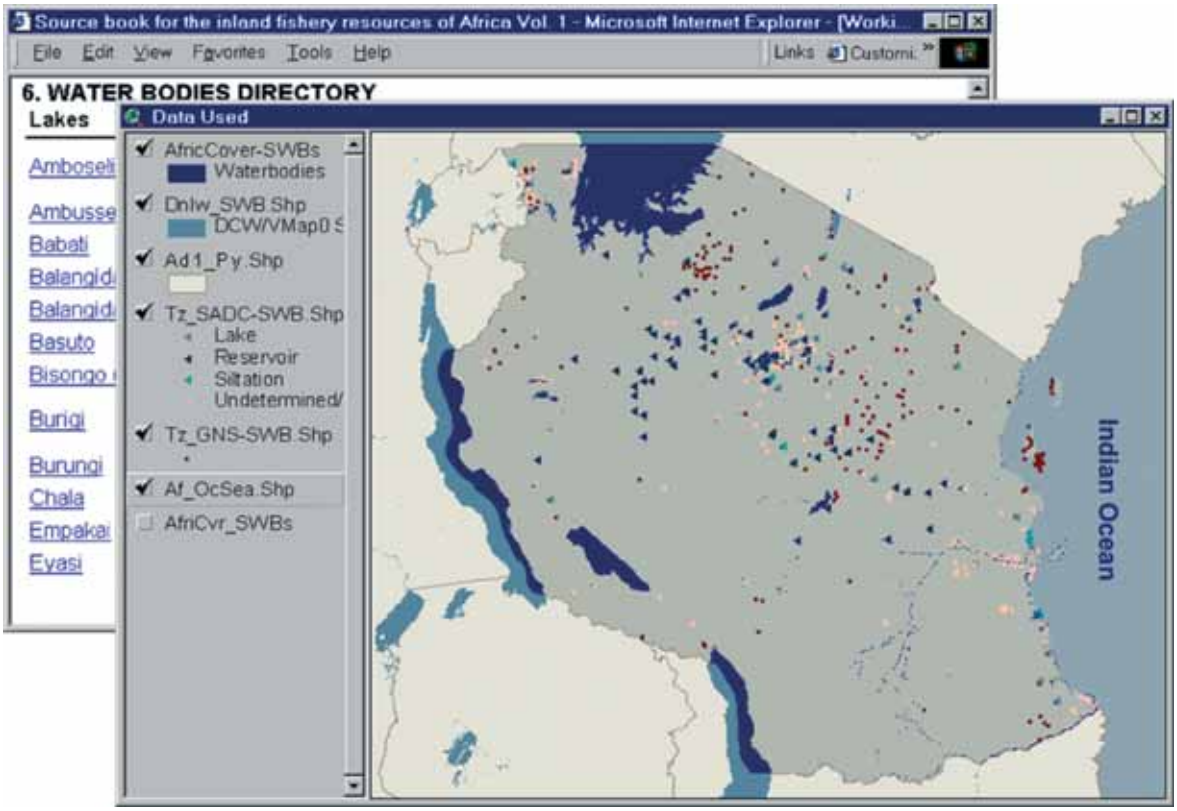


TABLE 2.16
Summary and purpose of data used for Tanzanian analysis

Data type	Data source	Data utilization or purpose
Africover polygonal data layer	AVEC-DBC: AfCvrSWB	The integration of a user specific SWB dataset into the AWRD for linkage to SIFRA data
SIFRA Compendium for Tanzania HTML based textual reference	AWRD SIFRA Document Archive: Tanzania	Limnological and fisheries data to be attributed to Africover waterbodies data for Tanzania
SADC-WRD SWB point data layer	SWB-DBC: SADC_SWB	Potential source of names for Africover SWBs for linkage to SIFRA waterbodies reporting data
NIMA GNS Gazetteer SWB specific subset point data layer	SWB-DBC: GNS_SWB	Alternate source of names for Africover SWBs for linkage to SIFRA waterbodies reporting data
VMap0 "Basic" political boundaries data layer	AVEC-DBC: Ad1_Py	Used to create buffered Tanzanian subsets of SADC-WRD and GNS SWB data layers

