Nile Basin Initiative

Nile Transboundary Environmental Action Project

The Wetlands of the Nile Basin: Inventory Manual

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Summary

The Wetlands of the Nile Basin: Inventory Manual

October 2009

Wetland mapping services for the Nile Basin have been carried out for the NBI NTEAP. The project includes the development of a wetland inventory manual to be used by countries for mapping, upgrading and monitoring wetland resources and changes in the Nile Basin.

The Nile Basin wetland inventory, delivered as an outcome of the wetland mapping project is a baseline database, summarizing the currently available wetland information in the whole of the Nile Basin in a compiled form. Due to the relatively coarse level of detail and the fact that wetlands are dynamic systems, the inventory will require frequent updates to add detail and to include changed conditions. The manual gives recommendations on these updating aspects, considering both administrative and technical issues.

The Ramsar Handbooks 11 and 12 (2007) have been used as baseline documents do develop the wetland inventory manual with their requirements adapted to the conditions in the Nile Basin. Basic principles and recommendations have been given in the main report of the wetlands inventory project; this manual describes the issues of concern in more detail and adds technical details and guidelines for the specific work with the developed geodatabase.

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1. Introduction

The Nile Basin wetland inventory, build on a geodatabase architecture, was designed in a way to allow updating and refining of its contents through future initiatives as well as through continuous data collection activities both by planned periodic maintenance activities as well as by small scale stakeholders. Considering the size of the Nile basin, the variety of initiatives in several countries and the speed of data generation from different sources, keeping the wetlands inventory up to date and on a high quality standard will be a task that needs careful planning and implementation.

Inventory, assessment and monitoring of wetlands are fundamental tools for their efficient and sustainable management. The Ramsar Convention of Wetland has issued some general guidelines for wetland inventory and updating that are widely applicable and give basic information about updating procedures. Regionally, the task will be challenged from several sides, including administrative, legislative, managerial, cooperative, and technical and standardization issues that vary from country to country and catchment to catchment. These issues as well as proposed ways to handle them have been described in the main report and are further detailed in the following customized wetland inventory and updating sections, specifically following the lines of the respective Ramsar Handbooks 11 (approach and purpose) and 12 (technical aspects and implementation) but being focused on the situation in the Nile basin and points of importance in that regard.

2. The Importance of Identifying, Assessing and Reporting the Status of Ramsar Sites and other Wetlands in the Implementation of the Convention

The delivery of the conservation and wise use of wetlands, in line with the commitments embodied in the Ramsar Convention, entails:

a. establishing the location and ecological characteristics of wetlands (baseline inventory)
b. assessing the status, trends and threats to wetlands (assessment)
c. monitoring the status and trends, including the identification of reductions in existing threats and the appearance of new threats (monitoring)
d. taking actions (both *in situ* and *ex situ*) to redress any such changes causing or likely to cause damaging change in ecological character (management)

At the site scale, the Convention's guidance on management planning, including the *New Guidelines for management planning for Ramsar sites and other wetlands* (Resolution VIII.14; Ramsar Wise Use Handbook [16, 3rd edition]), stresses that establishing the ecological character features of a site, and the factors that are positively or adversely affecting or likely to affect this character, is essential to the implementation of an effective management planning process.

Monitoring and reporting the conservation status of designated Ramsar sites and other wetlands will also provide an indication of the success of the Ramsar Convention as an international treaty and its mechanisms for achieving wetland conservation and wise use. Resolution VII.11 is explicit in Objective 4.1 of the *Strategic Framework and guidelines for the future development of the List of Wetlands of International Importance*: "To use Ramsar sites as baseline and reference areas for national, supranational/regional, and international environmental monitoring to detect trends in the loss of biological diversity, climate change, and the processes of desertification." The Convention's *Ecological 'outcome-oriented' indicators for assessing the implementation effectiveness of the Ramsar Convention* have been designed to address this issue, for which reporting and assessment mechanisms will be established during the 2006-2008 triennium.

3. Structured Guidance for planning Wetland Inventory Updating

This section lays out the structure to carry out an updating exercise of the existing wetland inventory on an organized and guided format. The steps and guidance was derived in accordance with the Ramsar *Framework for Wetland Inventory*.

