

African Water Resource Database

GIS-based tools for inland aquatic resource management

2. Technical manual and workbook



Cover graphic:

José Aguilar-Manjarrez and Jeff Jenness

Copies of FAO publications can be requested from:

SALES AND MARKETING GROUP
Communication Division
Food and Agriculture Organization of the United Nations
Viale delle Terme di Caracalla
00153 Rome, Italy

E-mail: publications-sales@fao.org

Fax: (+39) 06 57053360

Web site: <http://www.fao.org>

African Water Resource Database

GIS-based tools for inland
aquatic resource management

2. Technical manual and workbook

by

Jeff Jenness

Consultant

Joe Dooley

Consultant

José Aguilar-Manjarrez

Fishery Resources Officer

and

Claudia Riva

Consultant

Aquaculture Management and Conservation Service
FAO Fisheries and Aquaculture Department

The designations employed and the presentation of material in this information product do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations concerning the legal or development status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. The mention of specific companies or products of manufacturers, whether or not these have been patented, does not imply that these have been endorsed or recommended by the Food and Agriculture Organization of the United Nations in preference to others of a similar nature that are not mentioned.

The views expressed in this publication are those of the author(s) and do not necessarily reflect the views of the Food and Agriculture Organization of the United Nations.

ISBN 978-92-5-105647-9

All rights reserved. Reproduction and dissemination of material in this information product for educational or other non-commercial purposes are authorized without any prior written permission from the copyright holders provided the source is fully acknowledged. Reproduction of material in this information product for resale or other commercial purposes is prohibited without written permission of the copyright holders. Applications for such permission should be addressed to:

Chief

Electronic Publishing Policy and Support Branch

Communication Division

FAO

Viale delle Terme di Caracalla, 00153 Rome, Italy

or by e-mail to:

copyright@fao.org

Preparation of this document

This study is an update of an earlier project led by the Aquatic Resource Management for Local Community Development Programme (ALCOM) entitled the “Southern African Development Community Water Resource Database” (SADC-WRD).

Compared with the earlier study, made for SADC, this one is considerably more refined and sophisticated. Perhaps the most significant advances are the vast amount of spatial data and the provision of simplified and advanced custom-made data management and analytical tool-sets that have been integrated within a single geographic information system (GIS) interface.

The publication is presented into two parts to inform readers of various levels of familiarity with the benefits of spatial analyses for aquatic resources management.

Part 1 is divided into two main sections:

- The first section is aimed at administrators and managers with only a passing knowledge of spatial analyses but who would be interested to know the capabilities of the African Water Resource Database (AWRD) to assist with their decision-making. They may be department or division heads in government, non-governmental organizations (NGOs) and international organizations. Thus, a few examples of decision-making at this level based on spatial analyses from AWRD are described.

- The second section is addressed to professionals in technical fields who may actually or potentially employ the results of spatial analyses in their work. They may be in international organizations, government, universities or in the commercial sector. The case studies best serve to inform them of AWRD capabilities.

Part 2 is also divided into two main sections:

- The first section is written for spatial analysts in government, international organizations or the private sector.

- The second is for university teachers and students who may wish to use AWRD for educational purposes. This section includes a workbook with exercises, offering educational possibilities of AWRD.

Foreword

The “Status and Development of the African Water Resources Database (AWRD)” was presented at the twelfth session of the Committee for Inland Fisheries of Africa (CIFA) held in Yaoundé, Cameroon, from 2 to 5 December 2002. The Committee acknowledged that such GIS-based products are “powerful tools for fishery and aquaculture management, planning and development.” The Committee also noted that there were still outstanding issues to be resolved before such tools could practically and effectively be used by Member countries. The present report represents the follow-up activities based on CIFA’s recommendations.

Inland aquatic resources in developing regions around the world are immensely significant for food security as well as economic growth and poverty alleviation. However, the rational and sustainable use of essential resources is critical. The multi-purpose nature of inland water use patterns creates distinct sets of challenges for implementation of responsible development and management measures, and hence to the promotion of water, food and environmental security.

Geospatial information is increasingly being used for better understanding development issues and improving decision-making. The Millennium Development Goals (MDG) and their 2015 targets for halving the proportion of people living with hunger and poverty, and improving living conditions in the sector of education, gender, health and sanitation have heightened this awareness.

This report is one of a series of GIS-based publications under production by FAO’s Aquaculture Management and Conservation Service (FIMA) to update an earlier project led by the Aquatic Resource Management for Local Community Development Programme (ALCOM) entitled the “Southern African Development Community Water Resource Database” (SADC-WRD). The body of work presented represents both an expansion to the data and an enhancement of the original SADC-WRD analytic interface. Extended to cover the entire African continent, the new WRD has been entitled the “African Water Resources Database” and it is aimed at facilitating responsible inland aquatic resource management. It thus provides a valuable instrument to promote food security.