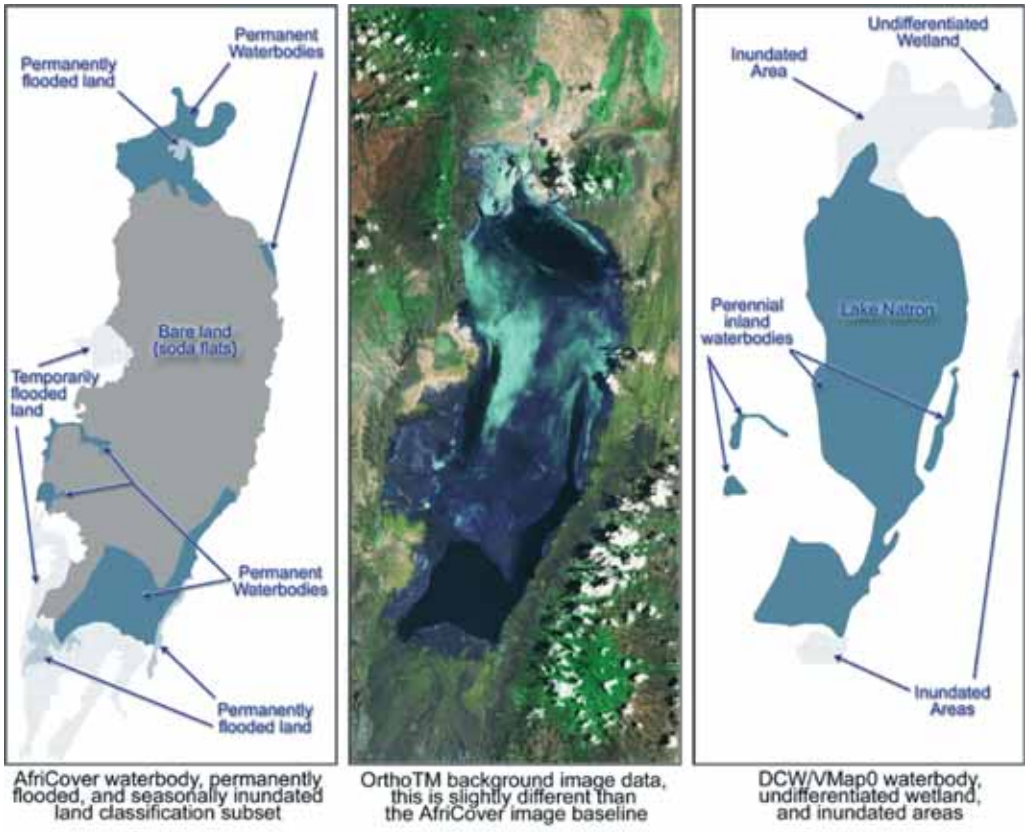
Methods

Data analysis

The Africover SWB data layer provides a comprehensive set of perennial or standing waterbodies, extracted from the larger Africover dataset of all wetland types. For the purposes of this case study the SWB layer was deemed appropriate.

Perhaps the major difference between the Africover SWB data layer and the lakes and other polygonal waterbody layers available from the AWRD SWB-DBC (based on the VMap0 data library), is the partitioning of waterbodies based on the seasonal fluctuation of the waterbody in question. This is demonstrated by the depiction of Lake Natron in Figure 2.31. In this figure, the Africover data for Lake Natron is actually partitioned into distinct "Standing" water polygons, separated by either other SWB features or land classified as "Bare". In comparison, the SWB features derived from the DCW/VMap0 data libraries depict Lake Natron as a much larger and more cohesive waterbody.

FIGURE 2. 31
Comparison of composite Africover surface waterbodies features with a satellite image base and similar features derived from the DCW/VMAP0



The Africover SWB data layer contains 394 standing waterbody features providing coverage for the United Republic of Tanzania. While this number does not include the extensive permanent and temporarily flooded land classes, mangroves, etc. of the full Africover land classification dataset, it does include those polygons representing rivers that are wide enough to be depicted as waterbodies. On maps, such rivers are commonly referred to as "double-lined" rivers because the boundaries of the polygons used to represent these features show both banks of the river.

In comparison to the Africover dataset, some 175 and 173 permanent SWB features, including double-lined river features, can be identified as intersecting with the United Republic of Tanzania based on either the seamlessly processed VMap0-Ed5 or the harmonized DCW/VMAP0 data layers of the AWRD.

Unfortunately, although a name has been added to the VMap0-Ed5 baseline of SWBs, only 70 of these 170 features were named; and as yet, a validated name for the SWBs represented in the Africover dataset has still to be developed. For this reason, SWBs must be assigned a name or unique numerical identifier before they can be cross-referenced with the SIFRA reports or other historical data.

Naming the Africover waterbodies

To simplify the naming process for this case study, only the Africover permanent waterbodies dataset was considered. The source name databases were limited to the SADC-WRD surface waterbody data layer and the SWB subset of the GNS gazetteer database. The "Nearest Feature" AWRD Add-on extension was used to assign a unique numeric identifier to the Africover waterbody dataset, based on the nearest waterbody in the SADC-WRD and GNS Gazetteer datasets. The tool also records the proximity for each point feature, with a value of zero representing actual containment in the Africover waterbody. After the nearest SADC-WRD and GNS Gazetteer SWBs have been identified, then the name of that SADC-WRD or GNS waterbody can be assigned to the Africover waterbody.