1. Problem statement, why is new information required
2. State purpose and objective of the exercise, what shall be achieved
3. Contact master wetland dataset administrator for overview of current knowledge and metadata of existing data
4. Review other existing information regarding the area of interest
5. Review technical requirements, what is needed to obtain comparable and overall compatible data
6. Review existing methods and select method appropriate to objective based on study area extent, required accuracy, desired resolution, timeframe, skills and budget
7. Establish dataset including spatial, tabular and narrative information. Fitting the date, resolution and spatial extent required for the purpose of the study
8. Establish data management system for base dataset and generated data
9. Setup schedules, responsibilities resources and coordination as well as reporting and review needs
10. Fulfil administrative requirements
11. Implement study
12. Contact master wetland dataset administrator for data exchange and potential provision with upgraded wetland information product based on the submitted data.

The *Framework for Wetland Inventory* identifies a set of core data for biophysical assessments and management of wetlands (Table 1). It is suggested that these data should be collected in each study, depending on the specific purpose of the activity.

The *Framework for Wetland Inventory* recognizes that wetland inventory has multiple purposes, including:

a. listing particular types, or even all, wetlands in an area
b. listing wetlands of local, national and/or international importance
c. describing the occurrence and distribution of wetland taxa
d. describing the occurrence of natural resources such as peat, fish or water
e. establishing a baseline for measuring change in the ecological character of wetlands
f. assessing the extent and rate of wetland loss or degradation
g. promoting awareness of the value of wetlands
h. providing a tool for conservation planning and management
i. developing networks of experts and cooperation for wetland conservation and management

Table 1 Core data fields for inventory of biophysical and management features of wetlands (derived from the Annex to Ramsar Resolution VIII.6)

Biophysical Features

- Site name (official name of site and catchment)
- Area and boundary (size and variation, range and average values) *
- Location (projection system, map coordinates, map centroid, elevation) *
- Geomorphic setting (where it occurs within the landscape, linkage with other aquatic habitat, biogeographical region) *
- General description (shape, cross-section and plan view)
- Climate – zone and major features
- Soil (structure and colour)
- Water regime (periodicity, extent of flooding and depth, source of surface water and links with groundwater)
- Water chemistry (salinity, pH, colour, transparency, nutrients)
- Biota (vegetation zones and structure, animal populations and distribution, special features including rare/endangered species)

Management Features

- Land use – local, and in the river basin and/or coastal zone
- Pressures on the wetland – within the wetland and in the river basin and/or coastal zone
- Land tenure and administrative authority – for the wetland, and for critical parts of the river basin and/or coastal zone
- Conservation and management status of the wetland – including legal instruments and social or cultural traditions that influence the management of the wetland
- Ecosystem benefits/services derived from the wetland – including products, values, functions and attributes (see Ramsar Resolution VI.1) and, where possible, their relevance to human well-being (see Ramsar Resolutions VI.23 and VII.8)
- Management plans and monitoring programs – in place and planned within the wetland and in the river basin and/or coastal zone (see Ramsar Resolutions 5.7, VI.1, VII.17, and VIII.14)

* These features can usually be derived from topographical maps or remotely sensed images, especially aerial photographs.

The *Framework* also stresses that an inventory should contain a clear statement of its purpose and objective. This should identify the habitats that will be considered, the range of information that is required, the time schedule, and who will make use of the information. A clear statement of the purpose will assist in making decisions about the methods and resources needed to undertake the inventory.

Unlike the use of wetland assessment techniques, there is less likelihood that more than one inventory technique will be applied simultaneously. Since wetland inventory can be carried out at different levels of detail, it is far more likely that sequential inventory, starting simply and subsequently undertaking more detailed work, will be undertaken.