The AWRD allows for the integration of different types of information, e.g. fishery statistics, into a cohesive program that, because of its visual nature, is easy to understand and interpret. Systems such as the AWRD are excellent means to attract and direct investments in aquaculture and fisheries development.

I am confident that further explorations and applications of the AWRD data will deepen our understanding of inland aquatic resource management and will demonstrate the usefulness of the AWRD tool, whilst being immediately applicable to assist in a wide variety of recent issues addressed at CIFA such as: improving the reporting on status and trends in inland fisheries and aquaculture; co-management of shared inland fisheries resources; transboundary movements of aquatic species; and increased participation of stakeholders in the decision-making process about watershed area uses.

Alfred Yeboa Tetebo
CIFA Chairman
Director of Fisheries
Ministry of Fisheries Ghana

Abstract

This report represents a follow-up activity based on the recommendations by the Committee for Inland Fisheries of Africa (CIFA). The report is an update of an earlier project led by the Aquatic Resource Management for Local Community Development Programme (ALCOM) entitled the “Southern African Development Community Water Resource Database” (SADC-WRD). The body of work presented in this publication represents both an expansion to the earlier data and an enhancement of the original SADC-WRD analytic interface. Extended to cover the entire African continent, the new set of data and tools has been entitled the “African Water Resource Database” (AWRD). The overall aim of the AWRD is to facilitate responsible inland aquatic resource management. It thus provides a valuable instrument to promote food security.

The AWRD data archive includes 28 thematic data layers drawn from over 25 data sources, resulting in 156 unique datasets. The core data layers include: various depictions of surface waterbodies; multiple watershed models; aquatic species; rivers; political boundaries; population density; soils; satellite imagery; and many other physiographic and climatological data types. The AWRD archival data have been specifically formatted to allow their direct utilization within any geographic information system (GIS) software package conforming to Open-GIS standards. To display and analyse the AWRD archive, the AWRD also contains a large assortment of new custom applications and tools programmed to run under version 3 of the ArcView GIS software environment (ArcView 3.x). There are six analytical modules within the AWRD interface: 1) the Data and Metadata Module; 2) the Surface Waterbodies Module; 3) the Watershed Module; 4) the Aquatic Species Module; 5) the Statistical Analysis Module; and lastly, 6) the Additional Tools and Customization Module. Many of these tools come with simple and advanced options and allow the user to perform analyses on their own data.

The case studies presented in this publication illustrate how the AWRD archive and tools can be used to address key inland aquatic resource management issues such as the status of fishery resources and transboundary movements of aquatic species. This publication by no means cover all the issues that could be resolved using the AWRD, but they do provide a solid reference base for inland aquatic resource management in Africa. Based on a review and recommendations by CIFA, a number of opportunities to implement the AWRD tools and data in Africa have already been identified. Likewise, a number of future developments for the AWRD have been proposed, including AWRD-like frameworks for Latin America and Asia.

This publication is organized in two parts to inform readers who may be at varying levels of familiarity with GIS and with the benefits of the AWRD. The first part describes the AWRD and is divided into two main sections. The first presents a general overview and is addressed to administrators and managers while the second is written for professionals in technical fields. The second part is a “how to” supplement and includes a technical manual for spatial analysts and a workbook for university students and teachers.

The primary AWRD interface, tool-sets and data integral to the function of the AWRD are distributed in two DVD's accompanying part 2 of this publication and are also available for download on the Internet in FAO's GeoNetwork and GISFish GIS portals. A more limited distribution of the above primary database/interface, but divided among ten separate CD-ROM disks, is available upon request to FAO's Aquaculture Management and Conservation Service. Also, high resolution elevation datasets and images amounting to 38 gigabytes are available upon request for those who need them.

Jenness, J.; Dooley, J.; Aguilar-Manjarrez, J.; Riva, C.

African Water Resource Database. GIS-based tools for inland aquatic resource management. 2. Technical manual and workbook. CIFA Technical Paper. No. 33, Part 2. Rome, FAO. 2007. 308 p.

Acknowledgements

This report was funded by regular programme funding of the Aquaculture Management and Conservation Service (FIMA) of the FAO. Special thanks goes to Dr J.M. Kapetsky for his valuable advice, contributions to the organization of this publication, review of part 1, suggestions of applications examples for the GIS interface and writing the case study on “Inventory of fisheries habitats and fisheries productivities”.

Appreciation goes to John Moehl for his general advice; Luigi Maiorano, for his contributions to the technical edits of part 2 of the present publication; and John Jorgensen for his review of part 1 and for suggesting references to the introduction of this publication.

Patrizia Monteduro prepared the AWRD archive datasets for their publication on the Internet in FAO’s GeoNetwork GIS portal, and Roberto Giaccio wrote the script to convert the metadata documentation from the AWRD archive into an XML format for display in GeoNetwork.

Emily Garding made a final quality check on the AWRD tools and tested the exercises presented in the workbook of part 2 of this publication.

The authors benefited from the data provided by Jippe Hoogveen on the “Atlas of Water Resources and Irrigation in Africa” and by John Latham on “Africover” databases.