Results

Combined, approximately twenty minutes were required to set-up and to then run the add-on tool against both source name datasets. However, as multiple points can be assigned to each polygon, a further two hours were required to evaluate any duplicate matches. Finally, a further hour was required to join tables and assign names back to the polygonal Africover based on both point name sources. In total, 165 permanent waterbody polygons – or 42 percent – could be assigned names from one or both of the point data sources. Fifty-six of these waterbodies were named jointly by both the SADC-SWB and then GNS-SWB data layers.

Given the partitioning of certain larger SWB features in the Africover dataset, as illustrated for Lake Natron (Figure 2.31), and because the process did not consider double-lined rivers, the results of this semi-automated naming process were better than may first appear. In fact, since the simulated historic reporting data contain only 79 "records" for lakes and reservoirs, the results of the semi-automated process proved to be adequate for the purposes of this case study.

The SIFRA reports provide users of the AWRD with an important source of reference information on certain limnological factors and other physical characteristics of waterbodies including, in some cases, the historical reporting of both endemic fish species and catchment records. The SIFRA report for the United Republic of Tanzania documents 45 major lakes and 34 major reservoirs for the country. Table 2.17 provides a summary of the linkages between Africover and the SIFRA attribute information for these lakes and reservoirs.

TABLE 2.17
Summary of linkages between Africover and SIFRA

Number of Lakes	SIFRA lakes
36	Polygons from the Africover dataset which were linked to listings in the SIFRA report.
4	Additional lakes which were identified based on point features in either the SADC-SWB or GNS-SWB data layers, but could not be connected with an Africover polygon.
5	SIFRA lakes which could not be identified based on either of the name source point datasets.
45	TOTAL
Number of Reservoirs	**SIFRA reservoirs**
19	Africover SWB features which were directly linked to SIFRA listings.
9	Additional reservoirs which were identified based on point feature names from either the SADC-SWB or GNS-SWB data layers.
6	SIFRA reservoirs which could not be identified based on either of the name source point datasets. Three of these SIFRA listings contained possibly useful limnological or fisheries specific attributes.
34	TOTAL

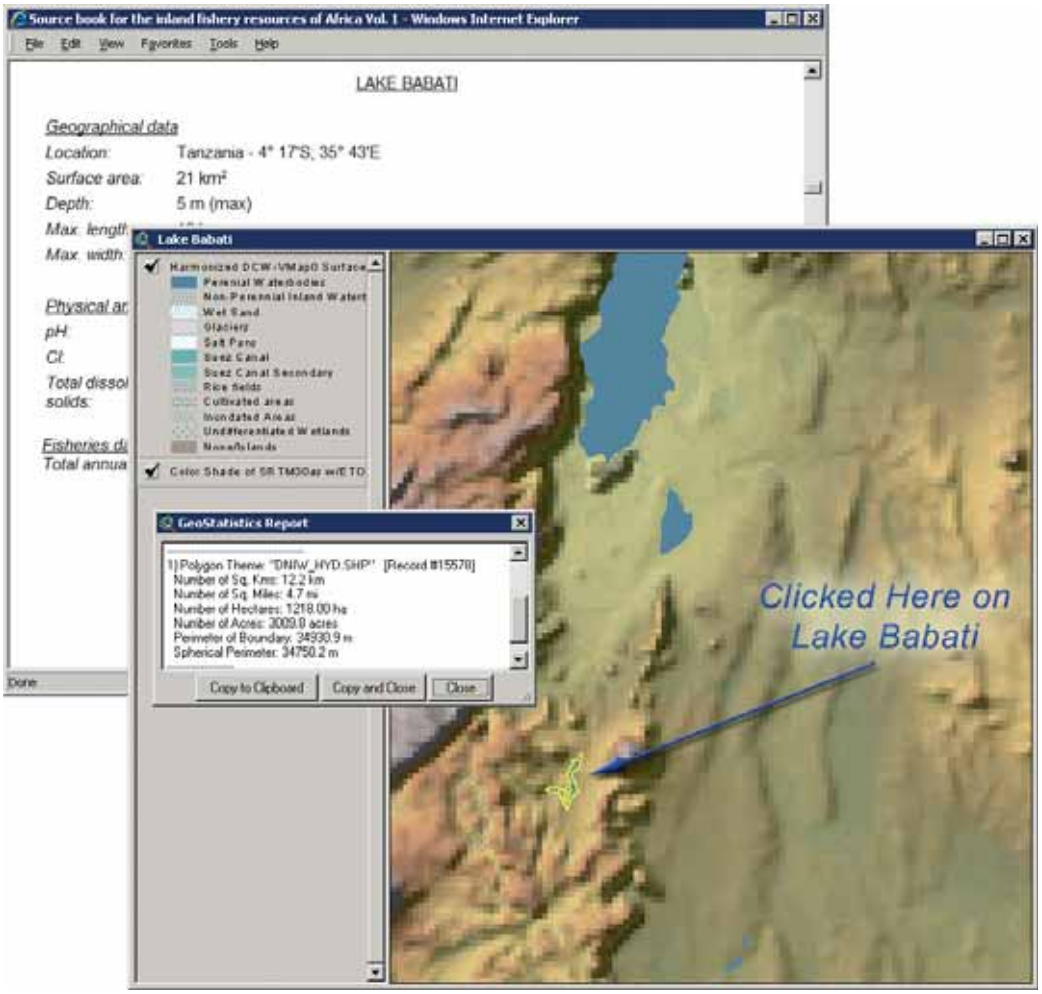
Within the United Republic of Tanzania, roughly half of the 79 lakes and reservoirs detailed in the SIFRA report contain limnological or fisheries attributes, while the majority contain only a basic reference to the SWB name and in some cases an approximate location and estimate of its size.