4. The Relationship between Wetland Inventory, Assessment, Monitoring and Management

Working definitions for wetland inventory, assessment and monitoring are incorporated into Ramsar's *Framework for Wetland Inventory* (Resolution VIII.6). They are:

- ***Wetland Inventory***: the collection and/or collation of core information for wetland management, including the provision of an information base for specific assessment and monitoring activities
- ***Wetland Assessment****:* the identification of the status of, and threats to, wetlands as a basis for the collection of more specific information through monitoring activities
- ***Wetland Monitoring****:* the collection of specific information for management purposes in response to hypotheses derived from assessment activities, and the use of these monitoring results for implementing management. The collection of time-series information that is not hypothesis-driven from wetland assessment is here termed *surveillance* rather than monitoring (refer to Ramsar Resolution VI.1)

Importantly, wetland inventory and wetland monitoring require different types of information. Whilst wetland inventory provides the basis for guiding the development of appropriate assessment and monitoring, wetland inventories repeated at given time intervals do not in themselves constitute monitoring.

Essentially, wetland (baseline) inventory is used to collect information to describe the ecological character of wetlands; assessment considers the pressures and associated risks of adverse change in ecological character; and monitoring, which can include both survey and surveillance, provides information on the extent of any change. All three are important and interactive data gathering exercises. They should be considered as linked elements of this overall integrated framework which, when implemented, provides for identification of key features of the character of wetlands. Taken together, they provide the information needed for establishing strategies, policies and management interventions to maintain the defined wetland ecosystem character and hence ecosystem benefits/services.

However, in practice a clear distinction between inventory and assessment is hard to draw, and many projects and initiatives described as wetland inventory also include elements of assessment of the status of, and pressures and threats to, wetlands.

The data and information collected through inventory, assessment and monitoring are essential parts of an overall wetland management planning process, at site, catchment, national or regional scales. The management planning process provides the mechanisms for maintenance of the ecological character of the wetlands, drawing on the data and information provided by inventory, assessment and monitoring, as is set out in the Convention's *New Guidelines for management planning for Ramsar sites and other wetlands* adopted by COP8 (Ramsar Resolution VIII.14) [Incorporated in Ramsar Handbook 16, Managing wetlands]

5. Multi-Scalar Approaches to Wetland Inventory, Assessment and Monitoring

Key issues in implementing wetland inventory, assessment and monitoring are the choice of the scale at which to undertake the work and the choice of appropriate methods for each scale.

Wetland assessment, as with inventory and monitoring, can be undertaken at discrete spatial scales using (different) appropriate techniques for each. Whenever possible, an integrated inventory, assessment and monitoring programme should be developed and conducted at a single appropriate scale. This can be achieved when an integrated analysis encompassing inventory, assessment and monitoring components is planned and implemented. However, these components are typically planned or undertaken separately. Wetland assessment should be undertaken at a spatial scale compatible with the scale of information contained within the wetland inventory. Subsequent monitoring should also be undertaken at a scale compatible with the assessment.

Since much wetland inventory, assessment and monitoring will be constrained by the scale and availability of information; practitioners are encouraged to aggregate data wherever possible rather than attempt to disaggregate data. This is possible when subsequent analyses draw on data from larger scales (e.g., combining data collected at 1:10,000 scale to represent a composite image at 1:50,000 scale) rather than smaller scales where issues of accuracy and precision will likely constrain effective analysis.

The issue of scale has so far been most fully addressed in methodologies for wetland inventory, and this is summarized below, using the Asian Wetland Inventory method as an example. However, many of the scale issues for inventory are equally relevant for the application of wetland assessment and monitoring, but further evaluation of options for these elements of the overall process may be necessary. Figure 1 shows details of this approach.

The initial analysis (Level 1) involves delineation of geographical regions (major river basins and islands) in Asia and encompasses a description of the geology, climate and ecology of each based on existing information sources. Level 2 analysis concerns delineation of wetland regions within each geographic region. This is done on the basis of similar climatic, geologic, hydrologic and vegetation features. Level 3 analysis undertakes grouping and description of wetland complexes within each region on the basis of more detailed information. Finally, Level 4 analysis makes detailed descriptions of individual wetland habitats.

This approach results in the production of more detailed information on wetlands as the inventory progresses from Levels 1 to 4, and it is anticipated that in many cases the implementation of an inventory will initially be undertaken at Levels 1 and 2, followed, as resources become available, by Levels 3 and 4.

