

2.3 AFRICAN WATER RESOURCE DATABASE INTERFACE


ArcView 3.x comes with many additional tools written or licensed by ESRI (Environmental Systems Research Institute, Inc., the publishers of ArcView), and these are installed automatically when ArcView is installed. These tools are referred to as “Extensions”. The AWRD tool itself is an example of an extension, and they are generally written for very specific analytical, graphical or data-management purposes. The AWRD provides an assortment of new custom-designed applications and tools in addition to those provided by ArcView 3.x.

Through the AWRD interface, users maintain the older SADC-WRD functionalities but can now access through a single interface not only tabular and spatial data viewers for the creation of spatial distribution maps, but can for the first time: test and visualize complex spatial relationships; conduct robust statistical analyses concerning the spatial extent and distribution of such relationships; locate and reference similar areas identified during previous analyses; save analytical criteria; export and/or map results; and perhaps most important of all, integrate their own data for comparison or individual analysis.

Currently, there are six analytical modules which comprise the core of the AWRD interface and tool sets: (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. Most of the analytical modules and tools come with simple and advanced options and all of the modules and tool sets of the AWRD are available throughout the interface.

This section provides a brief overview of the general AWRD Interface and the various tool-sets available within each of the six modules. The main tools are described with examples along with a brief of their benefits and potential applications in inland aquatic resource management with a focus on inland fisheries and aquaculture.

A set of application case studies illustrating various decision support scenarios using the AWRD data and tools are available in Section 2.4 to users as aids and training examples; more detailed descriptions of all the modules and tools are available in the AWRD Technical Manual (part 2 of this publication), and educational materials and training exercises are provided in a workbook (part 2 of this publication).

The full suite of tools provided with the AWRD are available through several buttons and menu options on the ArcView View, Table and Layout interfaces. These include a variety of statistical tools and general enhancements to the basic ArcView 3.x interface as well as several functions specifically designed to analyse surface waterbodies, watersheds and aquatic species. There are three main interfaces to access the different tools and modules developed for the AWRD: (1) AWRD Interface, (2) AWRD Modules menu and (3) AWRD Tools. For most users, the primary source for AWRD functions will be the AWRD Interface, accessible by clicking the  button in the ArcView View button bar. The “AWRD Modules” and “AWRD Tools” menus provide direct access to the four primary analytical modules and to many of the additional GIS-based tools respectively. Most of these functions are also available on the AWRD Interface, but some users may also find it convenient to access the functions directly from these menus.

These interfaces are illustrated in Figure 2.3 and are described in detail in the AWRD technical manual (part 2 of this publication).


FIGURE 2.3
GIS interface



Data and Metadata Module

Within GIS terminology, metadata are the descriptive data about both spatial data and any tabular data which can be used to classify or attribute the individual features of such spatial data. The Data and Metadata Module is comprised of a “Data Inventory” and metadata tools.

Data Inventory

The “Data Inventory” button  on the AWRD interface allows users to quickly search for and load all data from the AWRD data archive. This function also provides basic descriptive data for all datasets, and includes a button to open the dataset metadata.

Metadata Viewer


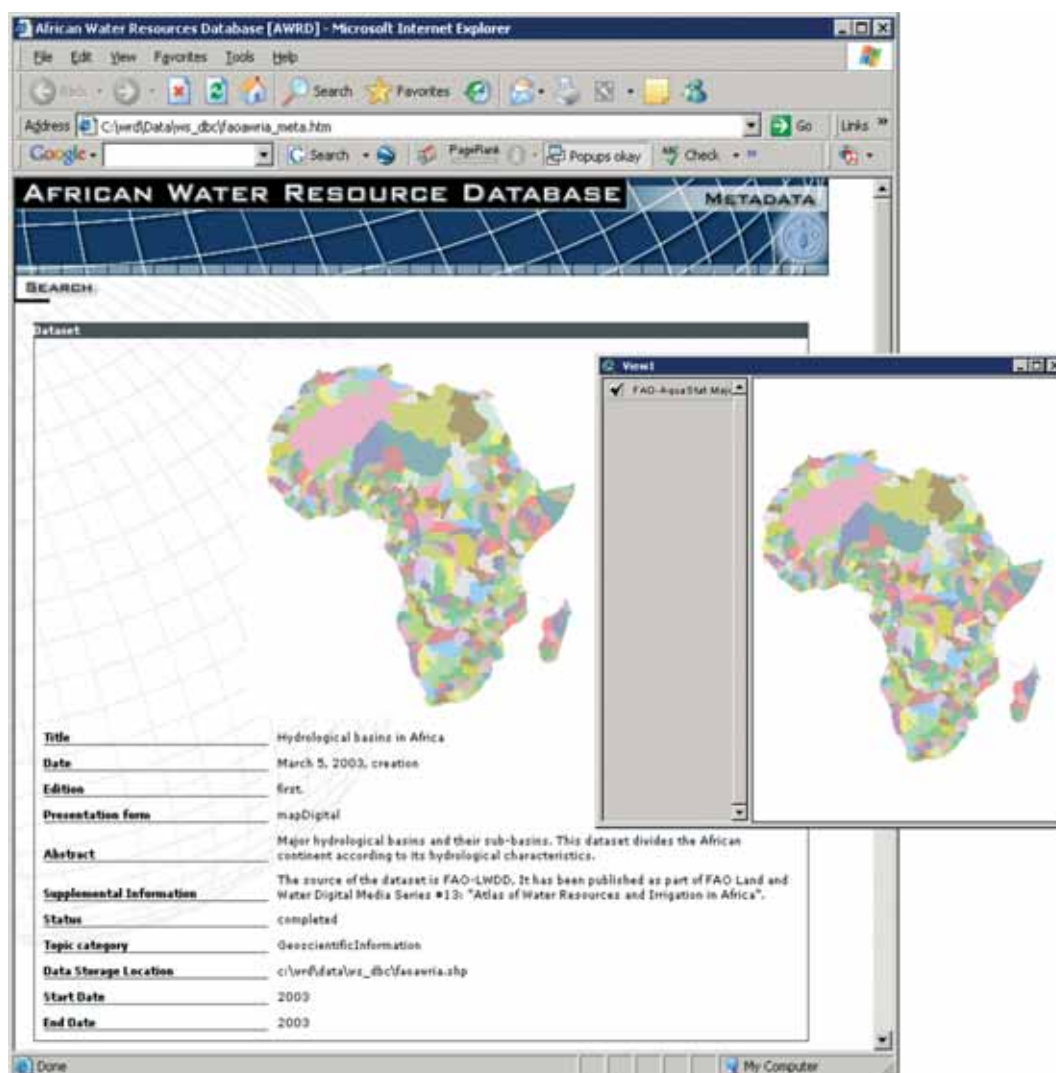
Using the AWRD interface a user can opt to review the metadata for any of the AWRD datasets selected for display by clicking the Metadata Viewer button  on the AWRD Interface.


Figure 2.4 presents a metadata report for one of the AWRD datasets modelled on the layout generated by FAO’s Spatial Data and Information Portal, GeoNetwork (<http://www.fao.org/geonetwork/srv/en/main.search>). The inventory table also includes hyperlinks to the metadata reports of each data selected.

FIGURE 2.4
Metadata HyperText Markup Language (HTML) summary report



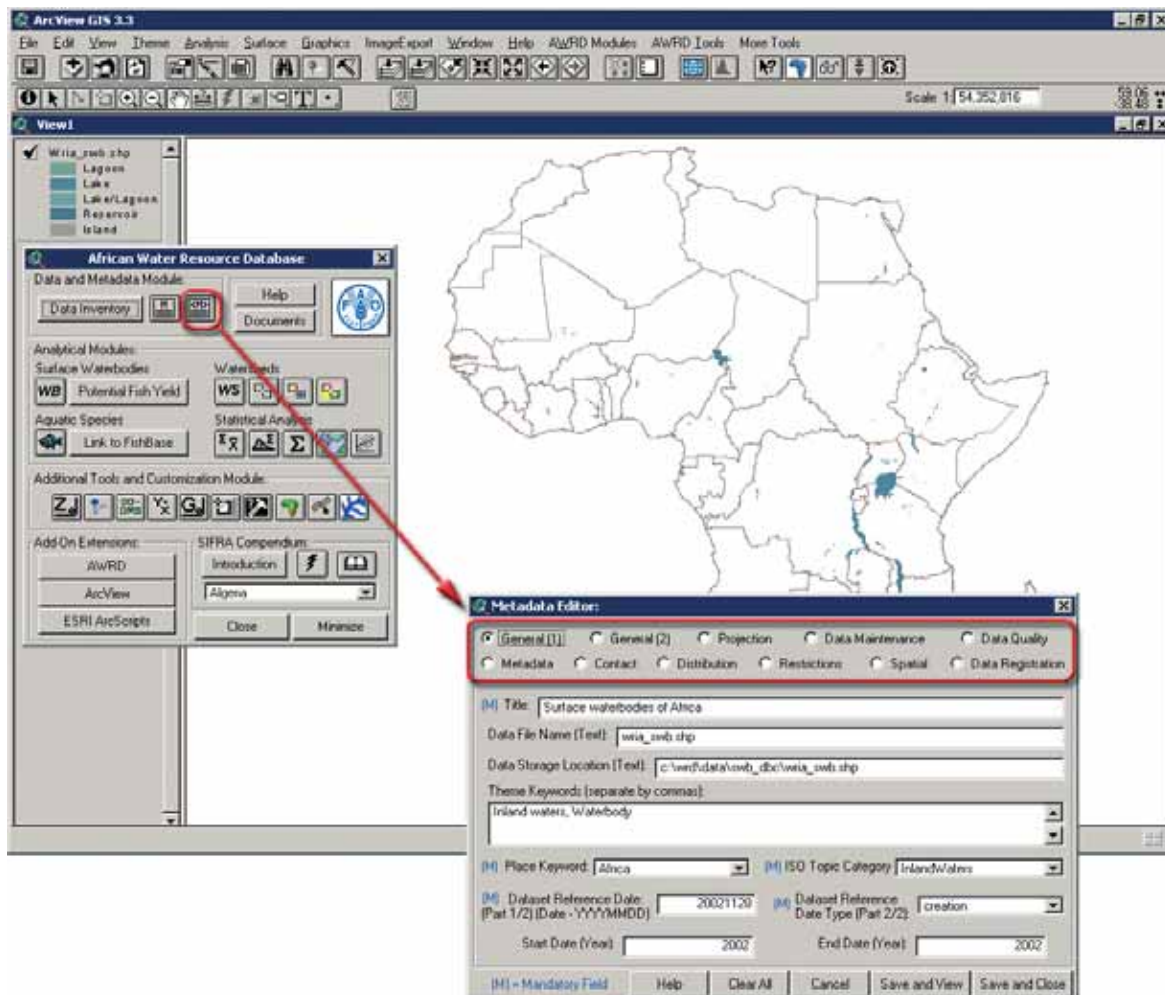
The Metadata tools provide users with the means to review the metadata concerning the 38 general topic divisions provided with the AWRD, as well as add metadata to their own data themes. In addition to providing users of the AWRD with a means of reviewing the metadata associated with the spatial data covered in Section 2.2, the Metadata tools allow users to capture, modify and distribute metadata. The module supports the review and production according to the ISO 19115 metadata standard and is fully compliant with the HyperText Markup Language (HTML) based reporting structure employed by FAO's GeoNetwork.

Metadata Editor

The user can use the Metadata Editor tool to quickly and easily generate a new metadata report for a new datasets or overwrite an existing version. The Metadata Editor tool can be opened by clicking the Metadata Editor  button on the AWRD Interface. As can be seen at the top of Figure 2.5, the Metadata Editor tool allows users to review and edit a wide variety of metadata associated with a spatial data layer. The topical metadata which can be evaluated include: General (1), General (2), Projection, Data Maintenance, Data Quality, Metadata, Contact, Distribution, Restrictions, Spatial and Data Registration references. Each of these eleven topical references has its own unique

viewing window such as the “General (1)” reference depicted in Figure 2.5. A complete description for each of the eleven metadata topical reference views are detailed in the AWRD Technical Manual (part 2 of this publication).

FIGURE 2.5
Metadata General (1) Reference Dialog



Benefits and applications

Metadata are extremely useful for analyzing and sharing data, providing such essential information as: the source and scale of the original data, the coordinate referencing system, and descriptive information on its quality, accuracy and attributes.

Surface Waterbodies Module

The Surface Waterbodies (SWB) Module is designed to give users of the AWRD quick and easy access to data on surface waterbodies in Africa. In addition, the SWB Module also provides users with a method to predict potential SWB fish yields based on two possible models. The module is designed to work with eleven surface waterbody datasets provided with the AWRD. The SWB Module can be opened by simply clicking on the **WB** button and then specifying which of the fifteen waterbody layers will be considered for analysis (Figure 2.6).

Statistical reporting

As with all of the viewers and tools of the AWRD, users of the SWB interface are provided with the means to “register” their own waterbody datasets for examination within the viewer. To “register” a dataset is to add that dataset to the AWRD GIS interface in such a way that the AWRD tools will be able to calculate statistics on those data. When a surface waterbody dataset is registered, then the Surface Waterbody viewer will allow you to select that dataset from a list and calculate statistics on it.


In Figure 2.6, Lake Tanganyika was selected from the surface waterbodies database component using the SWB selection tool available as a button  in the AWRD interface. Because the user has selected only this single waterbody, the viewer lists only a single record for review and by default will display the summary statistics concerning this SWB (Table 2.14).

FIGURE 2.6
Surface Waterbodies attribute and statistics report

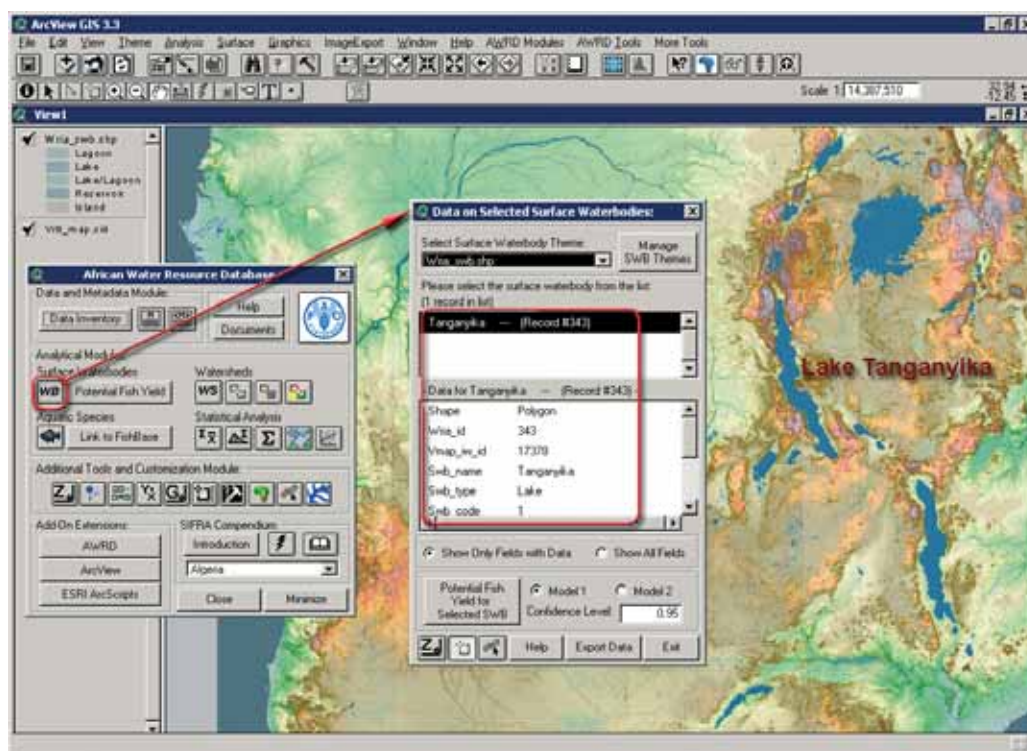


TABLE 2.14
Summary statistics for Lake Tanganyika

Description	Attribute field name	Value
ID	Field [Wria_id]	343
ID	Field [Vmap_iw_id]	17 378
Name	Field [Swb_name]	Tanganyika
Surface waterbody type	Field [Swb_type]	Lake
Surface waterbody code	Field [Swb_code]	1
Hydrological code	Field [Hyd_code]	1
Hectares	Field [Laea_ha]	3 284 471.8
Acres	Field [Laea_acres]	8 115 929.7
Perimeter	Field [Laea_prmtr]	1 878 035.7
Km ²	Field Area	32 844.7

Note: The fieldname “Laea”, means that these values are based on the Lambert Equal Area Azimuthal projection.