Further, as illustrated in Figure 2.32, the SIFRA data have not been reformatted from the historic textual reports into a tabular database format that would allow the direct linkage of attributes to features in spatial data layers. For this reason, only an HyperText Markup Language (HTML) based linkage between the Africover spatial data and the SWB listings in the SIFRA document for the United Republic of Tanzania is illustrated.

Figure 2.32 displays a partial report of the SIFRA data listing for Lake Babati at the centre of the United Republic of Tanzania against a map graphic from the main ArcView window. Lake Babati provides an example where the naming and harmonization of Africover features to SIFRA based listings for lakes and reservoirs was successful[11].

FIGURE 2.32

Example of the HyperText Markup Language based linkage of Africover spatial data to a surface waterbodies specific listing in the Tanzanian SIFRA report



[11] Due to an as yet unresolved issue with hot-links from ArcView to HTML pages containing internal anchor tags, clicking on a SWB will only link to the top of the *Section 6. Waterbodies Directory.* This may be resolved in the future by the use of basic Java scripts, however for the case study, a secondary click was required on the name of the SWB in this directory before the actual data listing could be accessed as shown above.

Discussion

The process of matching the named Africover SWB features to the SIFRA lakes and reservoirs was not as straight forward as was originally anticipated, and the harmonization of the two datasets required one additional day in order to account for differences in spelling, SWBs collocated in the AWRD and SIFRA source data but not represented by features in the Africover waterbody subset, and other inconsistencies or missing references between the datasets.

The levels of effort (LOE) required to complete the harmonization of the Africover waterbodies dataset and the SIFRA data can be summarized by the following tasks:

- Assignment of a name to the Africover waterbodies specific dataset using Tanzanian subsets of SADC-SWB and GNS-SWB data layers of the AWRD.
- Creation of a SIFRA sub-document of waterbody and wetlands, containing specific HTML anchor tags providing links to specific SWB listings.
- Modification of the existing AWRD tool providing access to the country based SIFRA reporting, to provide SWB specific HTML linkages.

In addition to the HTML hot-linking, the above tasks also result in an effective harmonization of the selected AWRD SWB features and the SIFRA data, and could therefore be used to create a more complete baseline of fisheries specific waterbodies.

All told, approximately one and a half days were required to complete the tasks described above linking the Africover SWB spatial features to the SIFRA report listings. However, because the processing methodology described for this exercise also represented a learning process, it is probable that this LOE would decrease with practice.

Based on the level of effort required for this method, it may be desirable to use a more streamlined process. For example, the order of the processing steps followed could be changed such that the linkage of SIFRA SWB listings would be undertaken across a core set of potential name source point datasets first. This would establish a SIFRA-specific spatial point data reference which could then be used to "inform" the linkage of attributes across polygonal data layers in a more cost effective manner. This more streamlined process was tested during the Zimbabwean exercise.

Republic of Zimbabwe

Materials and methods

Data utilized

The data employed during the Zimbabwean analysis were similar to those used in the Tanzanian exercise, including: the VMap0 Political boundary, the SADC-WRD SWB data layer, and the SWB subset of the GNS Gazetteer data layer. The Republic of Zimbabwe was chosen for this portion of the case study in order to benefit from the extensive listing of SWBs available for the country based on the original SADC-WRD SWB dataset. Africover datasets for the Republic of Zimbabwe were not available at the time this case study was prepared.

Figure 2.33, provides a pictorial view of the above baseline data layers.