While a hierarchical framework has been developed, it is not essential for all purposes to work through all levels of detail. The hierarchical approach is designed to respond to existing needs to obtain information at different levels and detail. A key point of this approach, however, is the adoption of compatible data fields and data management procedures to allow maximum use of the data, whether this is immediately planned or not for the particular purpose of an inventory exercise. However, for such reuse for

different purposes, it is important to recognize the limits or constraints on interpretation of the original data.

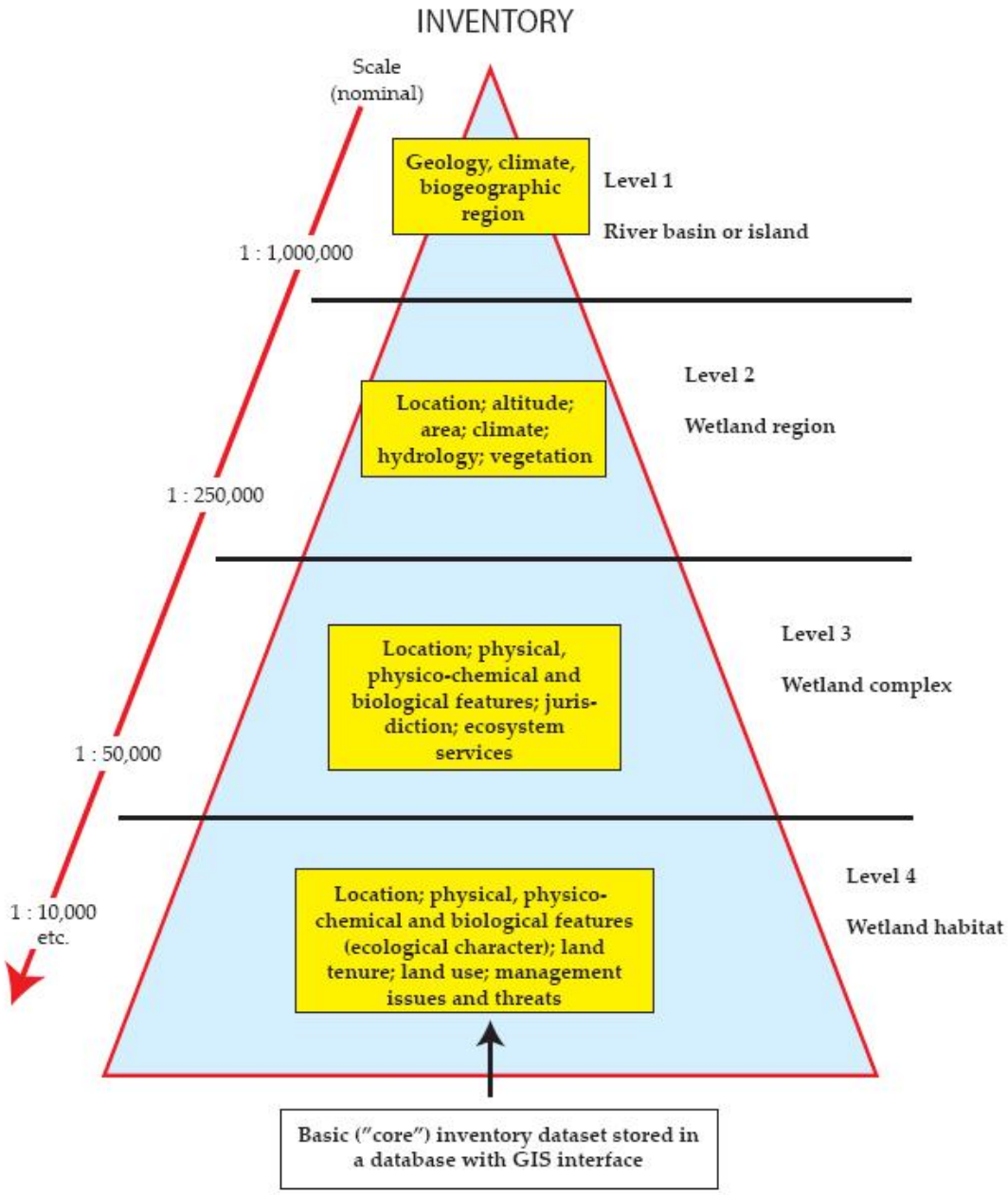

Figure 1 The hierarchical approach to wetland inventory[1]