The potential fish yield report provides users with detailed information on the model applied, the data and values used to generate the predicted yield output, and the predicted yields in the original natural log values. The data in the report is automatically saved to the clipboard and it can be pasted into any text-editing program. A discussion on the use of confidence intervals and the predictive accuracy of this analytical tool are contained in part 2 of this publication.

Benefits and applications

Potential yield is a critical value for fisheries managers. Historical data or current observed fish yield values should generally provide more accurate estimates of potential fish yield than the AWRD models, but these models provide a statistically-based guide when better data is unavailable.

Other functions of the SWB Module

In addition to the general statistical reports and predictive yield functions of the module, users are also given tools to: (a) Export selected sets of SWBs to a separate ArcView dBASE table, which can facilitate the ongoing analysis of subsets of data (e.g. in Excel); (b) Access extensive Zooming and Locational Reference tools and (c) Calculate general descriptive spatial statistics on the selected waterbodies.

Watersheds Module

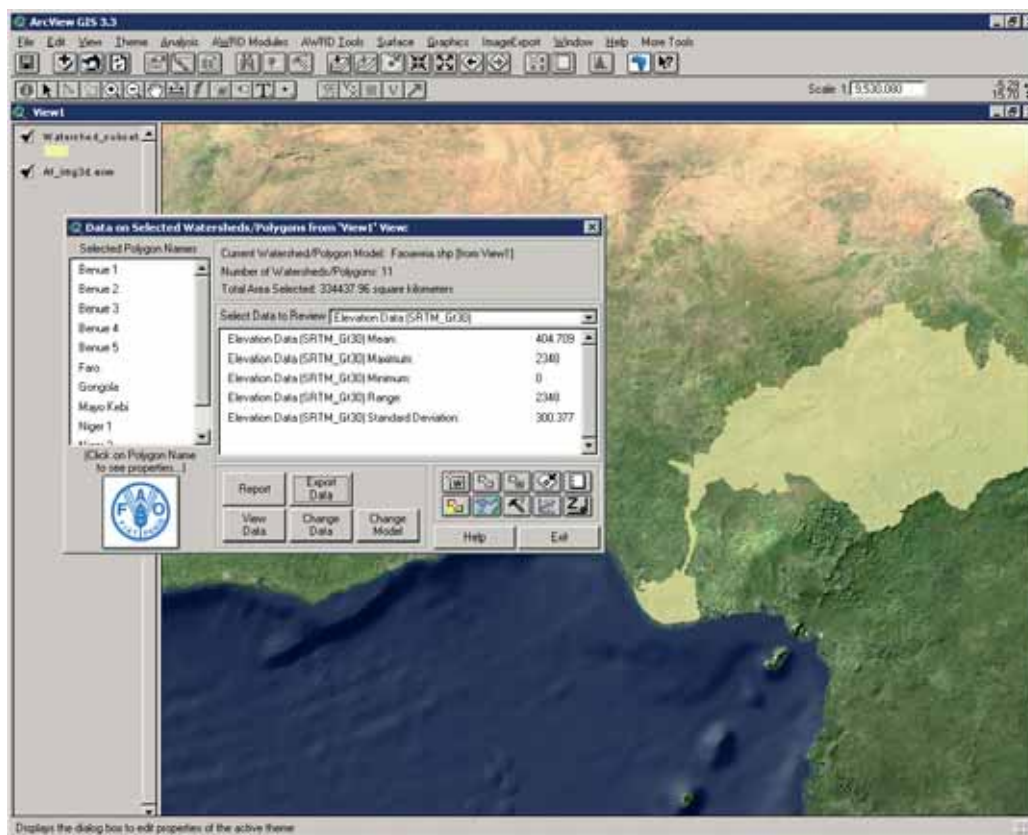
The Watersheds Module and related analytical tools represent perhaps the most comprehensive and intensive programming effort undertaken within the AWRD interface. This module offers a wide variety of tools specifically designed to analyse and visualize watersheds. These tools take advantage of the hydrological relationships between watersheds and use these relationships to identify which watersheds are upstream, which are downstream, and which make up the overall flow regime and/or megabasin.

Watershed data layers can be simple or complex. Some watershed data layers are basic watershed delineations composed only of polygons outlining the watershed boundaries. Other watershed data layers are more complex watershed models, in which each watershed is encoded so that the upstream and downstream watersheds can be easily determined. Watershed models also often include the hierarchical level of the watershed within the river system network.

Within the AWRD, to be considered a valid watershed model for analysis via the Watersheds Module, each of the watersheds within a theme must have both an ID field and a field indicating the ID value of the watershed immediately downstream, and these attribute fields must be “registered” within the module. The AWRD WS-DBC currently contains five watershed layers, and three of these layers represent validly encoded WS models which come pre-registered with the Watersheds Module.

At the top centre of the module, users are presented with basic information describing the current watershed model, the current view, the number of watersheds selected, and the total land area selected, while on the left side of the module is a list of all the currently selected watershed records (Figure 2.8). Users may examine the attribute data associated with any of these watersheds by simply clicking on the name or reference available in the record list. A representation of the tool using elevation data is illustrated in Figure 2.8.

FIGURE 2.8
Watersheds Module interface



In addition, at the bottom left of the dialog the Watersheds Module also contains the WS Maintenance tools, available as buttons to generate a text report describing the currently selected watersheds, export those watersheds to a new table (allowing users to analyse the data in some other analytical software), view the original background data used to generate the statistics, change the data to analyse, and change the watershed model.

Watershed Selection and Analysis tools

Many of the analytical functions within the AWRD are designed to work on only a subset of features out of the overall dataset. This allows users to identify an area of interest, and then restrict all analyses to only that region. Within the Watersheds Module, this means the user must select those watersheds of interest before conducting any analyses. The AWRD Watersheds Module provides several tools to select watersheds based on their location, their hydrological relationship with neighbouring watersheds, and their proximity to other features in other datasets.


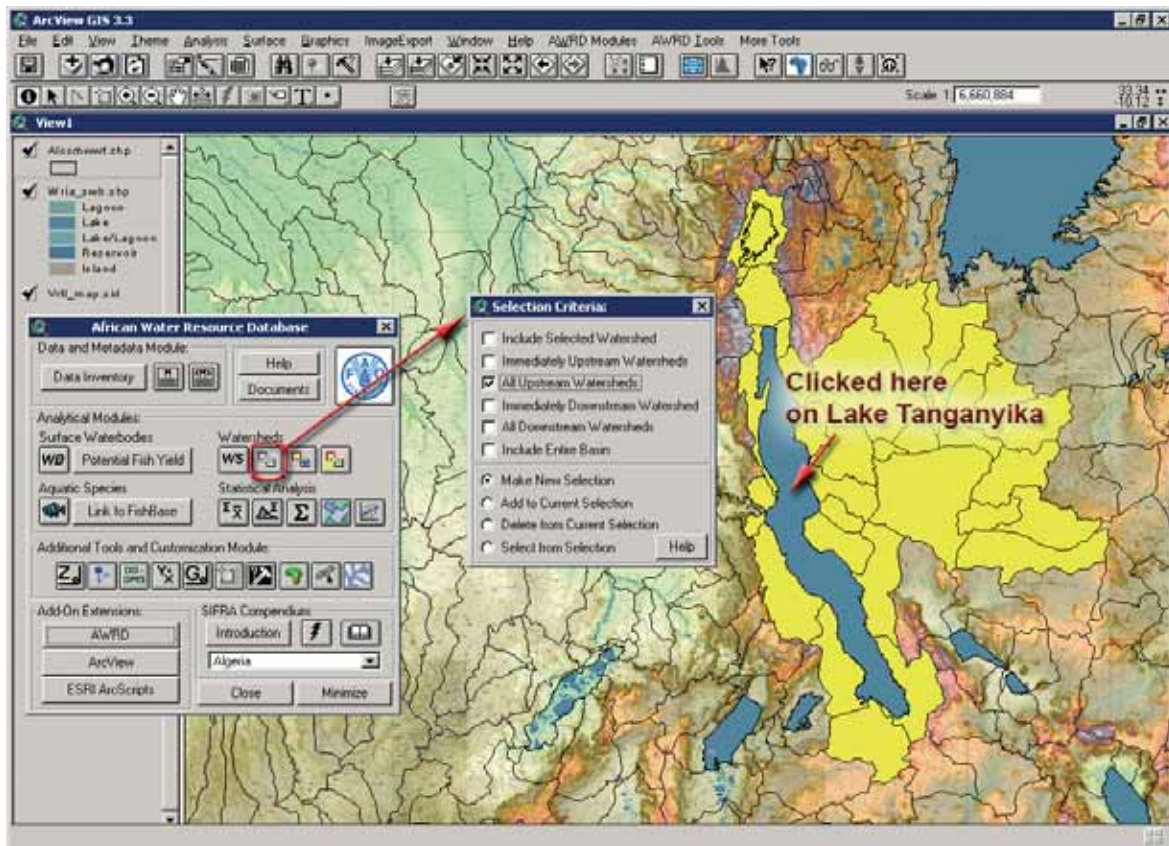
The Watershed Selection tool can be opened by clicking the  button on either the AWRD Interface or on the Watersheds Module dialog. Because this tool operates directly on a “registered” watershed model, the tool will only be enabled if such a model is present in the view and if valid hydrological relationships are defined for it. The “Selection Criteria:” dialog in Figure 2.9 opens when this button is clicked, and the tool is used by simply clicking on any watershed within the active view. The “Selection Criteria” dialog stays open as long as the tool is used.

FIGURE 2.9
Upstream drainage basins for Lake Tanganyika




In the example displayed in Figure 2.9 the user was interested in identifying all those areas that drained into Lake Tanganyika, so they first checked the “All Upstream Watersheds” option, and then chose “Make New Selection”, and lastly clicked anywhere on Lake Tanganyika. The watersheds selected based on this query are highlighted in yellow on the display and illustrate the upstream areas representing the Lake Tanganyika drainage basin. Any further statistical calculations conducted by the user on the watershed model would now be limited to the selected set of watersheds.

Multiple selection options can also be considered, such that the user could add all the areas that drained into Lake Victoria to the selected set as well, or possibly choose to remove selected features from the set.

Benefits and applications

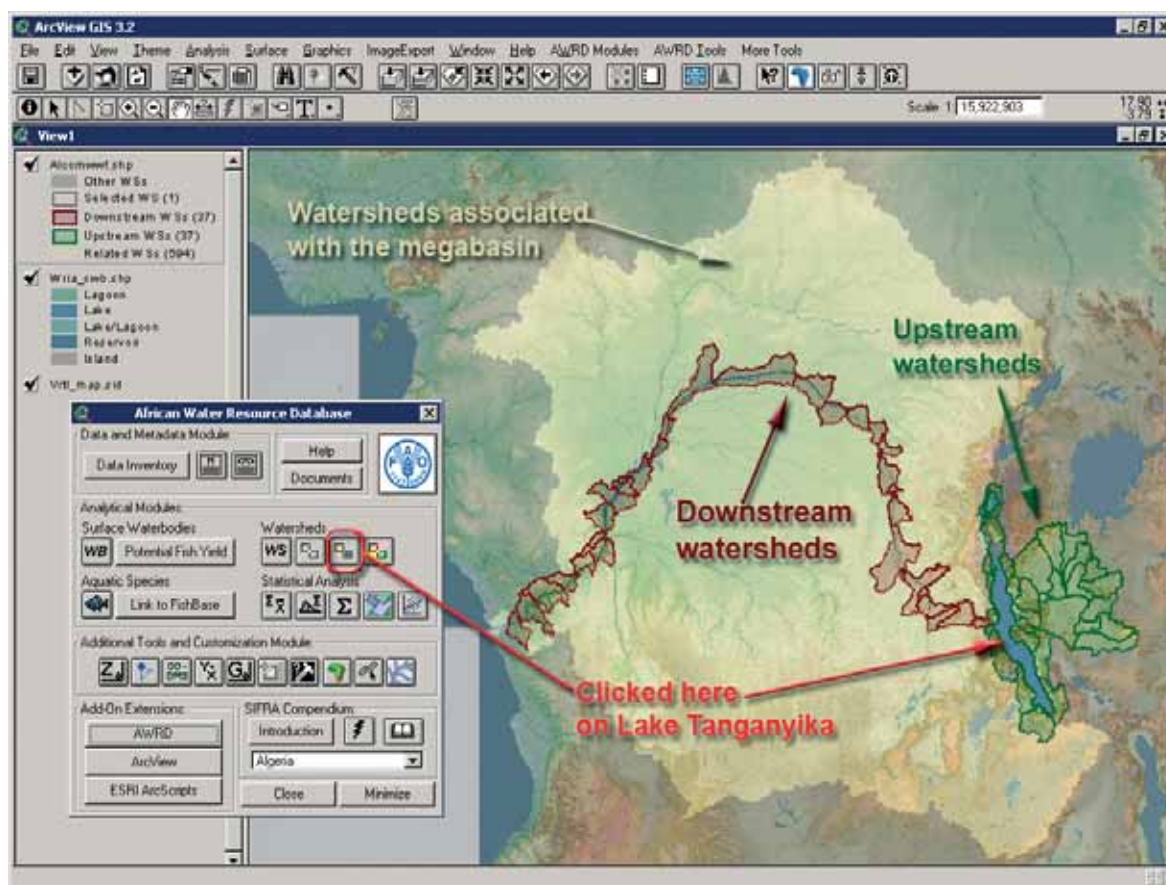
The identification of “upstream watersheds” enables the spatial delineation of factors that directly or indirectly affect fishery potential. Thus this tool can be used in conjunction with models to predict fishery potential under natural conditions for various kinds of waterbodies and in tropical and sub-tropical waters.

Identify Upstream and Downstream Watersheds

The primary tool for visualizing and exploring the hydrological network or flow regime associated with a watershed is the “Identify Upstream and Downstream Watersheds” tool.  This tool allows users to identify all upstream, downstream and megabasin watersheds and shade them in such a way that they are easy to identify; the resulting legend applied to the theme contains counts of how many watersheds are upstream, downstream, associated, etc.

This tool works on the currently selected watershed model, and therefore is only enabled if this watershed model is present in the active view. Once the tool is open, any mouse click directed to the active view will result in the “preferred” WS model registered with the Watersheds Module by the user, being classified and displayed in a manner similar to Figure 2.10.