The following persons are recognized for their support, in alphabetical order: Devin Bartley, Gertjan de Graaf, Ashley Halls, Matthias Halwart, Eric Reynolds, Doris Soto, and Ashley Steel.

Some of the locational referencing tools for the AWRD were adapted from original tools developed for the McLennan Co. 9-1-1 Emergency Assistance District in Waco, Texas, the United States of America, and are presented here with their permission. Several general purpose tools, including the Select by Theme tool, the Query Builder tool, the Summarize tool and the statistics Histogram window, are adapted from original tools developed for the Saguaro project (University of Arizona; Tucson, Arizona, the United States of America, and are also presented here with their permission. We gratefully acknowledge the generosity of both organizations for sharing these resources with us.

We thank all the organizations which created the datasets and made them available for our use.

Chrissi Smith, Françoise Schatto-Terrible and Tina Farmer proofed the document and supervised its publication. The document layout specialist was Nadia Pellicciotta.

Contents

Preparation of this document	iii
Foreword	iv
Abstract	v
Acknowledgements	vii
Acronyms and abbreviations	xvii
1. TECHNICAL MANUAL	1
1.1 Introduction	1
GIS training	1
Installation of software	2
Installation of AWRD extension	3
Installation of AWRD data archive	3
Loading AWRD Tools into ArcView	6
AWRD archive	7
Overview of AWRD interface, menus, and additional view tables and functions	11
AWRD interface	11
AWRD Modules menu	12
AWRD Tools menu	13
Additional AWRD tools	14
1.2 Data and Metadata Module	15
Metadata tools	16
Metadata viewer tool	16
Metadata editor tool	17
Loading AWRD datasets	29
1.3 Surface Waterbodies Module	32
Manage surface waterbody themes	34
Surface waterbody viewer	36
Export Data	38
Report GeoStats for surface waterbodies polygon themes	38
Predict potential fish yield	39
1.4 Watersheds Module	45
Watersheds maintenance tools	47
Registering new custom watershed models or other polygonal themes	55
Watershed selection and analysis tools	68
Watershed selection tool	69
Watershed visualization tools	74
Select by Relationships with Another Theme tool	84
Watershed statistic viewer	87

1.5 Aquatic Species Module	91
Aquatic Species Viewer	91
View image of species	94
Add to map, clear and link to FishBase	95
Identifying all species in a particular area of interest	97
Multipoint functions	99
Incorporating aquatic species data from non-AWRD sources	100
1.6 Statistical Analysis Module	104
Summary statistics on a Theme	105
Probability Distribution Calculator	109
Summarize Theme Tool	112
Classification and ranking tool	115
Classification and weighting strategies	120
Simple linear regression tool	125
Regression options	125
Output options	125
Example of performing analysis on different subsets of data	130
1.7 Additional tools and Customization Module	134
Locational referencing tools	135
Find locations by Theme	135
Enter Coordinates and Zoom to Location tool	138
Coordinates Converter tool	139
Report coordinates based on screen inputs	140
Zoom to Gazetteer Locations tool	142
Select by Theme tool	147
Query Builder tool	149
Add base map to a view	153
Tools for calculating and reporting Geostatistics	154
River identification tool	157
Image Export and Base Mapping tool	158
Loading and unloading the Image Export and Base Mapping Extension	159
Tools common between Views and Layouts	160
Tools only available while working with layouts	169
Tools only available while working with views	171
Load Theme Database	173
Adjusting polygon borders and patterns	175
1.8 Add-on extensions and additional AWRD Table and View functions	178
Adding additional extensions to your project	178
Add-on AWRD additional extensions	179
Add-on ESRI additional extensions	179
Additional extensions from the Internet	180
Additional AWRD table tools	181
Table editing tools (“Edit” menu)	182
Table information tools (“Table” and “Field” menus)	184
Additional AWRD View tools	189

1.9 SIFRA Compendium	190
Review of SIFRA data by clicking on a country	191
Review of SIFRA data Compendium data selecting from list	192
2. WORKBOOK	195
Exercise 1. Inventory of fisheries habitats and productivities	196
Exercise 2. Surface waterbodies inventory	203
Exercise 3. Predicting potential fish yield	212
Exercise 4. Preliminary hydrological reporting	219
Exercise 5. Invasive and introduced aquatic species	231
Exercise 6. Production of simple map graphical outputs and base mapping	245
3. GLOSSARY	271
References	283
APPENDIX	
A1. Index of Buttons for AWRD interface, AWRD modules, AWRD tools and AWRD table and view functions.	285
A2. Schematic diagram of AWRD interface and modules	307
A3. Schematic diagram of AWRD menus and additional buttons	308