At all levels of analysis the usefulness of existing information is first assessed and used as a basis for determining whether or not further analysis or collection of information is necessary. In many instances, analyses will be undertaken as follows: Level 1 – desk study to describe the broad geologic, climatic and ecological features of each geographic region using existing datasets, increasingly available on the Internet; Level 2 – desk study to identify the wetland regions within each geographic region using information already collated on geology, climate, hydrology, and vegetation; Level 3 –

[1] Data fields most appropriate for each level are shown with the most data being collected at level 4, shown at the base of the triangle (Ramsar Handbook 11, 2007)

fieldwork and analysis to identify the physical, physico-chemical and biological features of wetland complexes within each wetland region; and Level 4 – detailed fieldwork and analysis to describe the physical, physico-chemical and biological features of each wetland habitat within each wetland complex. This includes information on plant and animal assemblages and species, land and water use and wetland management.

Data collection and analysis is based on standardised procedures and data management formats, although flexibility is not discouraged where necessary. Proforma data sheets for each level of analysis have been developed and are accompanied by guidelines for collecting the required information.

Similar multi-scalar procedures can be developed for wetland assessment and monitoring. These procedures will most likely build on the multi-scalar information collected under the inventory process and provide managers and others with analyses suitable for the scale of investigation.

However, detailed monitoring at broad scales is usually not possible because of its high cost, and thus monitoring at this scale must be cost-effective and sufficiently rapid to generate adequate first-pass data over large areas. The data may be adequate for management purposes or they may help managers to decide what type of further information may be required.

Typically, rapid assessment methods, including rapid biological assessment and remote sensing, are applied at broad scales. For specific sites, however, more detailed, quantitative monitoring may be required, utilising designs that provide stronger inference about a putative impact.

6. Technical Guidelines for Updating the Database

The following sections give an introduction to the GIS system developed for the project. These sections are a means of getting familiar with the data included within the system and its functionalities.

6.1 DATA STRUCTURE AND LAYERS

Figure 2 shows the GIS database structure and the different layers that are included within this structure.

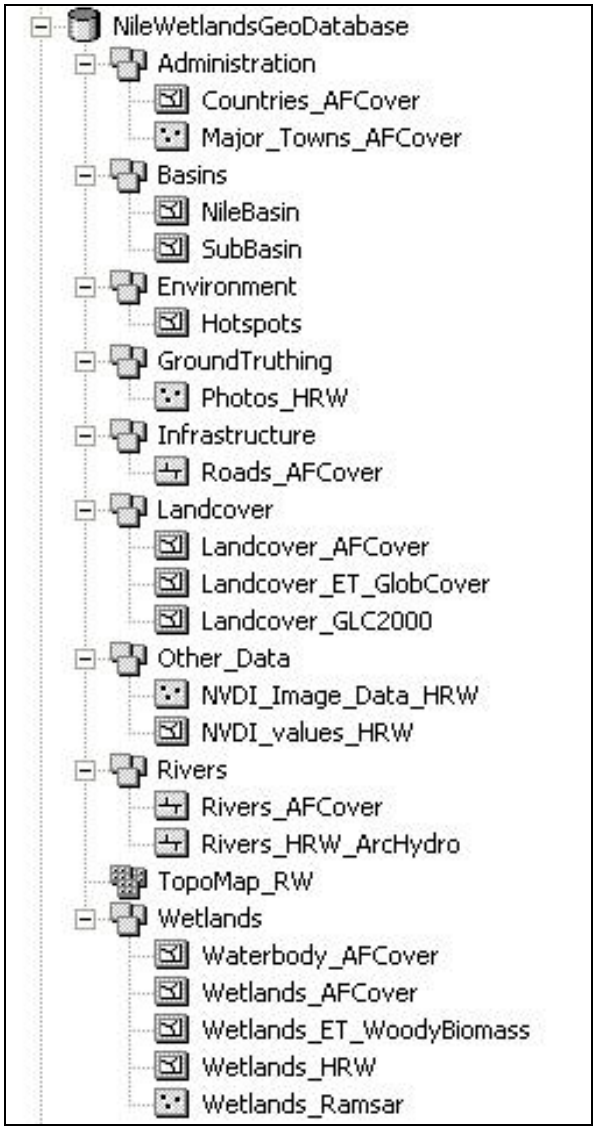

Figure 2 Data structure and layers

Layers are split into a number of categories as follows:

- Wetlands which include layers that hold information on the wetlands in the Nile basin from different sources such as this project and the Africover project

- Administration which includes layers that hold information on the political borders of the Nile basin countries and their major towns. These layers can be used to undertake queries by country or locate major towns that are with a certain distance from wetlands
- Basins which includes layers that hold information on the catchment of the Nile basin and also the sub-basins that were used within this project. As shown in Figure 3, the system allows the additions of user defined sub-basin (e.g. sub-basin C) within the existing sub-basins that were already defined within the project. These layers can be used, for example, to locate wetlands within one or a number of sub-basins to facilitate planning and management activities
- Environment which includes layers that hold information on the Hotspots within the Nile basin. This allows to linking them with wetlands location in the basin
- Ground truthing which includes layers that hold information on the location the ground truthing data that were collected to verify the wetlands mapping activities within this project
- Infrastructure which includes a layer that holds information on major roads network in the Nile basin. This layer was produced by the Africover project
- Land Cover which includes layers that hold information on the lands cover in the Nile basin. The data in this category have been collected from a number of sources such as the Africover and the Globcover projects
- River which includes layers that hold information on the rivers network in the Nile basin. This layer was produced by the Africover project and the Arc hydro module
- The system also include other data sets such the Topomaps produced in the fifties to allow comparison with current conditions and also the NDVI data produced by this project to detect the location of wetlands

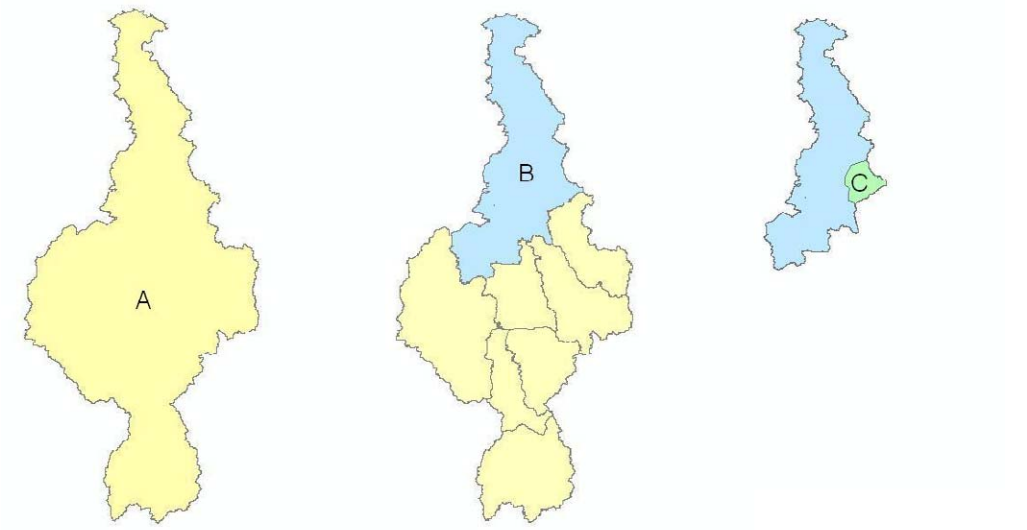

Figure 3 Basin definitions if the system

6.2 DATA STORAGE

The data described above is stored in geo-database that was created with the ArcGIS 9.2 software package. This was selected as it allows the storage of different types of data sets such as meta, vector and raster data in one location. Data can also be added or updated easily with the system. All of the above makes a flexible and easy to use system

that will help in undertaking different task that facilitate management and planning activities.