FIGURE 2.10
Visualization of the flow regime associated with Lake Tanganyika



As can be seen from the above figure, the “Identify Upstream and Downstream Watersheds” tool can be used to effectively classify on-the-fly any flow regime associated with an individual watershed or river basin. The tool produces a clear visual map of all the watersheds that are hydrologically related to any particular watershed based on classifying: those watersheds upstream; those downstream; those associated with the flow regime as part of the megabasin and lastly, those watersheds which are unassociated with the flow regime and outside of the megabasin.

This tool also automatically opens the Watersheds Visualization tools dialog, offering users twenty unique tool functions for zooming, panning, roaming and flashing the different aspects of a hydrological network as defined by the “Identify

Upstream and Downstream Watersheds” tool, modifying how those watersheds are displayed, and potentially exporting the results of any flow regime analysis to a new theme. The function of each of these tools are described in detailed part 2 of this publication.

Benefits and applications

This tool can be of great value for assessing pollution from runoff of “upstream” watersheds into aquaculture ponds or residuals from aquaculture ponds into “downstream” watersheds.

Analysis of invasive and introduced aquatic species is another area where this tool has great value because such introductions can have impacts both upstream and downstream within a hydrological system.

Select by Relationship with Another Theme


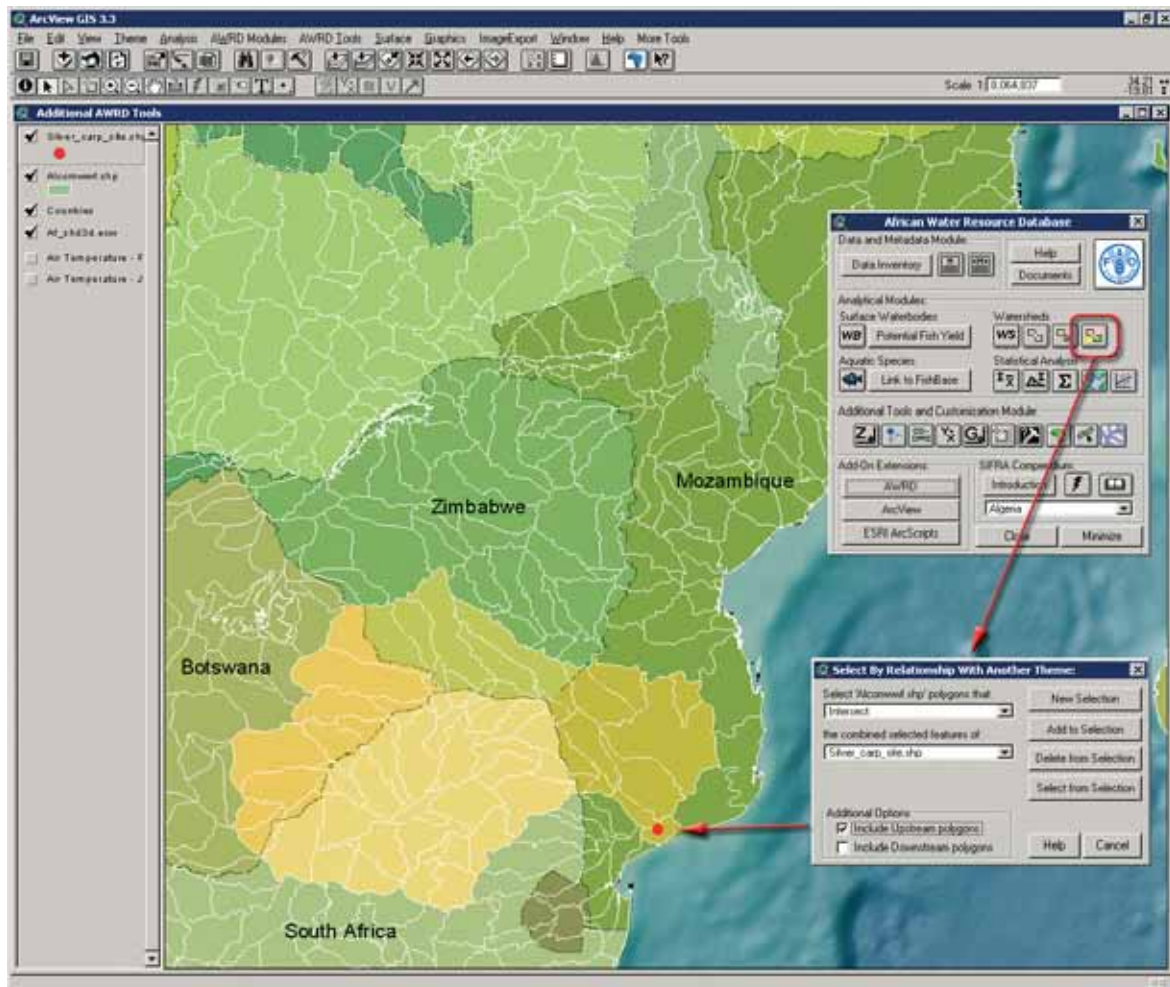
The “Select by Relationship with Another Theme” tool facilitates complex and possibly iterative selection(s) of watersheds based on where they lie in relation to the selected features of other theme(s). This tool is opened by clicking on the  button available directly on the AWRD Interface. In the example below (Figure 2.11), Silver carp are now in Limpopo drainage and the area in yellow (lower left) shows potential Distribution through 4 countries.

FIGURE 2.11

Distribution of Silver carp through four countries



Benefits and applications

This tool can assist in addressing transboundary issues, for example to help assess the risks and benefits from the use of alien species (i.e. introduced or exotic species) in fisheries and aquaculture.

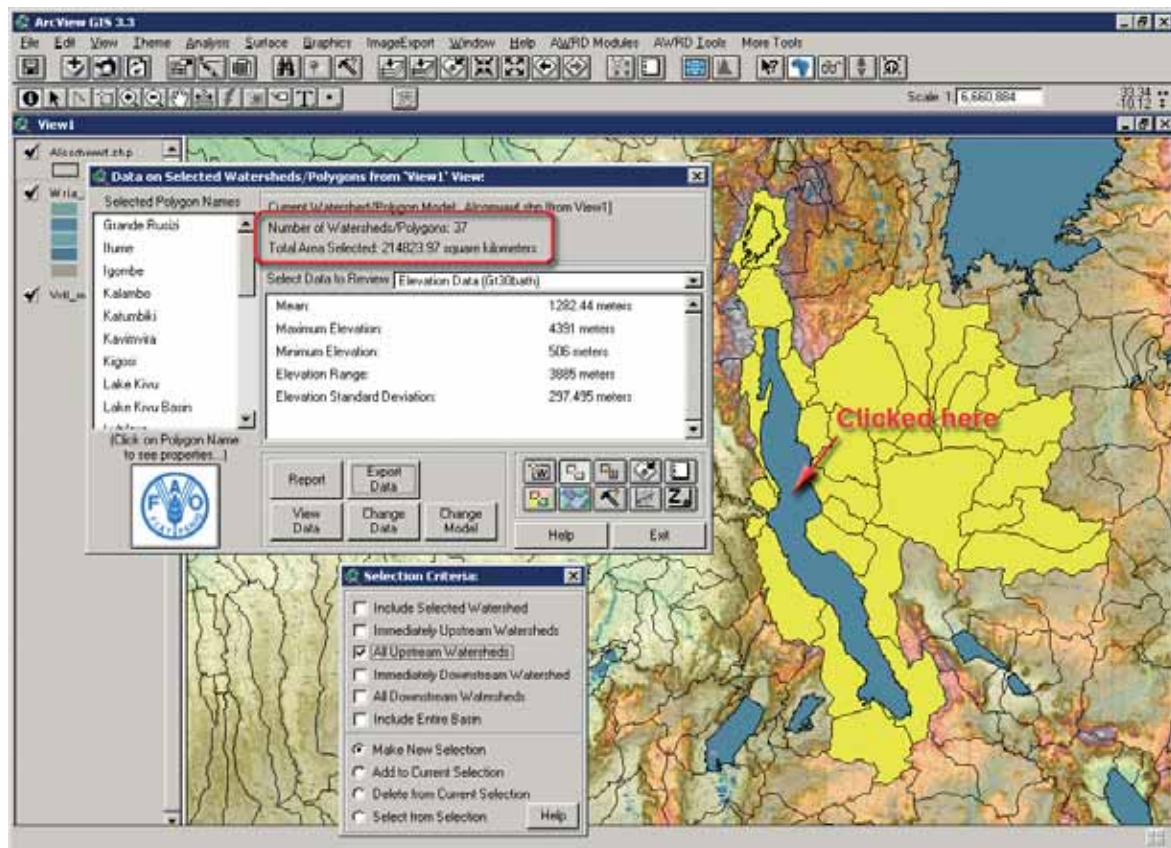
It is anticipated that the AWRD will provide an effective baseline for visualizing, measuring and reporting the parameters underlying the trans-boundary issues involved in the shared utilization of water resources and river basin planning.

Watershed Statistics Viewer

The Watershed Statistics Viewer offers users a wide variety of statistics based on the current set of selected watersheds. As was illustrated in Figure 2.10, a user could use the “Select Upstream and Downstream Watersheds” tool to select all the watersheds which drain into Lake Tanganyika. Given this or any other selection set, the user could now use the tools on the Watershed Statistics Viewer to generate sets of statistics across the entire selected area based on several possible datasets.

The Watershed Statistics Viewer can be opened by clicking on the **WS** button. Figure 2.12 highlights just such an example, where the cumulative elevation statistics for the thirty-seven watersheds in the Lake Tanganyika drainage basin results are presented.

FIGURE 2.12
Cumulative elevation statistics for upstream watersheds in Lake Tanganyika




Benefits and applications

In addition to the elevation data layer, the AWRD includes a number of useful data layers such as: population densities, mean air temperatures, precipitation and potential evapo-transpiration. By choosing another dataset listed under the “Select Data to Review” pull-down menu, users can customize this module to generate summary statistics for any or all of these data, or any other additional raster datasets a user “registers” within the Watersheds Module. Summary statistics can be generated for any “registered” polygonal data layer, and users are not limited to examining WS models alone with this module. They can, for example, generate summary statistics within administrative boundaries, and the watershed module includes an administrative boundary layer as one of the preregistered watershed models for exactly this purpose.

Aquatic Species Module

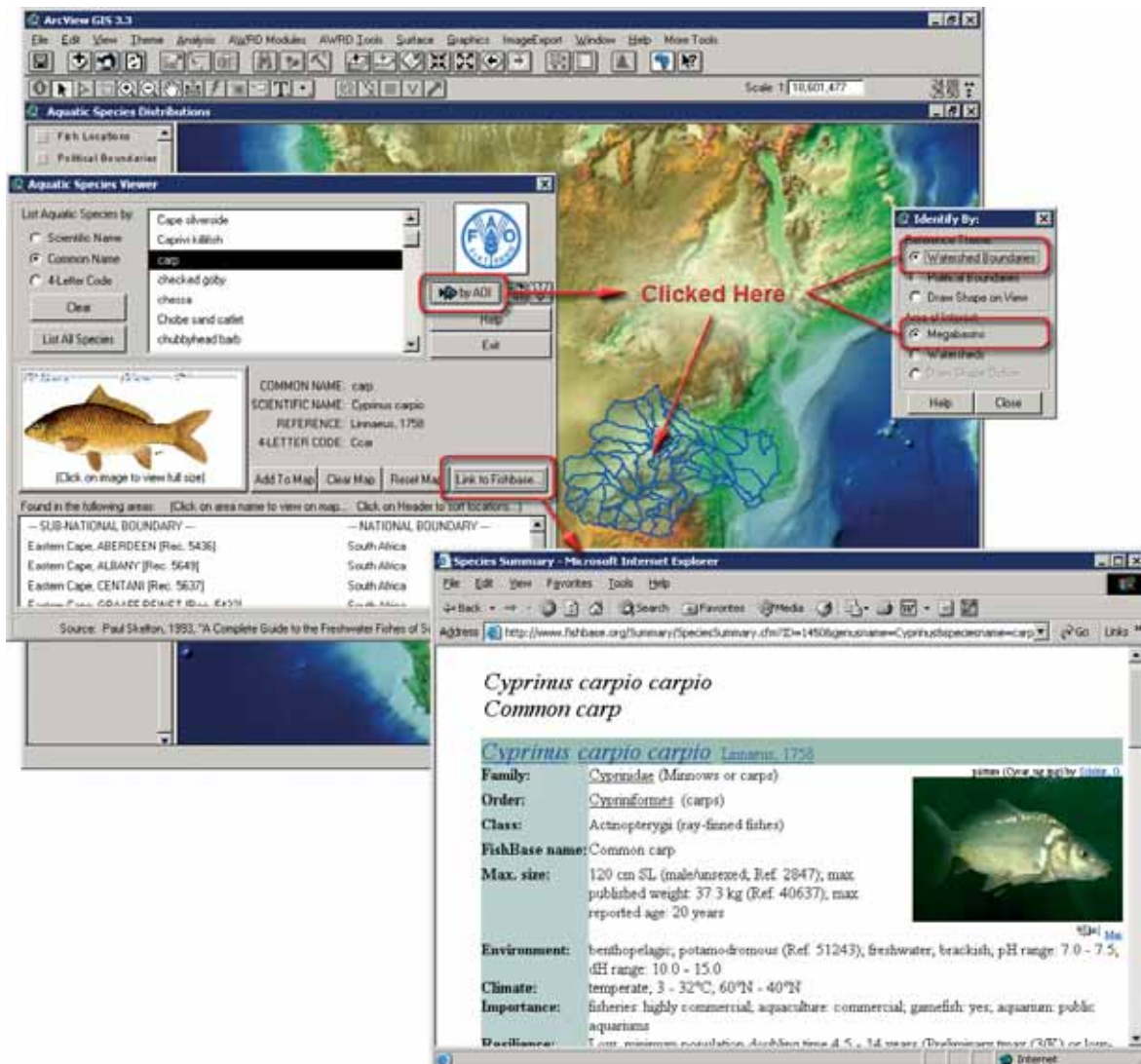
The Aquatic Species Module provides users with the ability to spatially represent and visualize the distributions of aquatic species, identify all species within a particular area, and to potentially access a large amount of descriptive information on those species via the “FishBase” Internet database. “FishBase” is a relational database with information to cater to different professionals such as research scientists, fisheries managers, zoologists and many more. FishBase on the web contains in-depth discussions and data on practically all fish species known to science.

The Aquatic Species Module interface is opened by clicking on the  button on the AWRD interface. Although the user can modify the base view associated with this module, the module defaults to providing the user with four themes. These themes include: the reference locations from the Aquatic Species database, a watershed model for mapping species distributions, an administrative data layer for creating thematic representations of the extents of species coverage, and a shaded relief graphic image of Africa.

Analysis of aquatic species distributions

Some of the key functions available through this module include the ability to: spatially represent and visualize the distributions of aquatic species; identify and review species endemic to a specific sub-national or national area, potentially access a large amount of descriptive information on those species via the Internet; and lastly, to select a particular area on the map and generate a species distribution map based on a linkage to a watershed model or administrative units. In the example illustrated in Figure 2.13, the user has chosen to list the > 700 species in the database by their common name, and has selected the “Carp” species for analysis. In addition, the user has chosen to add a map of this species’ distribution onto their view. Since an image of this species is available through the interface, a graphic of the species is also displayed. A list of sub-national and national regions in which this species has been observed displayed at the bottom of the module, and the user can sort this list by either sub-national or national attributes. Thematically, this module provides users with species locations from the reference database and produces either potential distribution maps based on a watershed model or broader containment maps from an administrative data layer. Finally, the user connected to FishBase and accessed a large body of additional data on the carp.