FIGURE 2.33
Data utilized during the Zimbabwean analysis

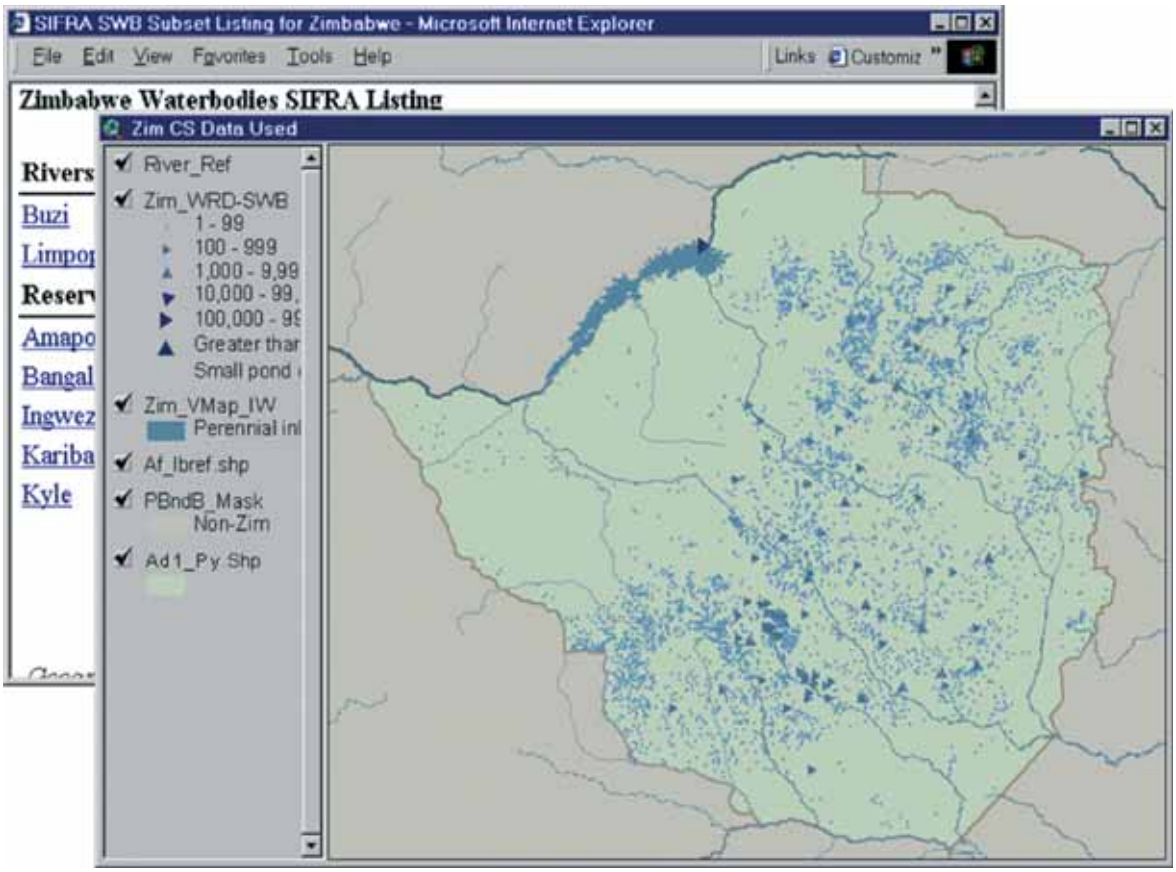


Table 2.18 provides a summary listing of the data utilized during the Zimbabwean portion of the case study.

TABLE 2.18
Summary and purpose of data used for Zimbabwean analysis

Data type	Data source	Data utilisation or purpose
Harmonized DCW-VMap0 Surface Waterbodies	SWB-DBC: dniw_hyd.shp	Primary baseline source for names and potential linkage to SIFRA Zimbabwean SWB reports
SIFRA Zimbabwe report	AWRD SIFRA Document Archive: Zimbabwe	Limnological and fisheries data to be attributed to Africover waterbodies data for Tanzania
SADC-WRD SWB point data layer	SWB-DBC: sadc_swb.shp	Secondary source of names for identifying SWBs for linkage to SIFRA waterbodies reporting data
VMap0 "Basic" political boundaries data layer	AVEC-DBC: Ad1_Py.shp	Used to create subsets of VMap0 and SADC-WRD SWB data layers for Zimbabwe

A subset of the Zimbabwean SIFRA report containing only the standard *Section 6. Waterbodies Directory* of the report was reformatted into a tabular database format for a direct linkage of attributes to the features in spatial data layers. The Inland Waterbody boundary data layer of the VMap0-5th Edition was used to provide a "named" polygonal baseline for the analysis.