Files in the geo-database adhere to the following naming convention:

(Information Type) _ (Country code (If applicable)) _ (Data Source)

E.g. A shape file created by the Globcover project showing the Landcover of Ethiopia should be named: 'Landcover_ET_Globcover'

Due to the large geographic area of the Nile Basin, the coordinate reference system applied to all spatial data throughout the project is the World Geodetic System 1984 (WGS84). All coordinates and X, Y values have been converted to latitude and longitude values. All data received in other systems were re-projected to this global system. The details of the WSG84 system are as follows:

Ellipsoid:	
Name:	World Geodetic System 1984
Semi Major Axis	6378137
Semi Minor Axis:	6356752.3142
Flattening:	298.25722356300003

6.3 SYSTEM USES

Figure 4 shows the GIS system user interface. The panel shown on the left hand side shows the different data categories and layers described in Section 6.1. The view panel on the right hand side shows the GIS information within those layers.

The system allows the user to undertake the following tasks:

- Switch layers on/off using the left hand right panel (See Figure 4).
- Zoom, pan and explore the layers data
- Change displays and create maps with legends (See Figure 5).
- Undertake queries using table or spatial data. This feature is a very powerful tool in the system as it can be used to locate wetlands with different attributes such as transboundary wetlands, wetlands within one country or wetlands that have certain species. Most of the managerial decisions can be supported using information obtained from these queries. Figure 6 shows and example of undertaking a spatial query to locate wetlands within one country.