FIGURE 2.13
Summary of functions available from the Aquatic Species Module



Benefits and applications

The AWRD can support the analysis of species distributions using either watersheds, administrative boundaries, and environmental criteria. It is also possible to analyze distributions based on structural features and environmental conditions which may impede the movement of certain species.


A more detailed example illustrating some of the many potential uses of this tool is presented in section 2.4 where a case study on "Invasive and introduced Aquatic Species" is described using this tool.

Another potential application of this tool could be to assess the fish species potentially present within a certain catchment, and therefore those which can be recommended for the sustainable stocking of dams and rivers.

Statistical Analysis Module

With the exception of the WS Module, the Statistical Analysis Module represents the most concentrated programming effort instituted within the AWRD, and in combination with the suite of tools provided for finding locations, provides a wholly new analytical component that was not available in the original SADC-WRD.

Field Summary Statistics tool

The Field Summary Statistics tool provides users of the AWRD with the ability to calculate a much broader range of summary statistical data, with a higher level of precision than the standard summary statistics provided with ArcView. The tool is available in the AWRD Interface, on button bar of any table and from a variety of the tools throughout the AWRD by clicking on the  button.

For example, the surface waterbodies database of the Southern African Development Community (SADC) contains more than 18 000 waterbodies with attribute fields including geographical, administrative, meteorological, socio-economic, physical and chemical data as well as data on the use of the waterbody, presence of plant and animal species and fishing activity. Although the database focuses on fish and fisheries, it has a very general scope and there are multiple applications in other disciplines: health (control of waterborne diseases), environmental issues (species distribution), development (water distribution), irrigation, etc. Figure 2.14 illustrates how this tool can use this SADC dataset to easily generate a wide variety of descriptive statistics on surface waterbodies.

Benefits and applications

Summary statistics are an essential part of any basic data analysis. The standard ArcView summary statistics do very well at reporting the minimum, maximum, mean, sum and standard deviation of a dataset. The AWRD summary statistics enhance this basic functionality by providing information on the shape of the distribution (skewness and kurtosis), the variation in the data (variance, average deviation and quartiles), and additional information on the dataset central tendencies (median, mode and standard error of the mean).

Probability Distribution Calculators

The AWRD includes two versions of a Probability Distribution Calculator. The first of these calculators, the “Probability Distribution Calculator” is designed to work from a view, while the second, the “Table Probability Distribution Calculator” is designed to be run from a feature attribute table or data table.

Both of these calculators are powerful and valuable tools for statistical analysis. The basic purpose of many statistical analyses is to determine whether some observed event is reasonable given some basic assumptions, or whether the odds against such an event are so great as to imply that the basic assumptions are wrong. These calculators provide a way to calculate the odds of an event happening based on those basic assumptions.


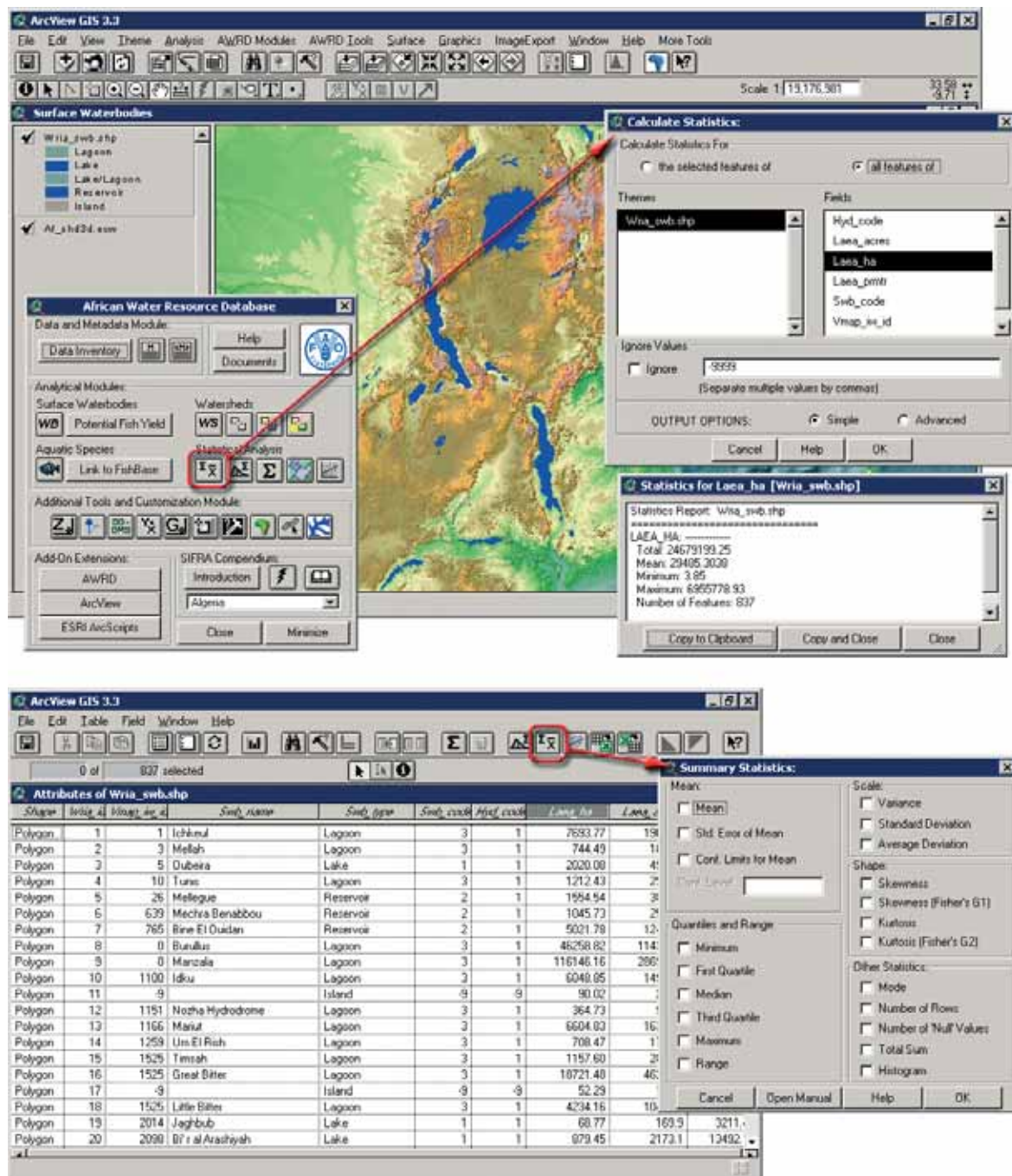
These tools are available on the Table button bar and in the AWRD Interface, by clicking on the  button. The tool works on the selected set of data, if such a set has been defined. A representation of the tool using the SADC surface waterbodies database can be found in Figure 2.15.

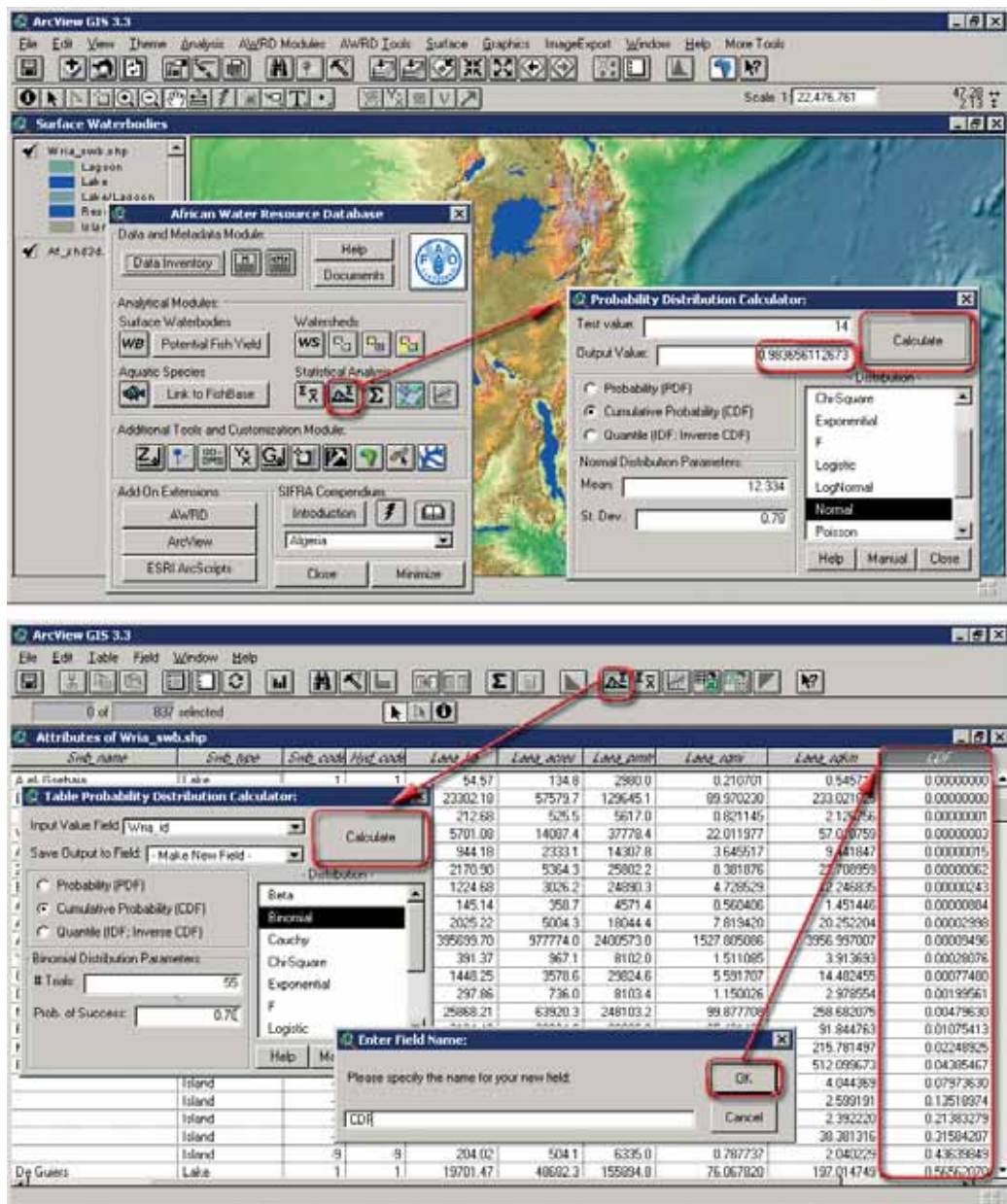
FIGURE 2.14
 Summary statistics calculator accessed from View (on the top) and from Table mode (on the bottom)



The Distribution functions included with either the view based calculator or the tabular calculator may be grouped into three categories.

In general, the *Probability Density Functions* return the probability that the Test Value = X given that particular distribution.

FIGURE 2.15
Probability distribution calculators accessed from
View (on the top) and from Table mode (on the bottom)



The *Cumulative Distribution Functions* return the probability that the Test Value $\leq X$, given that particular distribution.

The *Quantile Functions* (sometimes referred to as *Inverse Density Functions* or *Percent Point Functions*) return the Value X at which $P(X) = [\text{specified probability}]$, given that particular distribution.

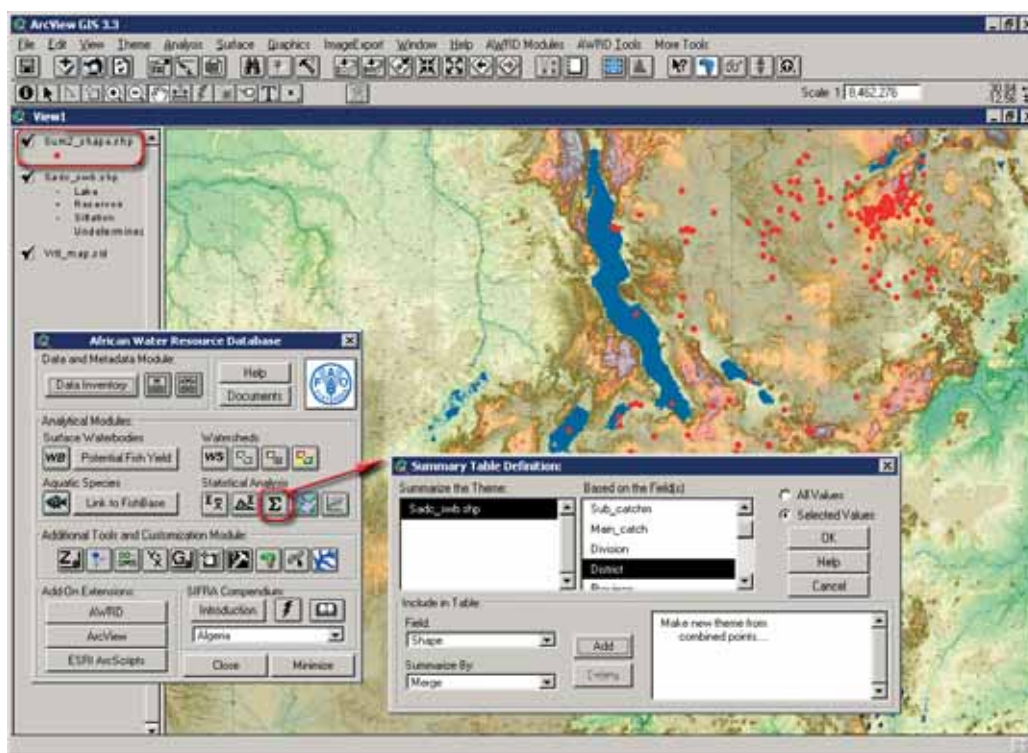
Benefits and applications

Very few software packages include tools to calculate statistical probabilities, and yet statistical probabilities form the basis of most sophisticated analysis. Typically users must purchase expensive statistical software to gain access to these functions and even then these expensive packages are rarely capable of integrating into a GIS system. These AWRD tools therefore provide powerful and critical functionality that is unobtainable for most GIS users.

Summarize Theme tool

The Summarize Theme tool allows users to divide up a dataset into smaller datasets based on some attribute value and then to calculate statistics for each group. For example, if we had a theme of several aquatic species locations, and if this theme included the country name of each location, then we could use the Summarize Theme tool to count how many unique species were observed in each country. Another scenario might involve a rivers theme, where we could calculate the total length of rivers within a region. This tool can be accessed by clicking the Σ button in the AWRD Interface. A representation of this tool using the SADC surface waterbodies is illustrated in Figure 2.16.

FIGURE 2.16
Summarize Theme tool



Benefits and applications

This tool can assist in reporting on individual waterbodies. For example, a user could use this tool to calculate the total waterbody area in a region, or the number of waterbodies of various types in a region. Effectively, it can provide a method and means to provide robust aggregate fisheries reporting while maintaining the disaggregate level data.

Classification and ranking tool

The Classification and Ranking tool provides users with the means to classify watersheds, or any vector theme, according to a wide variety of simple and complex functions. With these tools, users can rank features based on either single or multiple criteria, as well as identify features that do not meet any selection criteria at all. In addition, users can save specific sets of criteria so that a particular classification scheme can be replicated, modified and various scenarios matching different criteria tested.