Methods

Based on experience gained during the Tanzanian exercise, the analysis conducted for the Republic of Zimbabwe was more straight forward and required just over one day to complete. The majority of this time was spent: reformatting and applying HTML

anchor tags to the baseline SIFRA Report; creating a tabular listing of summary attributes available between the VMap0 and SADC-WRD SWB spatial data layers and the SIFRA data listings; and attempting to harmonize historical and spelling differences in names used to identify similar SWBs between the three primary data bases.
A tabular report for the Republic of Zimbabwe was facilitated by the existence of a baseline table covering 34 SWBs in the SIFRA report. Surprisingly, this baseline did not include records for 19 of the dams or reservoirs discussed in the SIFRA report. In all, data were available in varying degrees for some 41 SWBs in the SIFRA report for the Republic of Zimbabwe. Further, due to either the comparatively small number of SWB listings in the Zimbabwean SIFRA report or the de-facto inclusion of the GNS Gazetteer SWB data in the "named" VMap0-Ed5 inland waterbody data layer – see Zimbabwean Discussion section below – it proved unnecessary to use the derivative GNS SWB layer of the AWRD archive for the Zimbabwean exercise. It is likely that this facilitated the analysis and reduced the time required to complete the exercise. One unexpected spin-off of the exercise was that it was possible to differentiate actual SWB features from polygons representing double-lined river features for the VMap0 Inland Waterbodies data layer.

Results

The results of the exercise are summarized for the three input databases in Table 2.19. This listing is followed by a map (Figure 2.34) depicting these results and a comparative table (Table 2.20) of the 45 SWB features found common between the three data sources.

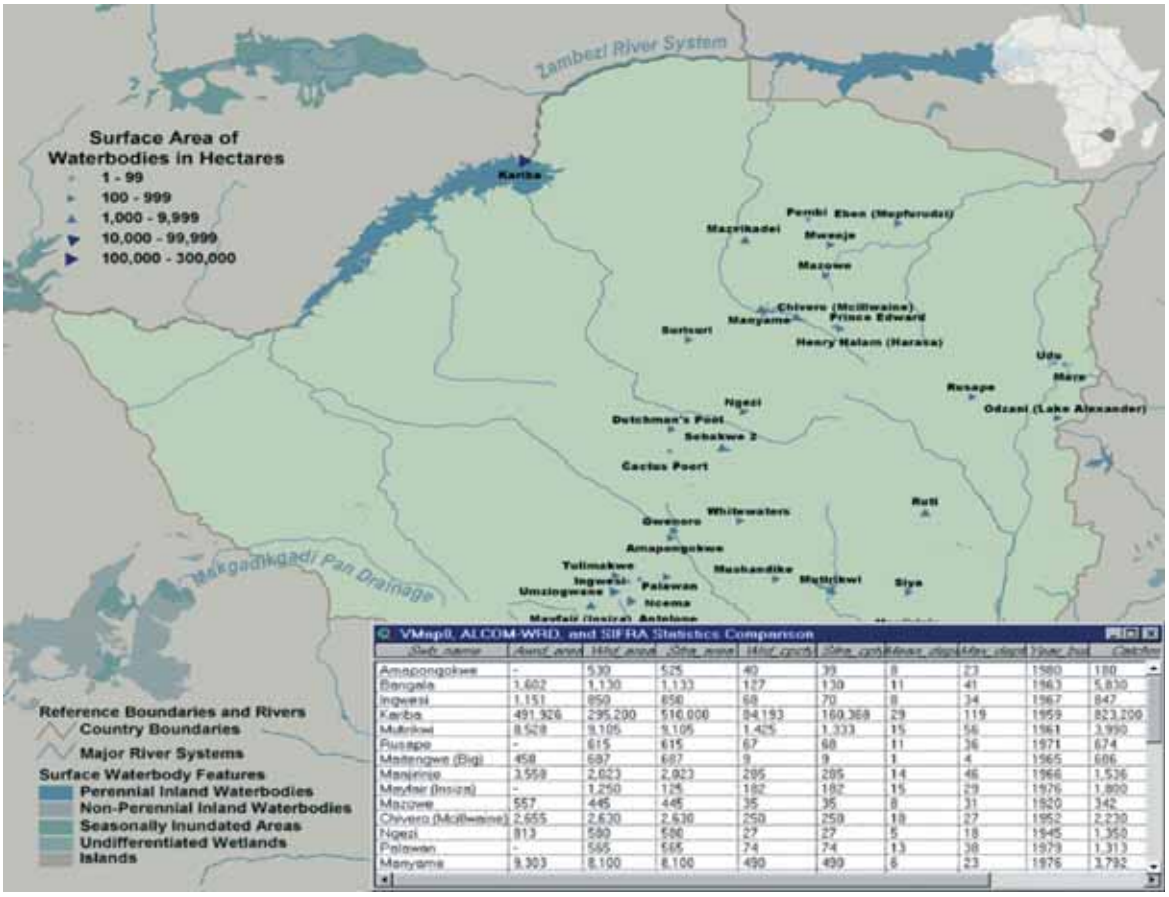
TABLE 2.19
Summary of Linkages between VMap0-Ed5, SADC-WRD and SIFRA