Tables

1.1	List of AWRD data layers	7
1.2	AWRD interface description	12
1.3	Additional AWRD tools	14
1.4	Data and Metadata Module buttons and menu items	15
1.5	Metadata editor tool buttons	18
1.6	General (1) reference dialog	18
1.7	General (2) reference dialog	19
1.8	Projection reference dialog	20
1.9	Data Maintenance reference dialog	21
1.10	Data Quality reference dialog	22
1.11	Metadata reference dialog	23
1.12	Contact reference dialog	24
1.13	Distribution reference dialog	26
1.14	Spatial reference dialog	28
1.15	Data Registration reference dialog	29
1.16	Surface Waterbodies Module buttons and menu items	33
1.17	Data on selected waterbodies module	34
1.18	Original data for 14 sample waterbodies	43
1.19	Watersheds Module buttons and menu items	45
1.20	Watersheds maintenance tools buttons	47
1.21	Watershed selection and analysis tools buttons	68
1.22	Watershed zooming tools buttons	77
1.23	Watershed flashing tools buttons	78
1.24	Other watershed visualization tools buttons	79
1.25	Select by relationship with another theme tool buttons	85
1.26	Aquatic Species Module buttons and menu items	91
1.27	Aquatic Species Viewer buttons and menu items	92
1.28	Statistical Analysis Module buttons and menu items	104
1.29	Water Requirement Submodel	119
1.30	Additional Tools and Customization Module buttons and menu items	134
1.31	Image Export and Base Mapping tool	159
1.32	Estimating the output pixel sizes based on pre-set DPIs	167
1.33	Add on Extensions buttons and menu items	178
1.34	SIFRA Compendium buttons and menu items	190
2.1	Summary of AWRD buttons and menu items	196
2.2	Summary and purpose of data used for comparison of surface waterbody counts and areas	196
2.3	Counts and surface areas of surface waterbodies from three sources with non-fisheries habitats removed	197
2.4	Summary and purpose of data used for comparison of surface waterbodies counts and areas	199
2.5	Surface areas of WCMC inland fisheries habitats of Africa	199
2.6	Summary and purpose of data used for comparison of surface waterbodies counts and areas	200
2.7	Counts of fishery habitats for the African continent from the GNS dataset	200
2.8	Summary of AWRD buttons and menu items	203
2.9	Summary and purpose of data used for Tanzanian analysis	204
2.10	Summary and purpose of data used for Zimbabwean analysis	207
2.11	Sample excel table for the Republic of Zimbabwe watersheds	209
2.12	Summary of AWRD buttons and menu items	212

2.13	Summary and purpose of data used for researching existing estimates of potential yield	213
2.14	Lake Tanganyika potential annual fish yield	213
2.15	Summary and purpose of data used for estimating potential yield from historical data	214
2.16	Summary statistics for historic catch: Nokoue Lagoon	214
2.17	Summary and purpose of data used for estimating potential yield from statistical models	216
2.18	Potential yield for Lake Sagara, the United Republic of Tanzania, and Lake Kabamba, the Democratic Republic of the Congo	216
2.19	Summary of AWRD buttons and menu items	219
2.20	Summary and purpose of data used to generate statistics on the Volta River megabasin	220
2.21	Statistics on Lake Volta megabasin	221
2.22	Summary and purpose of data used to generate statistics for the Republic of Ghana and Burkina Faso	223
2.23	Statistics on the Republic of Ghana and Burkina Faso	224
2.24	Summary and purpose of data used to generate statistics on the Volta River megabasin	226
2.25	Regression analysis on Lake Volta megabasin	226
2.26	Summary and purpose of data used to generate statistics on the Volta River megabasin	228
2.27	Lake Volta area values from multiple sources	229
2.28	Summary of AWRD buttons and menu items	231
2.29	Summary and purpose of data used	232
2.30	Summary and purpose of data used	235
2.31	Summary and purpose of data used	237
2.32	Summary of AWRD menu and button items	245
2.33	Summary and purpose of data used	246
2.34	Summary and purpose of data used	250
2.35	Summary and purpose of data used	255
2.36	Summary and purpose of data used	260
2.37	Summary and purpose of data used	264
2.38	Summary and purpose of data used	268
A1	AWRD interface description	286
A2	Additional AWRD tools	288
A3	Data and Metadata Module buttons and menu items	289
A4	Surface Waterbodies Module buttons and menu items	290
A5	Surface waterbodies viewer buttons and menu items	291
A6	Watersheds Module buttons and menu items	292
A7	Watersheds maintenance tools buttons	293
A8	Watershed selection and analysis tools buttons	294
A9	Watershed zooming tools buttons	295
A10	Watershed flashing tools buttons	296
A11	Other watershed visualization tools buttons	297
A12	Select by relationship with another theme tool buttons	299
A13	Aquatic Species Module buttons and menu items	299
A14	Aquatic Species Viewer buttons and menu items	300
A15	Statistical Analysis Module buttons and menu items	302
A16	Additional Tools and Customization Module buttons	303
A17	Add on Extensions buttons and menu items	304
A18	SIFRA Compendium buttons and menu items	305