This tool is intended to enable users of the AWRD to build up various selection sets based on a several criteria. For this reason, a certain amount of testing is implicit to the use of the tool. With the simple version of this tool, users can only choose to set a minimum and maximum range for the field(s) specified for testing, while with the advanced version, users can construct more sophisticated criteria sets which may then be used to rank different features. The advanced version offers greater power in terms of building cumulative scores, and the criteria can include attribute fields containing words, names or alphanumeric codes, as well as including weighting values, critical knock-out constraints and exclusion logic.


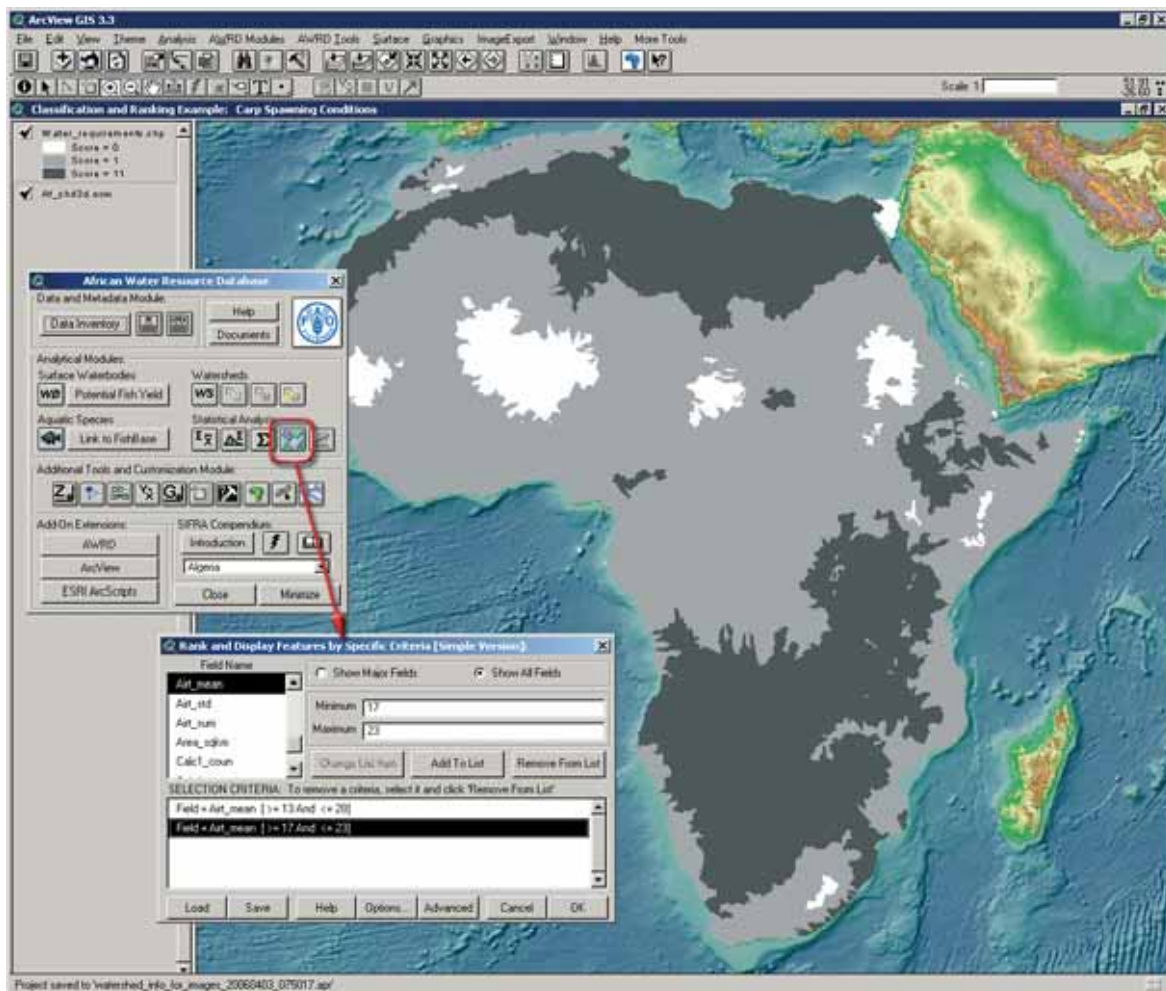
The Classification and Ranking tool is available by clicking on the  button in the AWRD Interface. Figure 2.17 highlights the application of the simple version of the Classification and Ranking tool. In this example, watersheds were classified according to the spawning temperatures for common carp. Two spawning temperatures were used for interest and for contrast. The two classes were (1) $13 \leq t \leq 28$ representing the lowest and highest temperatures found for reproduction to take place in the wild, and (2) $17 \leq t \leq 23$ representing the lowest and highest temperatures in the range of optimal temperatures for reproduction in the wild found in the literature.

FIGURE 2.17
Application of the simple classification and ranking tool to indicate spawning temperatures for common carp on a watershed-by-watershed basis



To illustrate the Advanced Classification and Ranking tool, we classified the landscape according to how suitable a watershed might be for pond construction, based on annual precipitation, potential evapotranspiration and an adjustment factor for ground seepage. An overall water requirement index was calculated as:

$$\text{Water requirement} = (\text{Precip. [mm]} \times 1.1) - (\text{Pot. Evap [mm]} \times 1.3) - \text{Seepage ([80 mm/mo])}$$

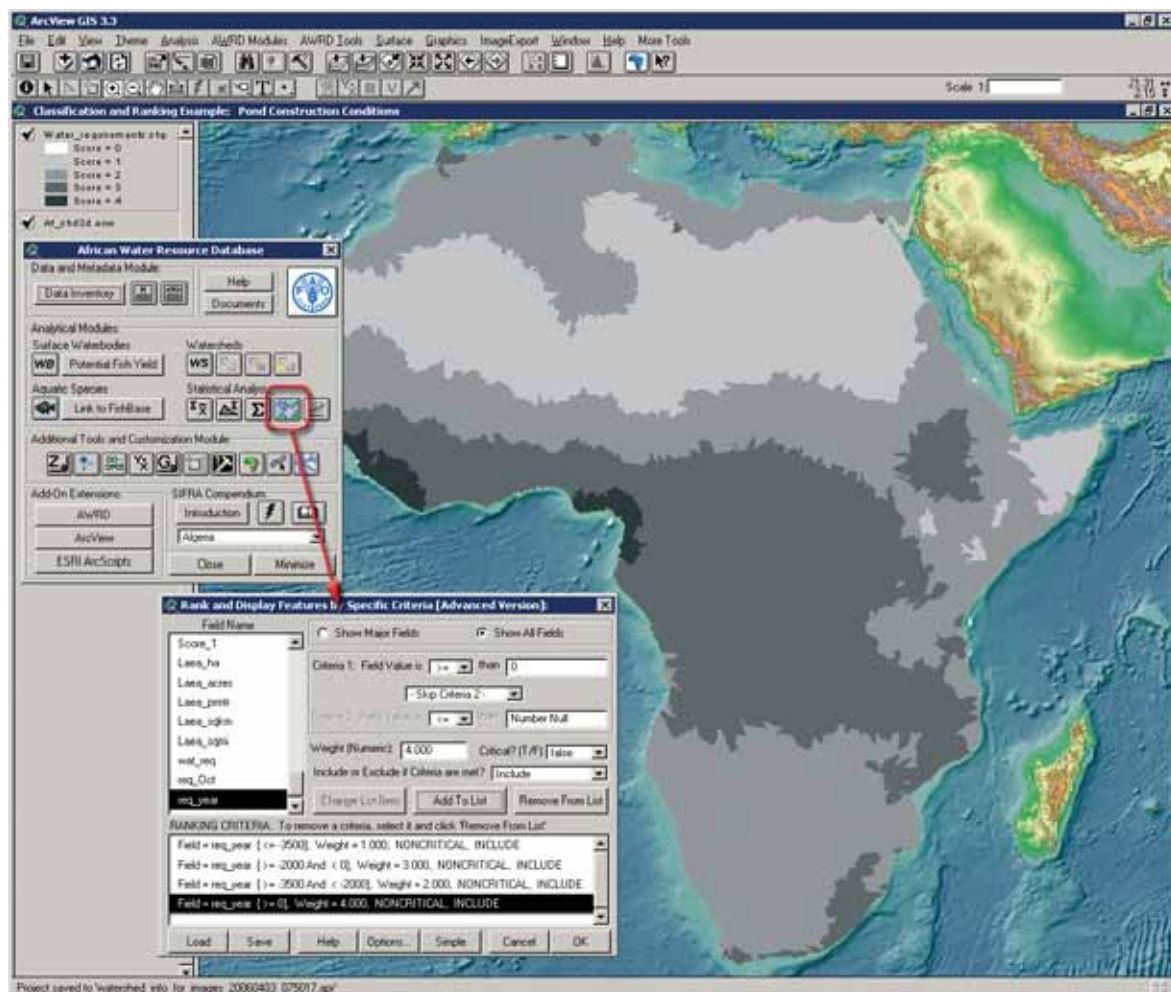
Based on criteria developed by FAO in *A Strategic Reassessment of Fish Farming Potential in Africa* (Aguilar-Manjarrez and Nath, 1998) we classified the landscape into 4 categories, where “4” was Very Suitable and “1” was Very Unsuitable. These categories are defined in Table 2.15 and illustrated in Figure 2.18.

TABLE 2.15
Water requirement submodel

Category value	Water requirement	Interpretation
1	< -3 500 mm	Unsuitable – Many problems
2	-3 500 to -2 000 mm	Very likely to encounter water availability problems.
3	-2 000 to 0 mm	Moderately suitable for ponds
4	> 0 mm	Very suitable as a water source for ponds.

Source: Adapted from Aguilar-Manjarrez and Nath (1998)


FIGURE 2.18
Application of the advanced classification and ranking tool to determine suitability of ponds for fish farming based on water availability



Benefits and applications

This classification and ranking tool can potentially be used to create an Index of Watershed Indicators (IWI) to characterize the condition and vulnerability of aquatic systems in each of the watersheds in Africa. The tool could also be used to help develop habitat suitability models, by identifying areas that meet sets of habitat criteria.

Simple Linear Regression tool

The Simple Linear Regression tool is opened by clicking on the  button on the AWRD Interface. This tool allows users to conduct simple linear regression analyses between two numeric fields in a table, and examine the values in these fields for any correlation. Similar to the other statistical tools available through the AWRD, the regression tool will either analyse all of the records in a table or only those records that lie within the currently selected set.

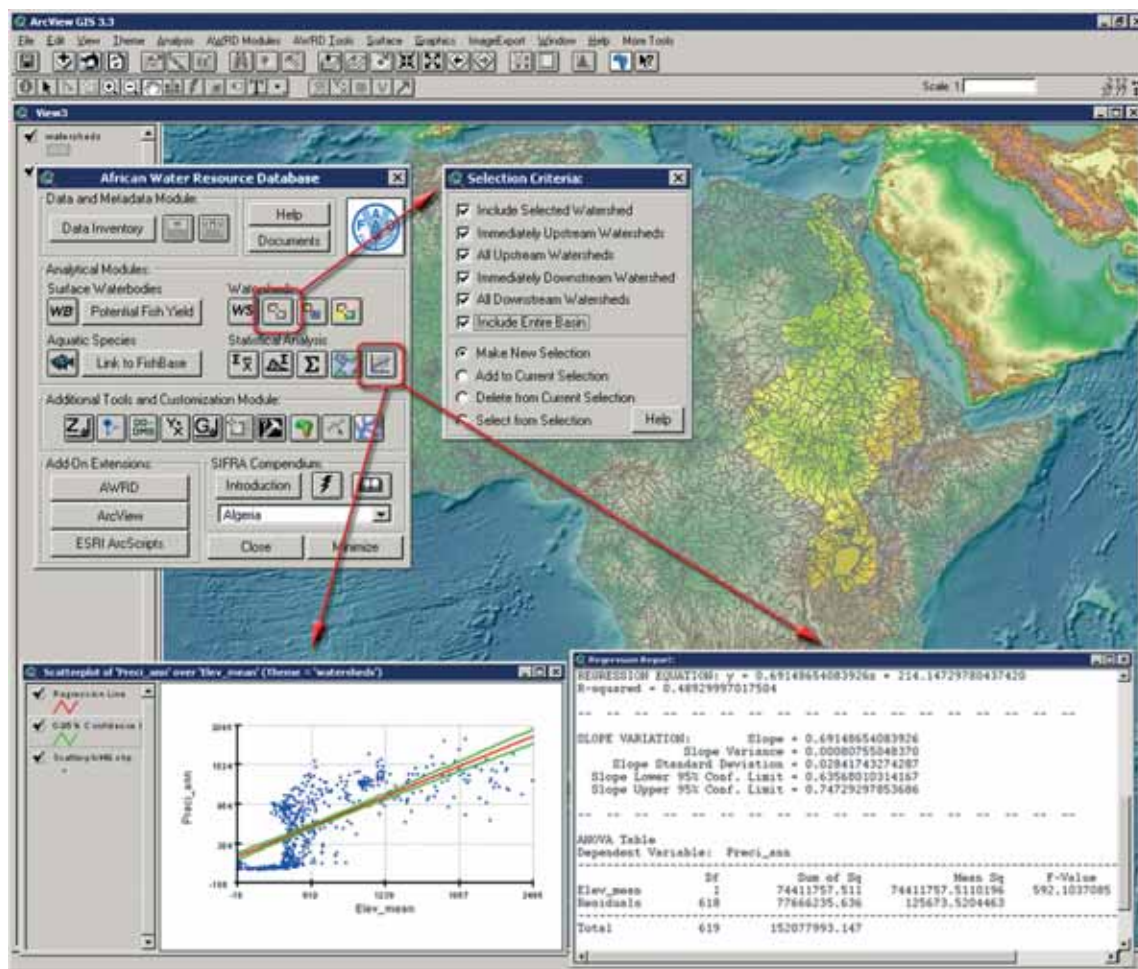
The Simple Linear Regression tool provides users with a robust method for analysing relationships between data. The tool can be used, for example, to tell a user whether fish stocks tend to rise or fall as nutrient levels in a particular surface waterbody rise and fall, and to provide the user with a probability that any relationship established is due solely to chance.

The results of the analysis do not, however, demonstrate any causative relationship, and because of this, a user could not for example, use the tool with any certainty to say that: an *X* rise in nutrient levels would cause fish stocks to increase to level *Y*, even if a strong correlation was established. Furthermore, regression analysis makes certain assumptions about the data, such as independence of samples and constant variance over the range of the sample data, which may be violated in some cases. When these assumptions are violated, the conclusions we draw from the analysis become weaker.

This said, linear regression is still one of the oldest and most commonly used statistical procedures available. This tool provides a wide range of statistical output options associated with the regression, as well as general descriptive statistics on the dependent and independent variables. A report is also automatically generated by the tool and is saved to the user's hard-drive and then opened in a text window for the user to review. Optionally, a user may also chose to generate a scatter-plot illustrating the regression relationship, and if the user elects to generate confidence bands, predicted values, residuals or standardized residuals, then the tool will also produce a new theme in the active view for review.

The optional list of summary statistics produced via the tool conform to those outlined in the "Field Summary Statistics" tool (Figure 2.14), and like that tool, the Simple Linear Regression tool can also restrict the analysis to a subset of features by selecting those features prior to analysis. Figure 2.19 highlights the use of the Simple Linear Regression tool in conjunction with the "Select Upstream and Downstream Watersheds" tool from the Watersheds Module, and is demonstrative of the tight integration between all the modules and tools of the AWRD. In this example, the Nile megabasin becomes the focus of the user's regression analysis, the result of which depicts a reasonably strong relationship between annual precipitation and elevation, with a *P-Value* of < 0.0000001 and an R^2 -value of 0.49, suggesting that the variation in elevation accounts for approximately 49 percent of the variation in precipitation within the Nile megabasin.