Number of SWBs	5th Edition of the VMap0 Inland Waterbody Layer
99	SWB features representing perennial and non-perennial waterbodies and seasonally inundated lands were either contained within or overlapped the borders of Zimbabwe.
60	Perennial SWB features containing a valid name attribute at the beginning of the exercise.
11	Additional VMap0-Ed5 Perennial SWB features that were named via the process.
31	Valid SWBs which could be differentiated from double-lined river polygons.
Of the 31 named and validated VMap0 SWB features identified, 26 features could be directly linked to SWBs in the SADC-WRD data layer and 13 features could be linked to the detailed SIFRA report listings for SWBs. Furthermore, 15 VMap0 SWB features could be linked directly to the original SIFRA summary table of Zimbabwean surface waterbodies.	

Number of SWBs	SADC-WRD (baseline of the three layers evaluated during the analysis)
6 230	SWB features represented in data layer for Zimbabwe
1 148	Features containing both a valid spatial reference and basic attributes valid for: a name, surface area, volume, capacity, and mean depth.
45	Features found to be common between the VMap0-Ed5 and SIFRA listing for Zimbabwean SWBs.
Only 4 of the SADC-WRD SWB Zimbabwean dam features > 1 000 hectares were found to be either not listed in the SIFRA document or not represented in the VMap0 data layer.	

Number of SWBs	SIFRA Compendium for Zimbabwe
19	SWB features for Zimbabwe containing detailed limnological and fisheries data in the SIFRA listing.
36	SWBs listed in the Zimbabwean SIFRA summary table containing both potentially useful data attributes and names. Surprisingly, this summary table did not contain a listing for the 19 SWBs for which more detailed data were available elsewhere in the report.
41	Unique SWB descriptions which were identified in total within the SIFRA report for Zimbabwe.
36	SWBs which could be geo-referenced based on either one or both of the VMap0-Ed5 polygonal or SADC-WRD point spatial data layers.

FIGURE 2.34
Surface waterbodies common between the VMap0, SADC-WRD, and SIFRA data including tabular attribute information



The complete table depicted as an inset graphic in Figure 2.34 is reformatted for clarity and presented in Table 2.20.

Discussion

The methods used during the Zimbabwean exercise employed the same AWRD tool-sets utilized for the Tanzanian exercise. However, because the process used for naming SWBs in the original VMap0-Ed5 dataset was based primarily on the proximity of the polygonal features to map annotation labels derived from the same cartographic source; and secondarily comparing the polygons to waterbodies from the GNS Gazetteer, the VMap0-Ed5 named waterbodies represents a potential surrogate for two of the more comprehensive gazetteers providing near global coverage of waterbodies.

Due to this, the VMap0-Ed5 may now provide a rapid mechanism to streamline the spatial referencing of historical reports containing statistical or limnological characteristics of SWBs, but which have no usable coordinate reference other than a name. In fact, although the validated SWB features in the VMap0 Inland Waterbody data layer contained less than 3 percent of the features in the SADC-WRD SWB dataset for the Republic of Zimbabwe, the VMap0 alone accounted for almost 40 percent of the waterbodies listed in the SIFRA report for the country. In comparison, the SADC-WRD data set was able to account for a further 44 percent of the SWBs contained in the SIFRA report. Combined, the two spatial datasets were able to provide valid spatial referencing for just over 85 percent of the SWB listed in the Zimbabwean SIFRA report.

TABLE 2.20
Summary of common surface waterbodies data available for the Republic of Zimbabwe