Figures

1.1	The AWRD data structure	4
1.2	The AWRD Interface	11
1.3	The AWRD Modules menu	13
1.4	The AWRD Tools menu	13
1.5	Data and Metadata Module	15
1.6	Link to AWRD Metadata Web page for the active theme	16
1.7	Recording metadata for the active theme	17
1.8	Metadata General (1) reference dialog	18
1.9	General (2) reference dialog	19
1.10	Projection reference dialog	20
1.11	Data Maintenance reference dialog	21
1.12	Data Quality reference dialog	22
1.13	Metadata reference dialog	23
1.14	Contact reference dialog	24
1.15	Adding new contacts	25
1.16	Distribution reference dialog	26
1.17	Restrictions reference dialog	27
1.18	Spatial reference dialog	27
1.19	Data Registration reference dialog	28
1.20a	Metadata for hydrological basins of Africa	30
1.20b	Loading data from the AWRD data archive	31
1.21	Surface Waterbodies Module	32
1.22	The surface waterbodies viewer dialog	33
1.23	Opening the “Manage Surface Waterbody Themes”	35
1.24	Surface waterbody attribute report associated with the selected waterbody (e.g. Lake Tanganyika)	37
1.25	Saving the new Export Table in an ArcView Project	38
1.26	Potential fish yield prediction for Lake Tanganyika using the general Potential Fish Yield Calculator	41
1.27	Potential fish yield prediction for Lake Tanganyika using the “Potential Fish Yield for Selected SWB” in the Surface Waterbodies Module dialog (Model 2)	42
1.28	Starting the Watersheds Module	45
1.29	The watershed maintenance tools	46
1.30	Saving the information regarding the selected watershed as a text file on the hard drive and viewing the report produced by the Report button on the screen	48
1.31	Saving the new dataset to a new dBASE table and viewing the dBASE table in the ArcView Project	49
1.32	Selection of the data layers	50
1.33	Viewing watershed statistics source data (e.g. mean annual air temperature) without Spatial Analyst (on the left) and with Spatial Analyst (on the right)	51
1.34	Changing data for calculating statistics on the selected watersheds	52
1.35	Changing the watershed model to analyse	54
1.36	Registering new custom watershed model (simple version)	55
1.37	Calculation of area in the originally defined measurement units	57
1.38	Generating new data from grid themes	58
1.39	Selecting and adding the grids of interest to the view from the AWRD Modules menu option or by clicking the View Data button on the Watersheds Module	59
1.40	Combining the four grids into a single grid	60
1.41	Viewing the new grid “Summer Precipitation”	60

1.42	Adding the new grid (Summer Precipitation) into the AWRD	61
1.43	Specifying the projection of the new grid	62
1.44	Registering the new grid	63
1.45	Visualization of the new registered grid	64
1.46	Calculation of summary data for the new grid	64
1.47	Selecting the watershed model to remove	65
1.48	Selecting the grid theme to remove	66
1.49	Deleting specific data tables	67
1.50	Watershed selection and analysis tools	68
1.51	Upstream drainage basins for Lake Tanganyika	70
1.52	Upstream drainage basins for Lake Tanganyika and drainage basins for Lake Victoria	71
1.53	Upstream and downstream drainage basins for Lake Tanganyika	72
1.54	Entire Congo-Zaire megabasin	72
1.55a	Selection of the portion lying upstream of the confluence of the Kasai and Sankuru rivers, in the Congo-Zaire megabasin	73
1.55b	Entire Congo-Zaire megabasin except the portion lying upstream of the confluence of the Kasai and Sankuru rivers	74
1.56	Identifying all upstream, downstream and megabasin watersheds by clicking on any watershed in the theme	75
1.57	The megabasin functions	76
1.58	Watershed zooming tools	76
1.59	Using the watershed zooming tools in the Niger megabasin	77
1.60	The watershed flashing tools	78
1.61	Other watershed visualization tools	79
1.62	Visualization of the watersheds directly upstream with the "Move Upstream" tool	80
1.63	The custom legend tool	81
1.64	Applying a semi-transparent green colour to the unassociated watershed	82
1.65	Saving graphics and themes of a flow regime	83
1.66	Various spatial relationships available with the Select by Relationship with Another Theme Tool	84
1.67a	Selection of the Republic of Botswana and selection of the correct parameters to identify its entire drainage basin	86
1.67b	Entire drainage area for the Republic of Botswana	86
1.67c	Areas which drain out of the Republic of Botswana	87
1.68	Attribute data of watersheds	88
1.69	Statistics on the combined set of selected watersheds	89
1.70	The Aquatic Species Module	91
1.71	Aquatic Species Viewer	92
1.72	The four base themes available for the Aquatic Species Module	93
1.73	Full-size image of southern mouthbrooder (<i>Pseudocrenilabrus philander</i>) available in the Aquatic Species Module	94
1.74	The Add to Map button displaying the geographic distribution of common carp	95
1.75	Automatic link to FishBase Web site	96
1.76	Identifying the extent of a specific sub-national or national area on the view	97
1.77	Identifying all the species located in the selected Area of Interest (megabasin)	98
1.78	Identifying all the species located in the selected area of interest (sub-national boundaries)	99
1.79	Converting Multipoints to Points (<i>Clarias gariepinus</i>) locations	100
1.80	Importing an Excel table into ArcView through the Aquatic Species Module	101
1.81	Importing data from FishBase into AWRD	103
1.82	The Statistical Analysis Module	104
1.83a	The statistics report (Simple output) for the FAO watershed model	106
1.83b	The statistics report (Advanced output) for the FAO watershed model	107
1.84	Summary Statistics Calculator on a Field in a Table	108