FIGURE 2.19
Regression analysis of rainfall and elevation for the Nile River megabasin



Benefits and applications

Linear regression is one of the most widely used and easily understandable statistical techniques available for identifying a linear relationship between variables. It is simple to say that one variable rises or falls as another variable rises or falls, but it is much more useful to be able to say exactly how much the variable changes, and to give a precise estimate of the uncertainty of the relationship. Linear regression gives users the ability to describe relationships in a useful and powerful way.

Additional Tools and Customization Module

Because of the range of tasks performed by the AWRD additional tools, there is no interface or concise dialog associated with these tools. In fact, although the development of a single viewer consolidating these would be a relatively straightforward programming task, it was determined that greater utility could be provided to users of the AWRD if these tools were distributed throughout the interface and available at anytime by a simple click of a button.

Tools for Finding Locations

The three primary tools available to assist a user in finding a location are: the "Find Location by Theme" tool; the "Enter Coordinates and Zoom to Location"; and the "Zoom to Gazetteer Locations" tool. Each of these tools has been designed to fill a specific niche, complimenting the different analytic requirements of users.

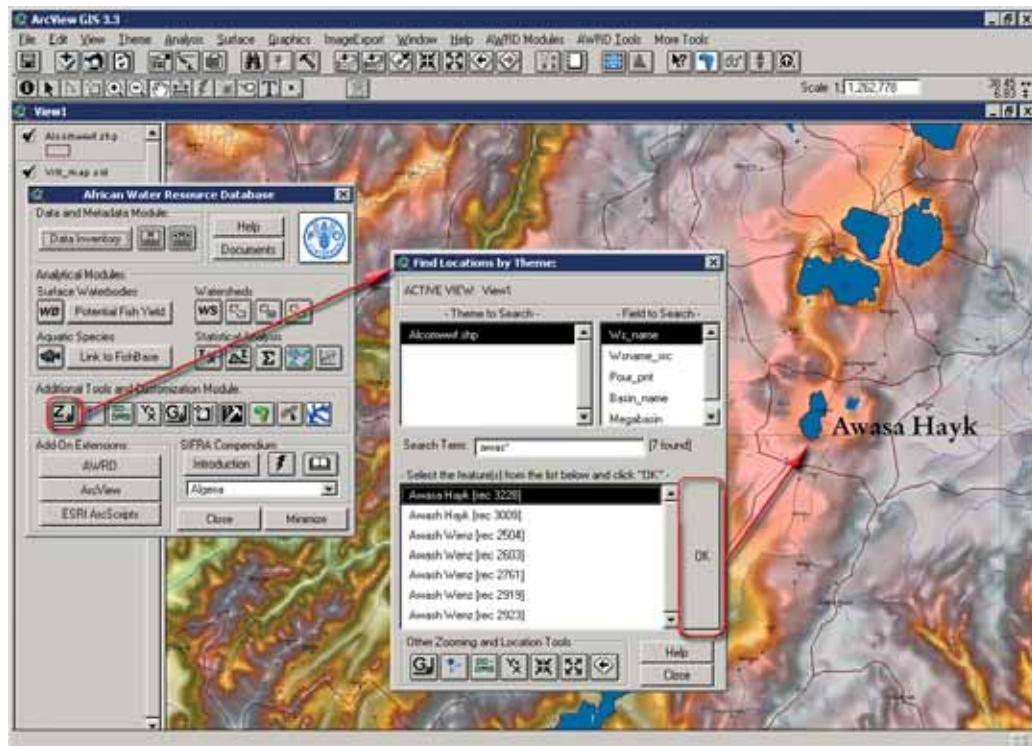
Find Location by Theme tool

The “Find Location by Theme” tool is designed to enable users to select features according to their attributes, and then zoom to the extent of those selected feature(s).

The tool is accessible through the  button in the AWRD Interface and on the Watersheds Module and Surface Waterbodies Module dialogs.

In Figure 2.20, the user was interested in locating the “Awasa Hayk” watershed within the “Alcomwwf.shp” theme layer, so they first selected the “Alcomwwf.shp” theme with the tool, and then entered the “awas” search string. Based on the results returned, the user then selected “Awasa Hayk” from the list, and by clicking the “Ok” button, was zoomed to the extent of the feature.

FIGURE 2.20
Find Location by Theme tool



Coordinates Referencing tools

In cases where a user is required to find a location based on either latitude and longitude or some other coordinate reference, the AWRD provides the user with a suite of complimentary zooming and locational reference tools. These tools provide users with the capability of zooming to any Latitude/Longitude or projected coordinate reference at a specified scale, of converting between decimal degrees, degree/decimal minutes and degree/minute/decimal seconds; and of getting coordinates by clicking on screen.

The primary tool within this suite is the “Enter Coordinates and Zoom to Location” tool. This tool is designed to allow a user to enter coordinates via a variety of formats and to then zoom to the specified coordinate reference at a scale which is also determined by the user. The tool provides the user with the option of entering coordinates as: decimal degrees, degrees/decimal minutes, degrees/minutes/decimal seconds, or in any custom projection coordinates that can be interpreted by ArcView’s projection engine.


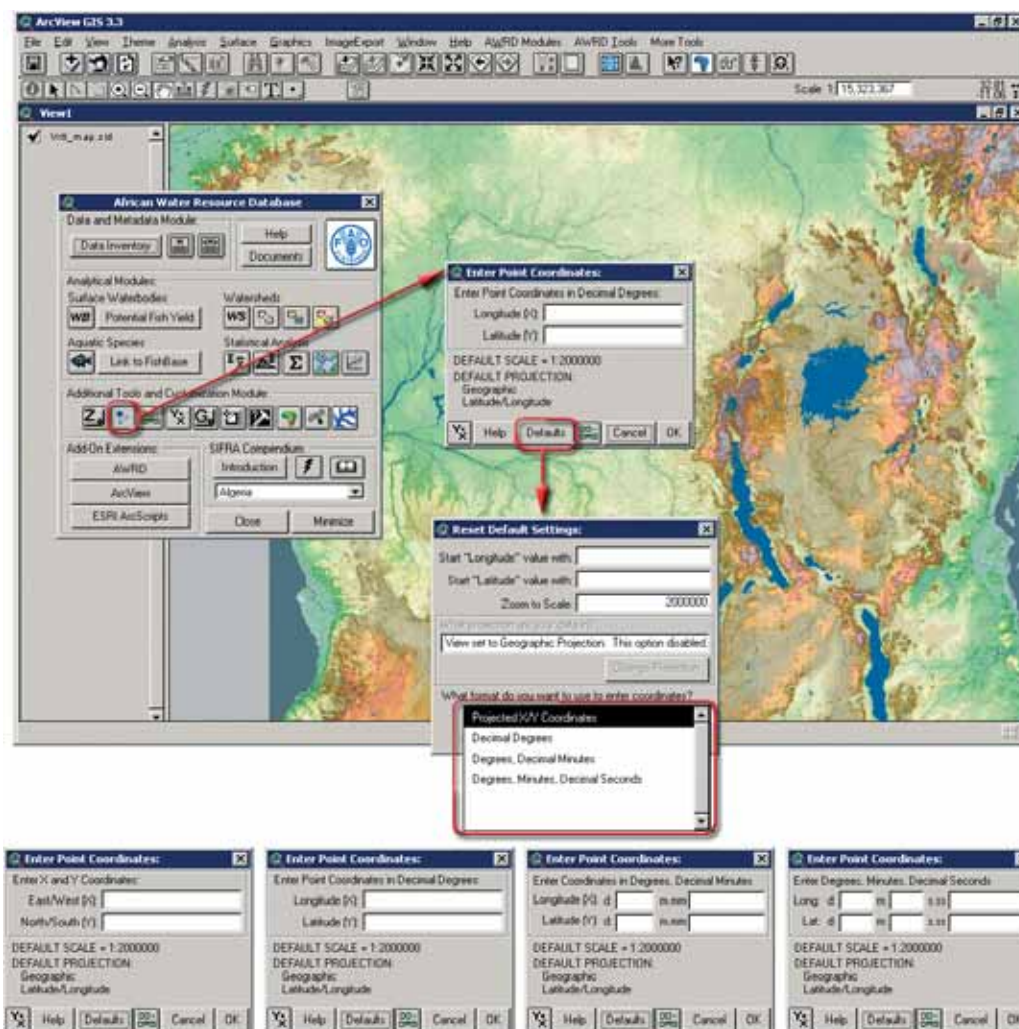
The tool can be opened by clicking on the  button on the AWRD Interface. Depending on whatever preferences the user has “registered” for this tool, one of the four dialogs displayed in Figure 2.21 will be opened when this button is clicked.

FIGURE 2.21
Enter Coordinates and Zoom to Location tool



Once the tool is opened, the user can begin entering coordinates in their “preferred” format, as shown in Figure 2.21. After a coordinate reference has been entered, the user needs only to click on the “OK” button to be zoomed to their desired location and scale specified in Figure 2.21.

Benefits and applications

This tool allows the user to quickly “switch” between these formats and/or scales by simply clicking on the “Defaults” button and opening the “Reset Default Settings” dialog to change the coordinate preference. The “Reset Default Settings” dialog is also where the user “registers” the default scale for zooming, and can be used to set up any standard or custom projection parameters on-the-fly.

Zoom to Gazetteer Locations tool

There are two Gazetteer database component layers currently residing within the AWRD archive. This tool provides users with a method for locating and zooming to a named location based on a particular feature class and subtype, given that they “know” the name or even just a part of the name reference.


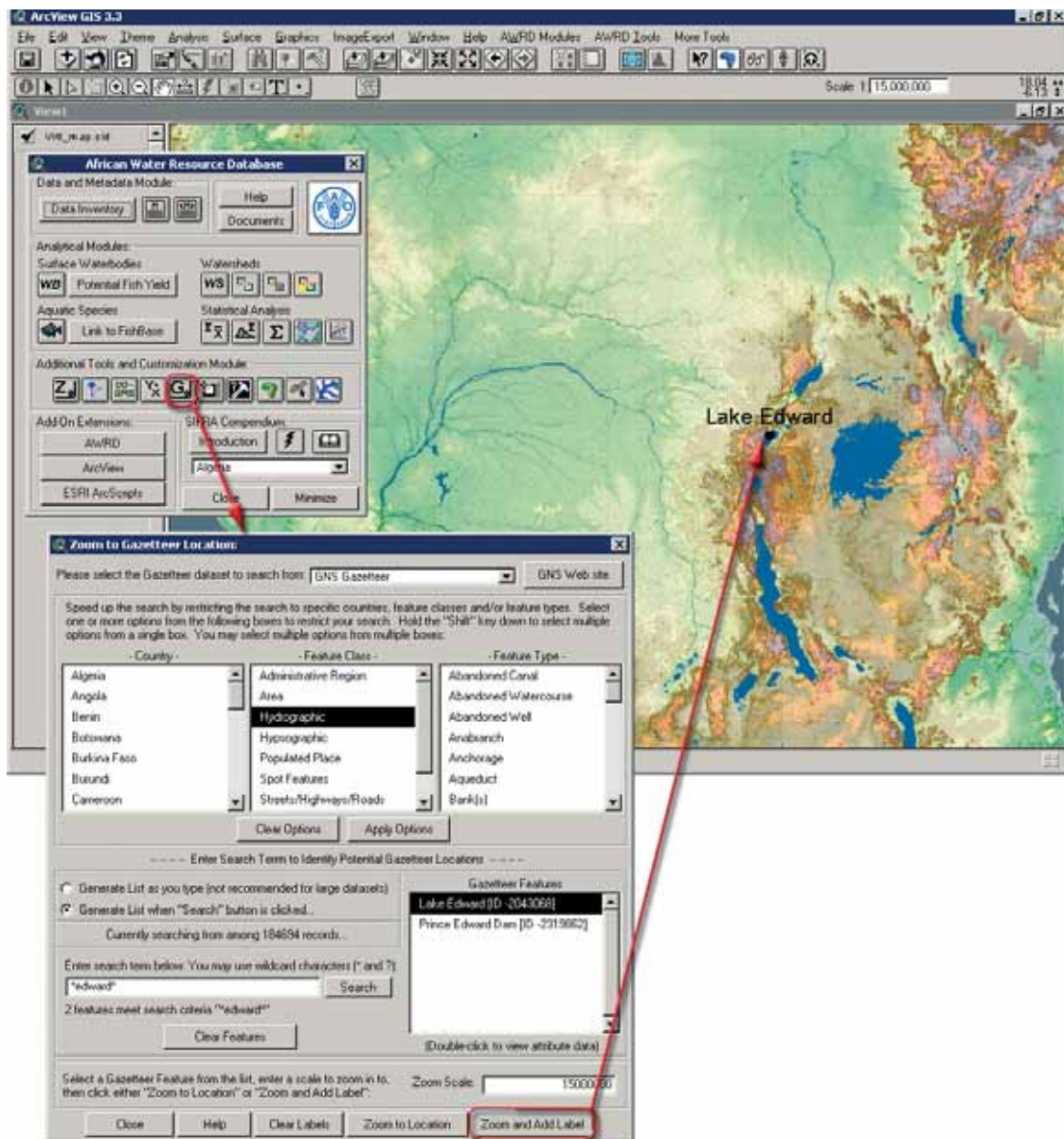
The “Zoom to Gazetteer Locations” tool is opened by clicking on the  button in the AWRD Interface. An illustrative example, using this tool to locate Lake Edward is displayed in Figure 2.22.


FIGURE 2.22
Find locations based on a gazetteer search



Benefits and applications

The “Zoom to Gazetteer Locations” tool enables users of the AWRD to effortlessly reference and spatially identify approximately 804 000 locations associated with over one million unique or alternate names.

Select by Theme tool

The Select by Theme tool  is similar to the standard ArcView “Select By Theme...” function found in the View Theme menu, but with many added functions. It allows the user to select features from one theme based on their proximity to features from another theme.