Name of Surface Waterbody	VMap0	ALCOM SADC-WRD Waterbodies				SIFRA				
	Area (Ha)	Area (Ha)	Capacity (10^6 m^3)	Mean depth	Catchment area (km^2)	Year built	Area (Ha)	Volume[1]	Maximum depth	Use[3]
Amapongokwe	-	530	40	8	180	1980	525	39	23	-
Antelope	205	290	15	5	732	-	-	-	-	-
Bangala	1 602	1 130	127	11	5 830	1963	1 133	130	41	i
Bariee	39	8	0.14	2	-	-	-	-	-	-
Blanket	285	122	5	4	-	-	-	-	-	-
Cactus Poort	-	77	3	4	1 279	1944	77	3	16	c
Chivero (Mcillwaine)	2 655	2 630	250	10	2 230	1952	2 630	250	27	w,i,r,f
Dutchman's Pool	277	283	5	2	4 298	1954	283	5	13	c,i
Eben (Mupfurudzi)	-	205	13	6	290	1968	205	13	20	i
Gwenoro	618	466	32	-	-	1958	466	32	24	w
Henry Halam (Harava)	-	215	9	4	696	1973	215	9	18	w
Hulube	22	4	0.05	1	-	-	-	-	-	-
Ingwesi	1 151	850	68	8	847	1967	850	70	34	-
Kariba	491 926	295 200	84 193	29	823 200	1959	510 000	160 368	119	p,r,f
Little Connemara	-	44	-	-	-	1961	44	1	9	r
Maitengwe (Big)	458	687	9	1	686	1965	687	9	4	-
Manjirinje	3 558	2 023	285	14	1 536	1966	2 023	285	46	i
Manyame	9 303	8 100	490	6	3 792	1976	8 100	490	23	w,f
Mare	-	13	0.26	2	-	1955	9	1	7	r
Matopos	-	67	4	6	10	1901	67	4	18	i
Mayfair (Insiza)	-	1 250	182	15	1 800	1976	125	182	29	-
Mazowe	557	445	35	8	342	1920	445	35	31	i
Mazvikadei	-	2 707	350	13	1 127	1973	485	21	18	w
Mushandike	502	437	38	7	325	1938	437	38	33	i,r
Mutirikwi	8 528	9 105	1 425	15	3 990	1961	9 105	1 333	56	i,r,f
Mwenje	-	468	42	9	557	1969	202	13	20	c,i
Ncema	143	152	18	12	713	-	-	-	-	-
Ngezi	813	580	27	5	1 350	1945	580	27	18	i,r
Odzani (Alexander)	-	145	7	5	78	1965	74	7	24	w
Palawan	-	565	74	13	1 313	1979	565	74	38	-
Pembi	-	61	-	-	40	1961	61	2	11	w
Prince Edward	159	93	4	4	-	1929	105	4	8	w
Rusape	-	615	67	11	674	1971	615	68	36	i,w
Ruti	-	1 510	140	9	2 615	1976	150	140	31	-
Sabadzhimba	59	4	0.05	1	-	-	-	-	-	-
Sebakwe 2	1 515	2 374	266	11	2 705	1957	1 518	155	32	w,i,r
Sheet	120	13	0.25	2	-	-	-	-	-	-
Siya	-	810	106	13	518	1977	810	106	47	-
Surisuri	-	192	10	5	260	1968	213	9	14	c,i
Tulimakwe	186	170	8	5	773	-	-	-	-	-
Udu	-	26	1	3	-	1973	15	1	14	r
Umzingwane	572	456	57	13	407	1958	456	45	32	w
Upper Ncema	439	769	45	6	643	1973	769	46	32	w
Upper Umgusa	-	77	3	4	405	1947	77	3	13	i
Whitewaters	262	152	5	-	250	-	-	-	-	-

Terminology; c-commercial/industrial, f-major fishery (over 100 tonnes/year), I-irrigation, p-power generation, r-recreation, w-water supply

Conclusions

The AWRD archive provides spatial data which can be used to develop more consistent baselines upon which both analytical, base mapping, and monitoring and evaluation tasks could be built to more fully support fisheries and integrated water resources management. The results of the two exercises conducted for this case study show that waterbody features can be named and attributed using multiple data sources, and can then be linked with a multitude of other data sources including textual reports. Further, such value-added databases present the opportunity to potentially create the most robustly attributed spatial database of SWBs covering Africa.

The simplest and most cost-effective solution for the development of such a database would be the harmonization of available spatial SWB feature datasets and then individual hot-linking of the point features to the relevant SWB listing in the SIFRA waterbodies directory. An average level of effort of one day per country could be anticipated for the production of such a database covering Africa.

The development of a database more suited to direct analysis of SWB features including both a hot-link as well as a direct tabular link to a set of common data attributes from the SIFRA reports would average approximately 2.5 days per country [the level of effort will vary slightly depending on the hardware used]. Since this later effort would result in tabular data containing both limnological and fisheries specific statistical data which could be directly linked to spatial data features, such an undertaking could provide a valuable tool to more directly support fisheries and integrated water resources management extension efforts.

References

Vanden Bossche, J.-P. & Bernacsek, G.M. 1990a. *Source book for the inland fishery resources of Africa*: 1. CIFA Technical Paper. No. 18.1. Rome, FAO. 240 pp. (also available at http://www.fao.org/docrep/005/T0473E/T0473E00.htm).

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