1.85	Probability Distribution Calculator	110
1.86	Table Probability Distribution Calculator	111
1.87a	Using the Summarize Theme tool to divide the data into subsets based on the District values	113
1.87b	Calculating the surface waterbodies average by Districts	114
1.87c	Saving the combined features into a new theme	115
1.88a	Application of the classification and ranking tool (Simple version)	117
1.88b	Setting different output options with the simple classification and ranking tool	118
1.89	Application of the classification and ranking tool (Advanced option)	120
1.90	Application of the advanced classification and ranking tool to determine potential fish farming areas for common carp	121
1.91	Saving list of ranking criteria ("Save" button)	122
1.92	Loading saved selection criteria sets ("Load" button)	122
1.93	Multiple Output Options for saving selection criteria sets	123
1.94	Generating a Summary Report about the classification criteria	124
1.95	Creating the new table illustrating how each score was established	124
1.96	The Summary Statistic Calculator	126
1.97a	Regression report of rainfall and elevation for all watersheds in Africa	127
1.97b	The scatterplot	129
1.97c	The new "regression " theme attribute table	130
1.98	Regression analysis of rainfall and elevation for the Nile River megabasin	131
1.99	Regression analysis of rainfall and elevation for the Niger megabasin	132
1.100	The Manage Data Sources	133
1.101	The Additional Tools and Customization Module	134
1.102	Selecting the Theme, the field and the term to search and viewing the results of the Find Location by Theme tool	136
1.103	Looking at the attributes to screen duplicate or closely matching named results	137
1.104	Entering coordinates in the preferred format and finding location based on a coordinate reference	139
1.105	Coordinates Conversion tool	140
1.106	Getting XY Coordinates by clicking on the screen (the Republic of Madagascar)	141
1.107	Constraining a search with the Zoom to Gazetteer Locations tool	143
1.108	Reviewing all the attribute data associated with the selected feature	144
1.109	Searching by gazetteer locations	145
1.110	Find location based on both a zoom-to-location and a gazetteer search	147
1.111	Using the Select by Theme tool to select all the rivers intersecting a particular watershed	149
1.112	Setting new Theme Definitions to the Terrestrial Watershed and Large Marine Ecosystem dataset	151
1.113	Selecting features from a theme through the query builder tool	152
1.114	Background images available in the AWRD	153
1.115	Reporting GeoStatistics for the selected features	155
1.116	Identifying the projection before reporting Geostatistics	155
1.117	Specifying geostatistics calculation parameters and viewing the results in the theme attribute table	156
1.118	Renaming the selected river segments	158
1.119	The IEEM tools for views (top) and for layouts (bottom)	160
1.120	Choosing the image type	161
1.121	Checking for other image format translation	161
1.122	Selecting the name and directory location for the image	162
1.123	Output reports from the export of Views	163
1.124	Prompts and output reports from the Image Export tool in Layout mode	164
1.125	Sample Report for a successful output with accompanying WorldFile	165
1.126	The Report View/Layout Details tools	166
1.127	The Resize Window Dimensions tool	168

1.128	The Make a copy of a View/Layout tools	169
1.129	The Create LO/ViewFrame-Page tool	170
1.130	The Resize LO/ViewFrame-Pixels tool	170
1.131	The Toggle View TOC On/Off tool	171
1.132a	The Create Fitted Map and Polygonal Mask Theme tool	172
1.132b	Basic layout resulting from the Create Fitted Map tool	173
1.133a	Importing a precompiled theme database by database component or for base mapping	174
1.133b	Object Database Import failure due to missing dependency	175
1.134a	Comparison of a polygon theme with and without polygon borders	176
1.134b	Comparison of a polygon theme with and without polygon transparency	176
1.134c	Adjust polygon border and pattern tool	177
1.135	The Add-on Extensions	178
1.136	Selecting additional AWRD Extensions	179
1.137	Opening the list of ESRI Extensions	180
1.138	Link to ESRI Arcscripts Web site	181
1.139a	Table information and editing tools (under "Edit", "Table" and "Field" menus)	182
1.139b	The attribute table to edit	183
1.139c	Adding record numbers	184
1.140	Identifying table source	185
1.141	Identifying field types	186
1.142	Showing field information	186
1.143a	Opening the table in Excel and selecting the data to import	187
1.143b	Importing the data into an ArcView table	187
1.144	Exporting data into an Excel spreadsheet	188
1.145	The SIFRA Compendium	190
1.146	Opening the SIFRA Compendium introduction	191
1.147	Reviewing the SIFRA Compendium data by clicking on a country	192
1.148	Reviewing the SIFRA Compendium data by selecting from list through the AWRD Interface or through the AWRD Tools menu	193
A1	The AWRD Interface	285
A2	The AWRD Modules menu	287
A3	The AWRD Tools menu	287
A4	Data and Metadata Module	288
A5	Surface Waterbodies Module	289
A6	The surface waterbodies viewer dialog	290
A7	Starting the Watersheds Module	292
A8	The watershed maintenance tools	293
A9	Watershed selection and analysis tools	294
A10	Watershed zooming tools	295
A11	The watershed flashing tools	296
A12	Other watershed visualization tools	297
A13	Various spatial relationships available with the select by Relationship with Another Theme Tool	298
A14	The Aquatic Species Module	299
A15	Aquatic Species Viewer	300
A16	The Statistical Analysis Module	301
A17	The Additional Tools and Customization Module	302
A18	The Add-on Extensions	304
A19	The SIFRA Compendium	305