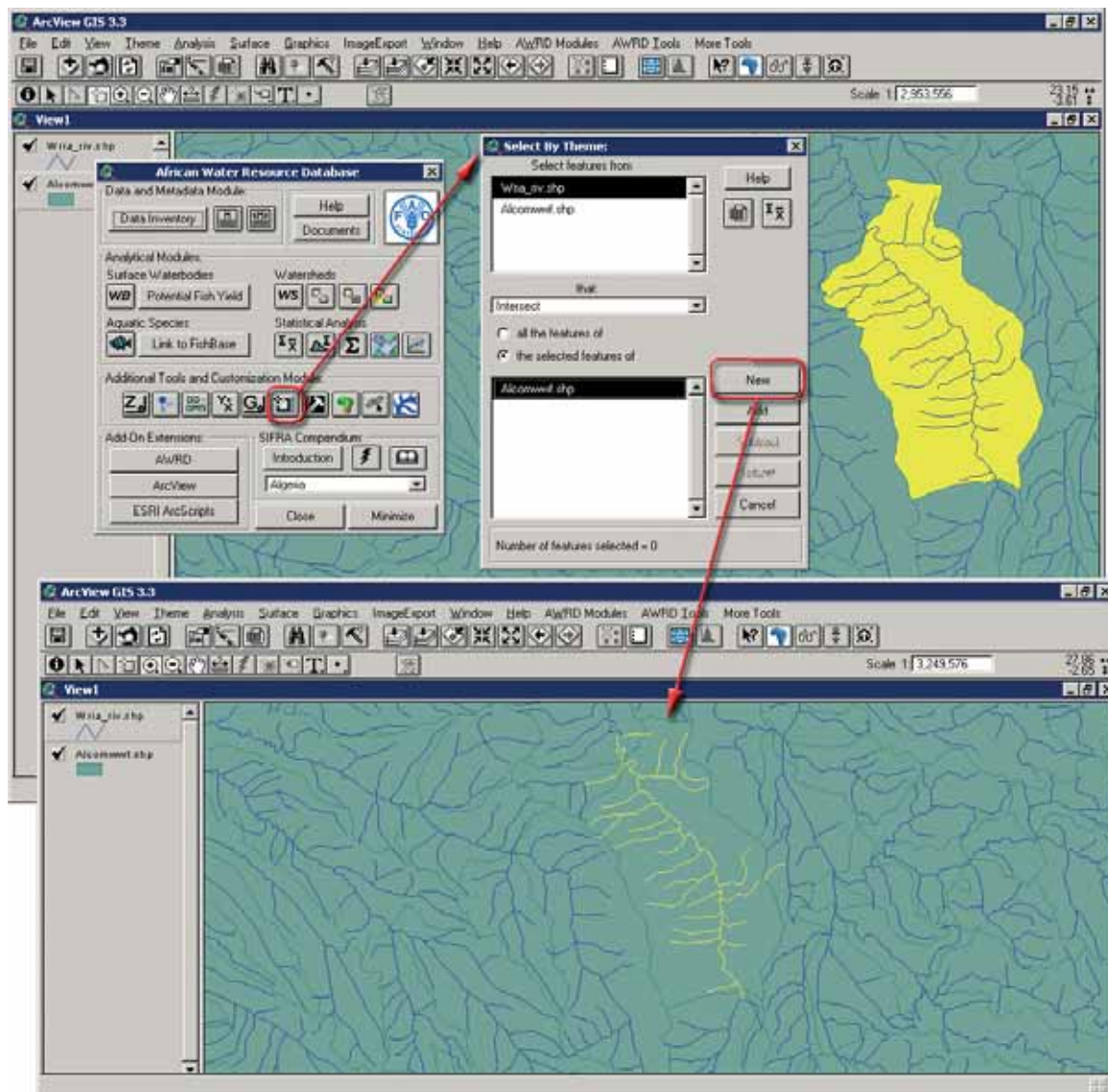
For example, if the user was interested in selecting all the rivers that intersected a particular watershed, they would begin by selecting that watershed in the view and then either clicking the  button on the AWRD Interface or selecting the menu option “Select by Theme...” in the AWRD Tools menu to open the Select by Theme tool dialog (Figure 2.23).


FIGURE 2.23
Selecting rivers that intersect a particular watershed





Benefits and applications

This tool facilitates the selection of features from other themes, which can then be used to calculate a wide variety of statistics.

Query Builder tool

The Query Builder tool is opened by clicking the  button on the AWRD Interface. This tool is similar to the standard ArcView Query Builder available in the View button bar, but with a variety of additional functions and features including the ability to apply complex queries to the data to either select features or to apply a theme definition.

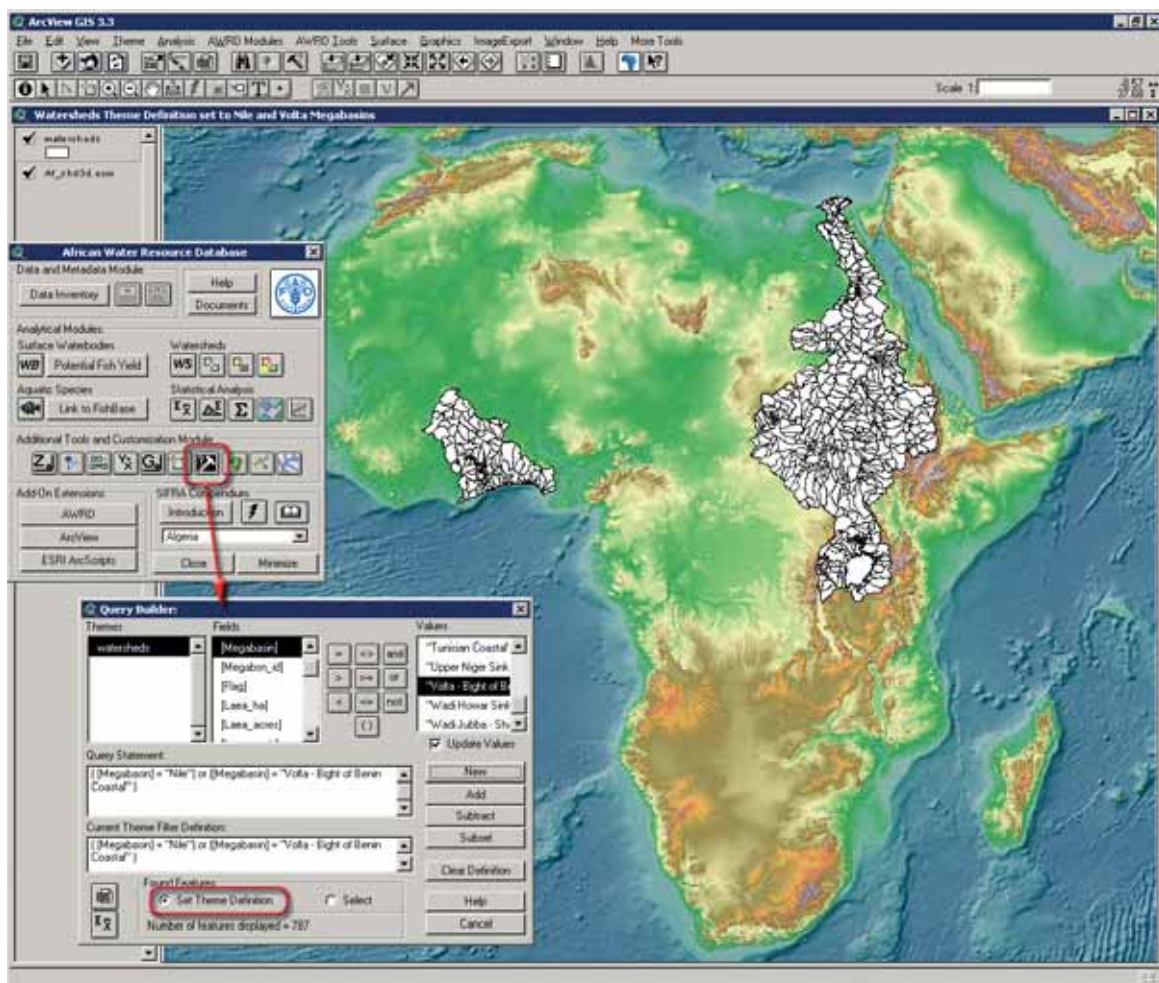
As with the “Select By Theme” tool above, the Query Builder dialog also offers two buttons that provide quick ways to view and analyse the attribute data for any of the themes in the view. The “Open Theme Table” button  will open the attribute table for the currently selected theme, and the “Field Summary Statistics” button  will open the Theme Summary Statistics dialog, from which you can calculate a wide variety of statistics on your theme.

Setting Theme Definitions

By setting a theme’s definition, you tell ArcView to show you only the features that meet that definition. This is similar in concept to selecting features for analysis, except that in this case any features that do not meet the definition are simply not shown in the view.

For example, we could set the theme definition of our Watersheds theme so that it only shows the watersheds in the Volta and Nile megabasins. If we opened the table for this theme, the table would also show only the records for these two megabasins as illustrated in Figure 2.24.

FIGURE 2.24
Setting new theme definition with the Query Builder



Benefits and applications

Using this tool, users have the ability to both visualize and analyse complex hydrological, ecological, physiographic and species specific relationships, and to restrict analysis to a subset of the original data.

Add Background Base Map Image to View

The AWRD Image database component comes with a large number of base map images of Africa at several resolutions, which provide high-quality backgrounds for both on-screen viewing and for printing maps. This tool offers a simple way to add these base map images of Africa to the view.


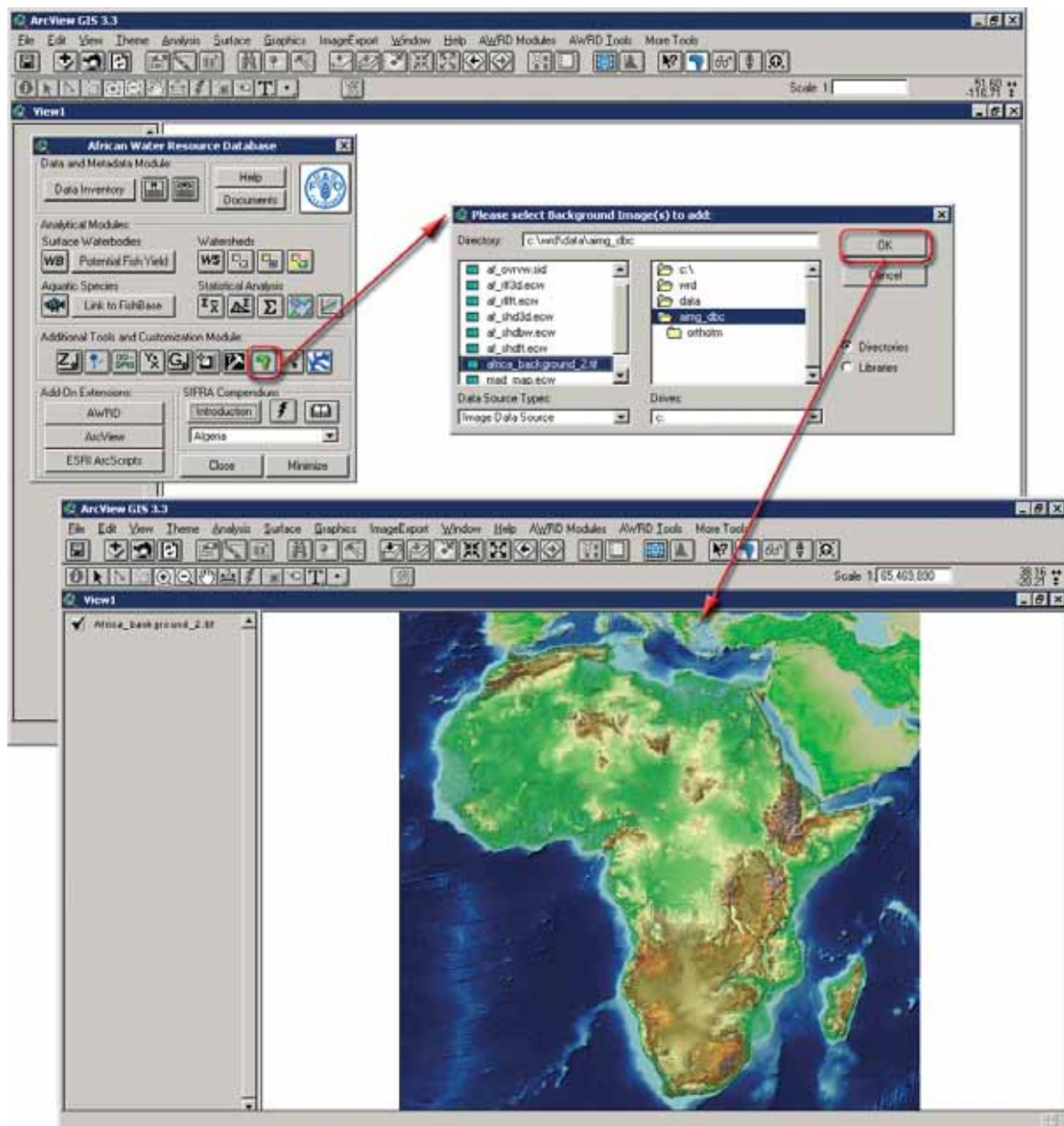
By simply clicking the  button on the AWRD Interface the user can choose the image or images to add (Figure 2.25).

FIGURE 2.25
The Add Basemap Image to View tool



Benefits and applications

These backdrop images provide a spatial reference against which the core functionality of the AWRD interface can be displayed, and provide users with a number of ways to visualise landscapes and differentiate hydrographic features.

Tools for Calculating and Reporting Descriptive Spatial Statistics


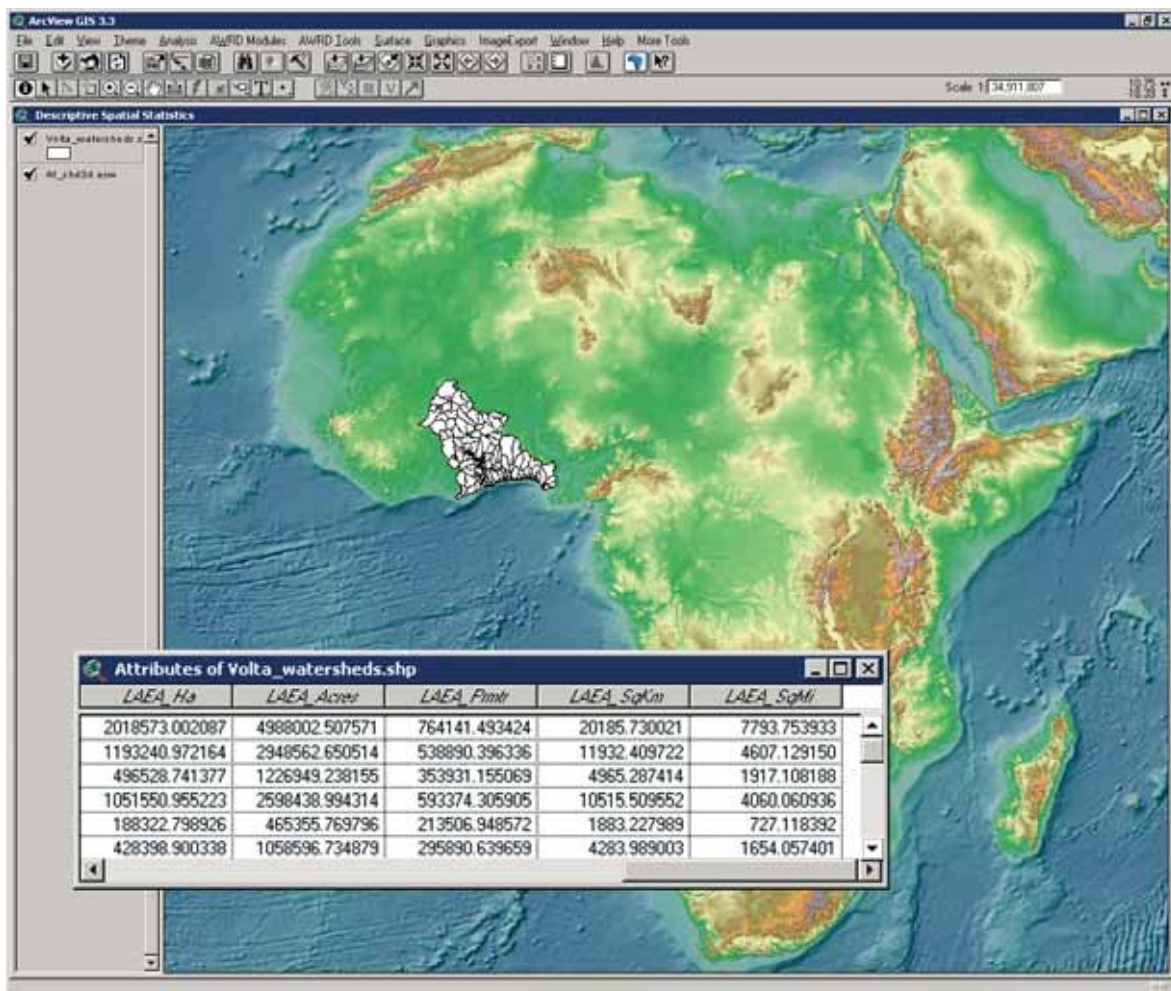
The AWRD provides two methods for calculating area and perimeter lengths for polygons, and lengths of lines. The “Report GeoStats for Lines or Polygons” tool on the AWRD Interface  allows you to click on polygons or lines and generate an immediate report, while the “Calculate/Update Geostats in Polygon Theme Tables...” menu item in the AWRD Tools menu allows you to calculate the values directly to the theme attribute table. A representation of this tool for Lake Volta can be found in Figure 2.26.