Acronyms and abbreviations

ADM	Administrative data layer
AFDS	African Data Sampler
AGLW	Agriculture, Land and Water Division
AIMG	Ancillary Image and Map Graphic
ALCOM	Aquatic Resource Management for Local Community Development Programme
ANNO	Annotation
ANOVA	Analysis of Variance
AOI	Area Of Interest
AQSP	Aquatic Species
ARAS	Ancillary Raster
ASCII	American Standard Code for Information Interchange
AVEC	Ancillary Vector
AWRD	African Water Resources Database
AWRIA	FAO-AGLW's African Water Resources and Irrigation in Africa
BADC	Belgian Administration for Development Cooperation
BIL	Band Interleaved by Line raster data format
BIP	Band Interleaved by Pixels image file format
BMP	Bitmap
BNA	Early ASCII mapping format for Atlas-Graphics thematic mapping package
BSQ	Band Sequential image file
CCRF	FAO Code of Conduct for Responsible Fisheries
CD	Compact Disk
CGM	Computer Graphics Metafile
CIA	US Central Intelligence Agency
CIFA	Committee for Inland Fisheries of Africa
CRES	Centre for Resource and Environmental Studies
CRU	Climate Research Unit
DAF	Digital Atlas of Africa
dBASE	Database
DBC	Database Component
DCW	Digital Chart of the World
DD	Decimal Degrees
DEM	Digital Elevation Model
DMA	The former U.S. Defense Mapping Agency, which is now entitled the U.S. National Imagery and Mapping Agency (NIMA)
DN/DNNET	DCW Drainage Network layer
DPI	Dots-Per-Inch
DTED	NIMA's Digital Terrain Elevation Data at various raster postings
EC	European Commission
ECW	Earth Resource Mapping's "Enhanced Compression Wavelet" format for raster imagery
EDC	United States Geological Survey Earth Resources Observation Systems (EROS) Data Center

EMF	Enhanced Metafile Format
EPS	Encapsulated Postscript (file extension)
EROS	Earth Resources Observation Systems
ESAD	NASA's Earth Science Applications Directorate
ESRI	Environmental Systems Research Institute, Redlands, California
ETM+	Landsat Enhanced Thematic Mapper Data
ETOPO2	A 2 minute Elevation Topographic DEM including bathymetry
ETOPO5	An early global 5 minute DEM
EU	European Union
FAO	Food and Agricultural Organization of the United Nations
FIMA	Aquaculture Management and Conservation Service
GARP	Genetic Algorithm for Rule-Set Production
GeoCover-LC	Land Cover based on Ortho-Rectified LandSat Imagery
GeoNet	Gazetteer Name Server
GeoNetwork	FAO's Spatial Data and Information Portal
GIEWS	FAO's Global Information and Early Warning System
GIF	Graphic Interchange Format (file extension)
GIS	Geographic Information Systems and software platforms
GIWA	Global International Water Assessment
GLOBE	NOAA distributed release of GTopo30
GNS/GeoNet	NIMA's Geographic Names Server Gazetteer of Named Locations
GSDI	Global Spatial Data Infrastructure clearing-house for SDI
GSM	Golden Software Map, a proprietary GIS format
GT30/GTopo30	Global Topographic 30 arc second DEM database, nominal 1km postings
GT30BATH	Combined GTopo30 and Scripps/Smith and Sandwell Bathymetry
GUI	Graphical User Interface
GZTR	Gazetteer/Named Location
H1k/HYDRO1k	Global Hydrological 1 kilometre database
HTML	Hyper Text Markup Language
HYD	Hydrological feature subset of the LC/LCPOLY (DCW Land Cover layer)
ID	Identifier, usually denoting a unique numerical or alphanumeric code
IEBM	Image Export and Base Mapping tool-set of the AWRD
IHO	Standards for Maritime Waterbodies based on the International Hydrographic Bureau of the International Hydrographic Organization
ISCGM	International Steering Committee for Global Mapping
ISO	International Organization for Standardization
IW	VMap0 Inland Water layer
JPG/JPEG	Graphics file type/extension (lossy compressed 24 bit color image storage format developed by the Joint Photographic Experts Group)
JPL	NASA's Jet Propulsion Laboratory
JRC	Joint Research Centre of the European Commission
LAEA	Lambert Azimuthal Equal Area projection system
LC/LCPOLY	DCW Land Cover layer
LCL	Lower Confidence Limit
LME	Large Marine Ecosystems