FIGURE 2.26
GeoStatistics tool



Benefits and applications

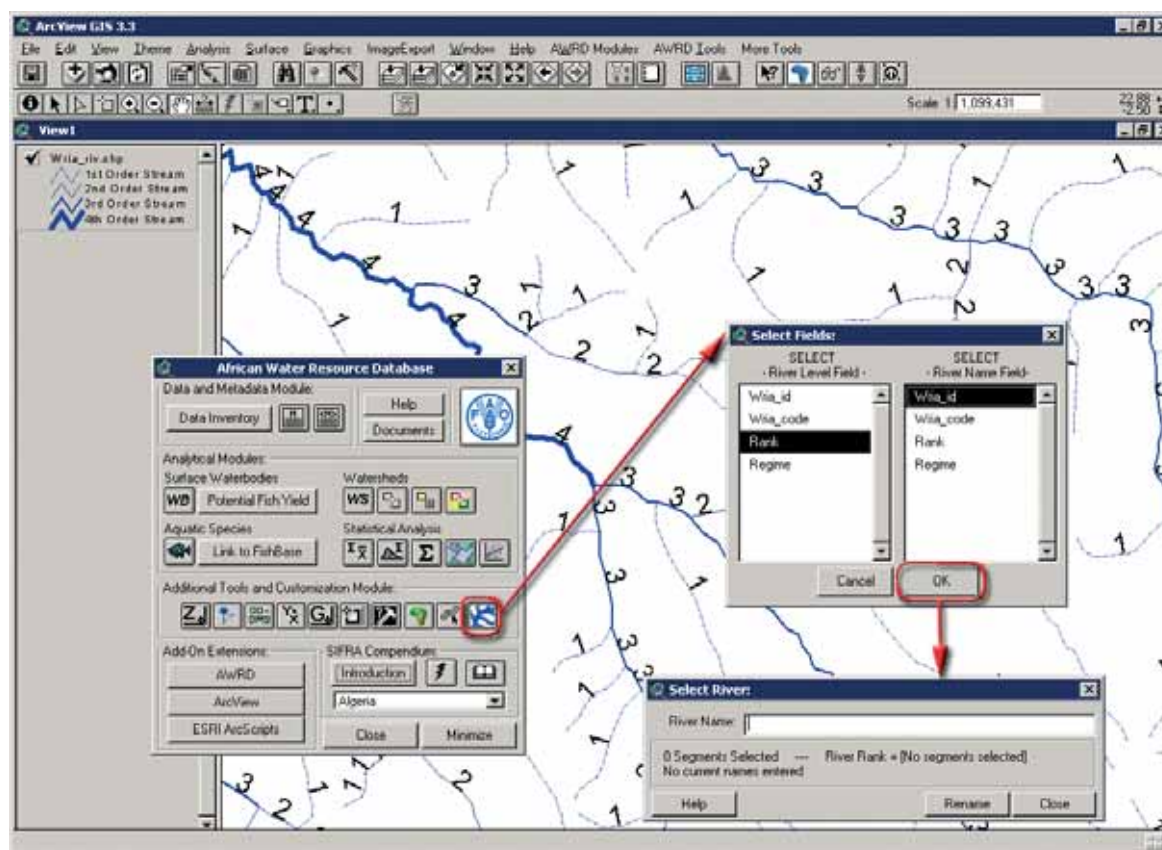
This is a useful tool to calculate areas and perimeter lengths for any polygon theme.

River Identification tool

The River Identification tool  is designed to allow the user to identify continuous sections of river which are at the same order level. This assumes that the river theme being examined has river segments ranked according to the standard river order system, such that smaller tributaries have lower values than larger tributaries.

In this example (Figure 2.27), the smallest tributaries are identified with “1” values, and when two Level-1 tributaries come together they form a Level-2 river. Two Level-2 rivers merge to form a Level-3 river, etc.

FIGURE 2.27
River order values for rivers of FAO's Atlas of
Water Resources and Irrigation in Africa



Benefits and applications

The River Identification tool provides a method of tracing river networks and for identifying errors in the dataset. It gives users an easy way to select, and potentially rename, all attached river segments of a particular order.

Image Export and Base Mapping tool

The Image Export and Base Mapping (IEBM) tool-set of the AWRD is comprised of a fairly complex set of geo-referenced image output, View, and Layout manipulation tools which are accessible through a menu driven interface. These tools are ideal for generating publication-quality images in a variety of formats, as well as for generating geo-referenced images that can be viewed alongside other GIS data.

Benefits and applications

ArcView comes with certain standard functions to generate map images for use in presentation and publication. However, these standard functions often produce poor-quality output. The AWRD IEBM tools provides planners and managers with the ability to create high-quality maps for presentation and publication, for either digital presentations or hardcopy reporting, without requiring any additional software purchases.

Add-on extensions and adding additional AWRD Table and View functions

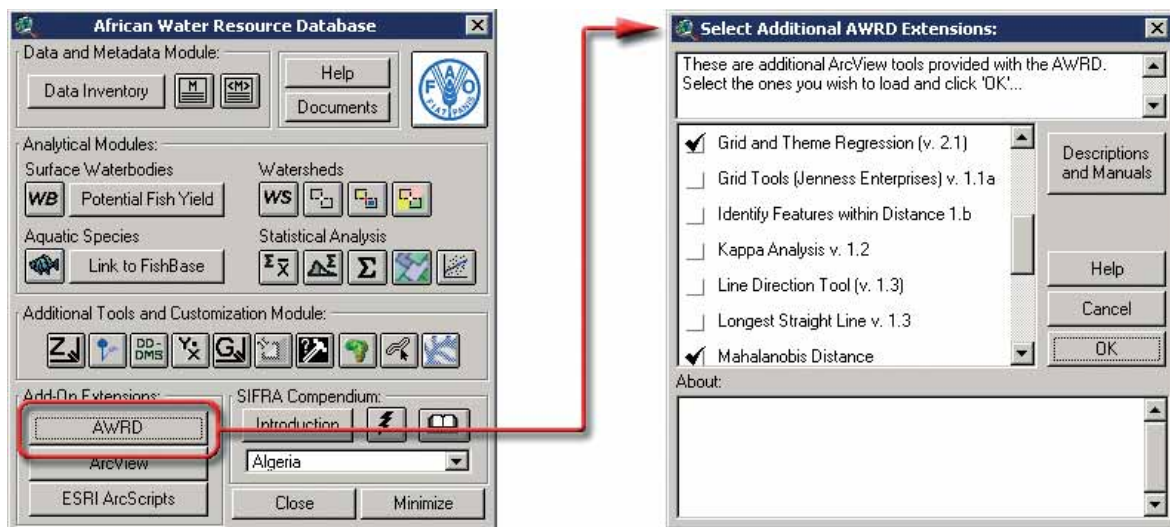
AWRD Add-on extensions

ArcView comes with many additional tools written or licensed by ESRI. These tools are referred to as “Extensions” and they are generally written for very specific purposes. The AWRD provides several additional extensions that are not directly related to the AWRD but which provide a number of useful tools. You can review and load any of these by clicking the “AWRD” button in the “Add-On Extensions” box (Figure 2.28) of the AWRD Interface.

Many of these additional extensions provide advanced analytical functions not available elsewhere in ArcView or the AWRD. These tools include more sophisticated regression functions, several specialized statistical tools, and several grid and vector data manipulation and analysis tools. The specialized statistics include the Kappa Statistic, which calculates the accuracy of predictive models, and the Mahalanobis Distances extension, which is an award-winning tool that identifies regions of the landscape that are most similar to some “ideal” set of conditions. Mahalanobis Distances are especially useful because they tell you exactly how similar any point on the landscape is to your ideal set of conditions, and they are sensitive to the relationships between different landscape variables. All tools come with complete manuals explaining how they work and what they can be used for.

FIGURE 2.28

Loading additional tools and extensions provided with the AWRD



ArcView Add-on extensions

To simplify the process of reviewing add-on extensions provided by ESRI, the AWRD includes a tool that shows you all these extensions. Click the “ArcView” button in the “Add-On Extensions” box.

ESRI ArcScripts

The ArcView User Community has produced a large number of ArcView tools which are freely available on the Internet. The largest compilation of these tools lies on the ESRI ArcScripts site and includes customized tools for ArcView and several other software packages produced by ESRI. The ArcScripts site provides links for over 2000 ArcView 3.x extensions and scripts. Because of the potential usefulness of this site, the AWRD offers this button to link you directly to the ArcScripts site: <http://arcscripts.esri.com/>. Click the “ESRI ArcScripts” button or select “*Additional ESRI Community Scripts and Extensions...*” in the AWRD Tools menu to link to the site (Figure 2.28).

Benefits and applications

The AWRD add-on extensions include a large number of powerful tools that enhance spatial analysis for a wide variety of different applications. This suite of tools provide simple solutions for many complex questions that typically arise in spatial analysis, such as nearest-neighbour analysis, grid projection and landscape management.

Additional ArcView Table and View functions


In addition to the standard AWRD tools available within the main dialog, the AWRD also includes several general tools to enhance the ArcView interface. These include functions to zoom forward and backward through a history of extents, tools to show and hide all legends in a view or to make all themes active or inactive, and several tools to edit or describe tables.

SIFRA Compendium

The Committee for Inland Fisheries for Africa Source Book for the Inland Fishery Resources of Africa (SIFRA) (Vanden Bossche and Bernacsek, 1990a; 1990b; 1991) is a compendium, waterbody-by-waterbody, country-by-country of information on inland fisheries and related topics. For an overview of the SIFRA Compendium, review the Introduction by clicking on the SIFRA Compendium “Introduction” button on the AWRD Interface or by selecting “*Open Introduction of SIFRA Compendium...*” in the AWRD Tools menu.

The AWRD includes two simple ways to review the SIFRA data for a particular country.

Review SIFRA Data Selecting from List

The drop-down list contains an alphabetized list of countries in Africa. Select a country from the list and then click the  button to open the SIFRA file on that country (Figure 2.29). You can also access this function from the AWRD Tools menu where you select the option “*Open SIFRA File for Specific Country...*”.

Review SIFRA Data by Clicking on Country




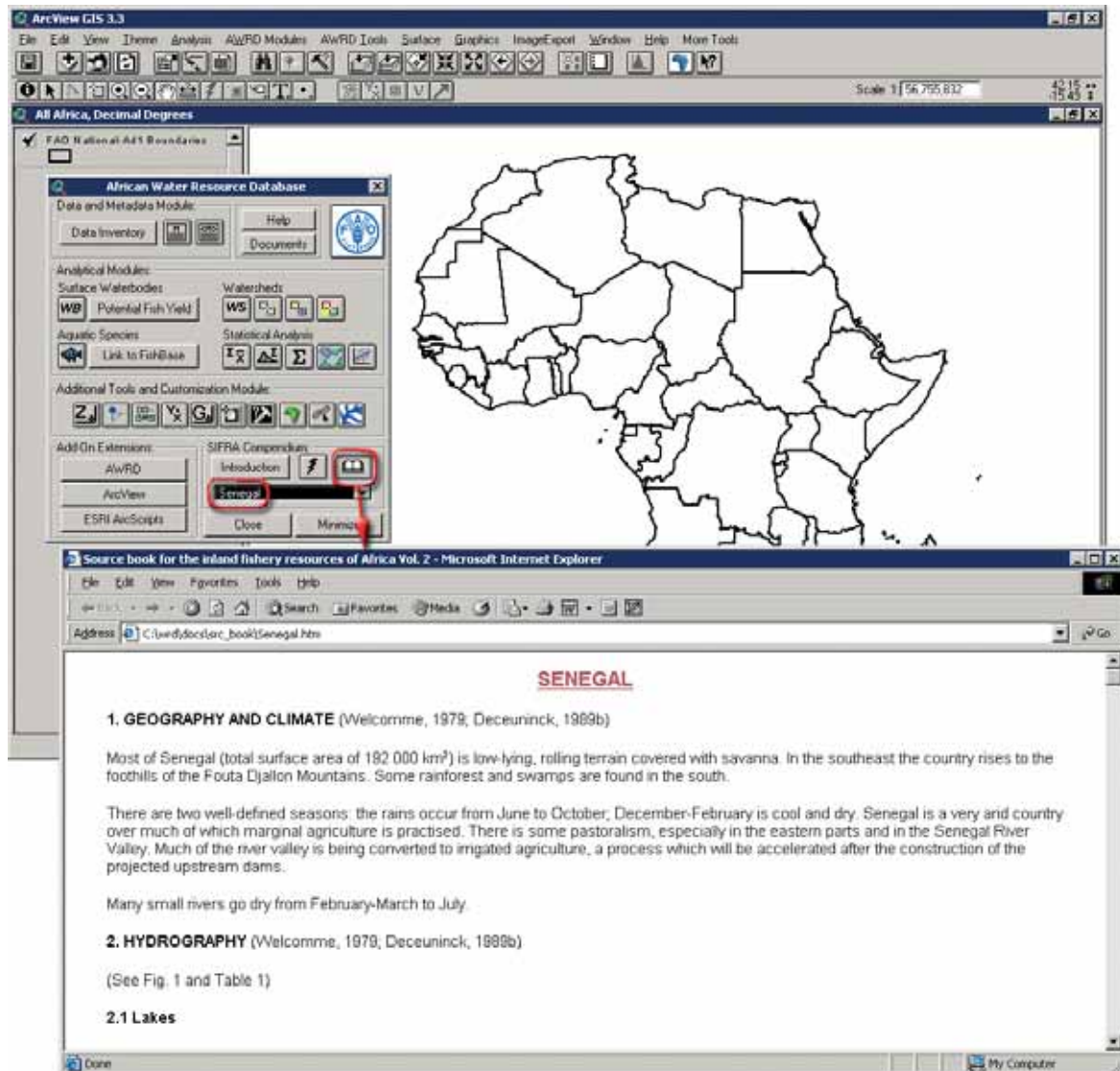
Alternatively, you can open the SIFRA file on a country by clicking on the  button on the AWRD Interface to enable the SIFRA Compendium tool. When the tool is enabled, the button will look indented and your cursor will change to a  symbol. One can use the  cursor to click on a country or region on the map. If you click on any of the countries in Africa, the SIFRA file for that country will open in your internet browser.

FIGURE 2.29
Select SIFRA country data from list



Benefits and applications

SIFRA provides a vast amount of comprehensive information on Africa's inland fisheries in a uniform format, so this tool makes this information more readily accessible and of greater use in conjunction with AWRD datasets.