LO	Layout
LOE	Level of Effort
LWDD	FAO's Land and Water Development Division
MADE	Multipurpose land cover databases
MGLD	MSSL Global Lakes Database
MM	The secondary maritime encoding parameter pertaining to the proposed FAO hydrological encoding standard
MODIS	Moderate resolution imaging spectroradiometer sensor on Terra satellite
MrSID	LizardTech's commercial compression format for spatial imagery
MSSL	Mullard Space Science Laboratory
NASA	U.S. National Aeronautical and Space Administration
NGA	National Geospatial-Intelligence Agency (new name for NIMA)
NGDC	NOAA's National Geo-Physical Data Center
NGO	Non-Governmental Organization
NIMA	U.S. National Imagery and Mapping Agency, formerly the U.S. Defense Mapping Agency (DMA)
NOAA	U.S. National Oceanographic and Atmospheric Administration
ODB	Object Database
ONC	Operational Navigation Charts
ORNL	U.S. Oak Ridge National Laboratory
Ortho/ORTH	Orthographically-rectified, i.e. flattened or adjusted for elevation changes
OrthoTM	Ortho-rectified or flattened imagery
OS	Operating System
OVRVW	A virtual Overview map
PAIA	FAO's Priority Areas for Interdisciplinary Action
PDF	Portable Document Format (Adobe Acrobat)
PNG	Portable Network Graphics (graphic file standard/extension)
PS	PostScript (file name extension)
PTES or Pfaf	Pfafstetter Topological Encoding Scheme, a 5 to potentially 22 long numeric digit or encoding string for encoding spatially based continental hydrographic data.
PY	Potential Yield
PYPUA	Potential Yield per Unit of Area
RAID	Redundant Array of Inexpensive Disks
RDBMS	Relational Database Management Systems
RGB	3 band spatial imagery forced into the Red:Green:Blue spectrum
RIV	Rivers and Drainage/Flow
RRSU	The SADC Regional Remote Sensing Unit located in Harare Zimbabwe
SADC	The Southern African Development Community
SAIAB	South African Institute for Aquatic Biodiversity (formerly known as JLB Institute of Ichthyology)
SARPO	The Southern African Regional Programme Office of WWF located in Harare Zimbabwe
SDE	see Manual (subsect. Excel Import and Export Tools)
SDI	Spatial Data Infrastructure
SHD	Shaded Relief

SIFRA	Source Book for the Inland Fisheries Resources of Africa
SRTM	Shuttle Radar Topography Mission
SSN-TF	FAO's Spatial Standards and Norm Task Force
SWB	Surface Waterbody
TIF/TIFF	Tagged Image File Format (graphics/image file format)
TM	Landsat Thematic Mapper.
TOC	Table Of Contents
TOR	Terms of Reference
U.S.	The United States
UCL	Upper Confidence Limit
UFI	Unique/Universal Feature Identifier
UN	United Nations
UN-CS	United Nations Cartographic Section
UNEP	United Nations Environment Programme
UN-GD	The UN-CS 1:10-1:5 million Global GIS Database
UNGIWG	United Nations Geographic Information Services Working Group
UNL	University of Nebraska at Lincoln, USA
URI	University of Rhode Islands, USA
URL	Universal Resource Locator for the identification of specific locations or web-sites on the WWW
USAID	The U.S. Agency for International Development
USFS	The U.S. Forestry Service
USGS	The United States Geological Survey
UTM	Universal Transverse Mercator
VMAP	NIMA's Vector Smart Map standard for various scales of vector data
VMAPO	Vector Map for Level 0
VPF	NIMA's Vector Product Format for the encoding of VMAP data libraries
VRTL	A seamless 1:750 000 Virtual basemap
WC	Water Course layer of VMAPO
WCMC	World Conservation Monitoring Centre
WDBII	CIA's 1:3 - 1:5m scale World Database II
WGS	World Geodetic Standard, 1984 standard datum and spheroid
WMF	Windows Metafile (file name extension)
WRD	The original SADC Water Resource Database produced by ALCOM
WRI	World Resources Institute
WS	Watersheds
WTLND	Wetlands
WVS	World Vector Shoreline
WWF	World Wide Fund for Nature (known as World Wildlife Fund in the U.S.)
WWW	World Wide Web