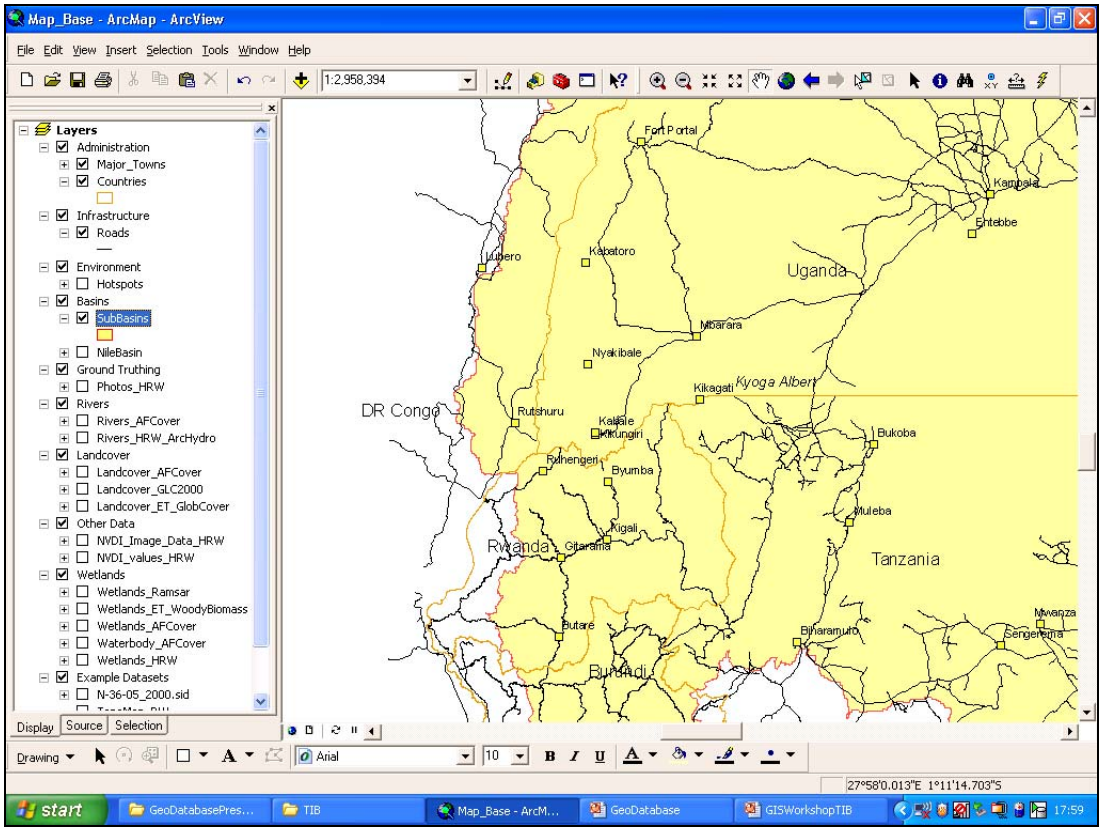

Figure 4 The GIS system user interface

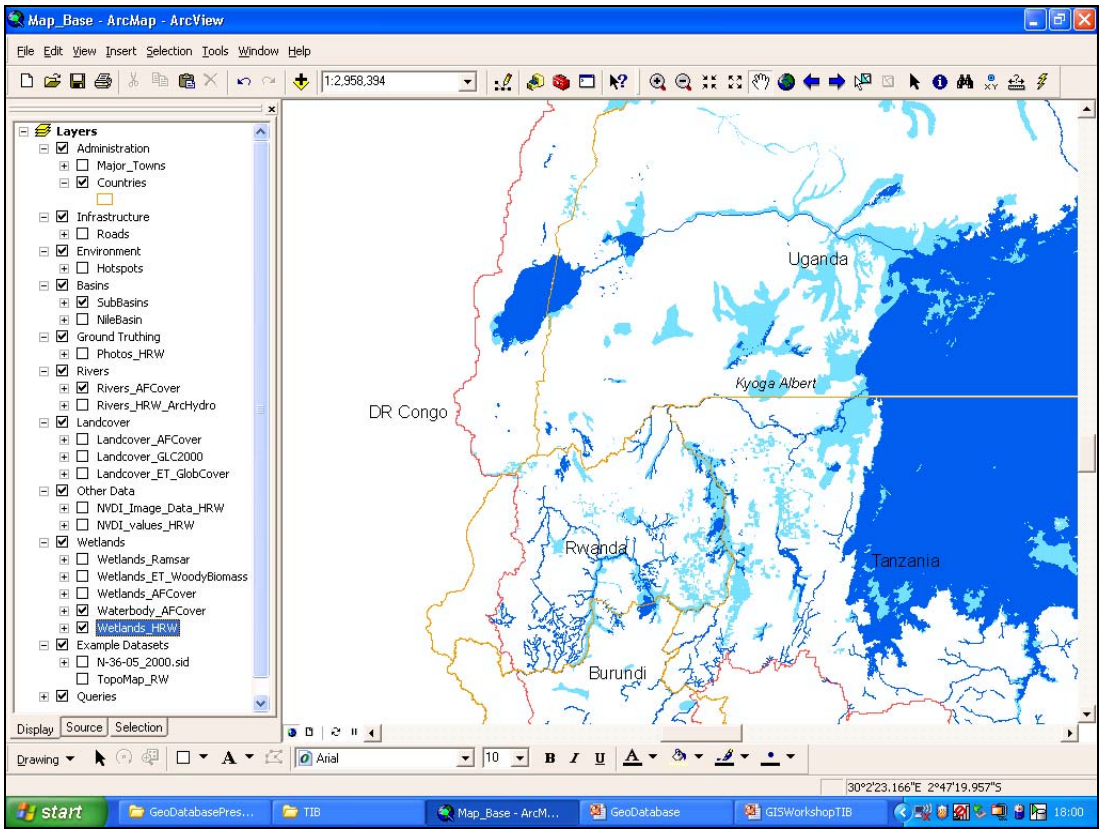

Figure 5 The GIS system user interface showing wetlands in part of the Nile Basin

6.4 SYSTEM MAINTENANCE AND UPDATING

The Wetlands data included in the GIS system represents a baseline survey of the wetlands in the Nile Basin including their location, physical parameters as well as certain attributes such as Ramsar class. It is recommended to undertake the following actions to maintain and update this data in the future:

- Provide adequate training to those involved in running, maintaining, updating the GIS system to ensure that stakeholders are fully aware of the benefits of the system.
- Update the wetland database through the following steps:
    1. Setup of the GIS database in a central location with defined use and access rules
    2. Widespread distribution of the wetland inventory and information about its structure and utilization possibilities
    3. Schedule for periodical maintenance of the database to work in user feedback and data provided through surveys and local knowledge of user groups.

It should also be noted that stakeholder ownership, open utilization of the database, easy access for patching, and periodic maintenance projects are key aspects to maintain a valuable and up to date database

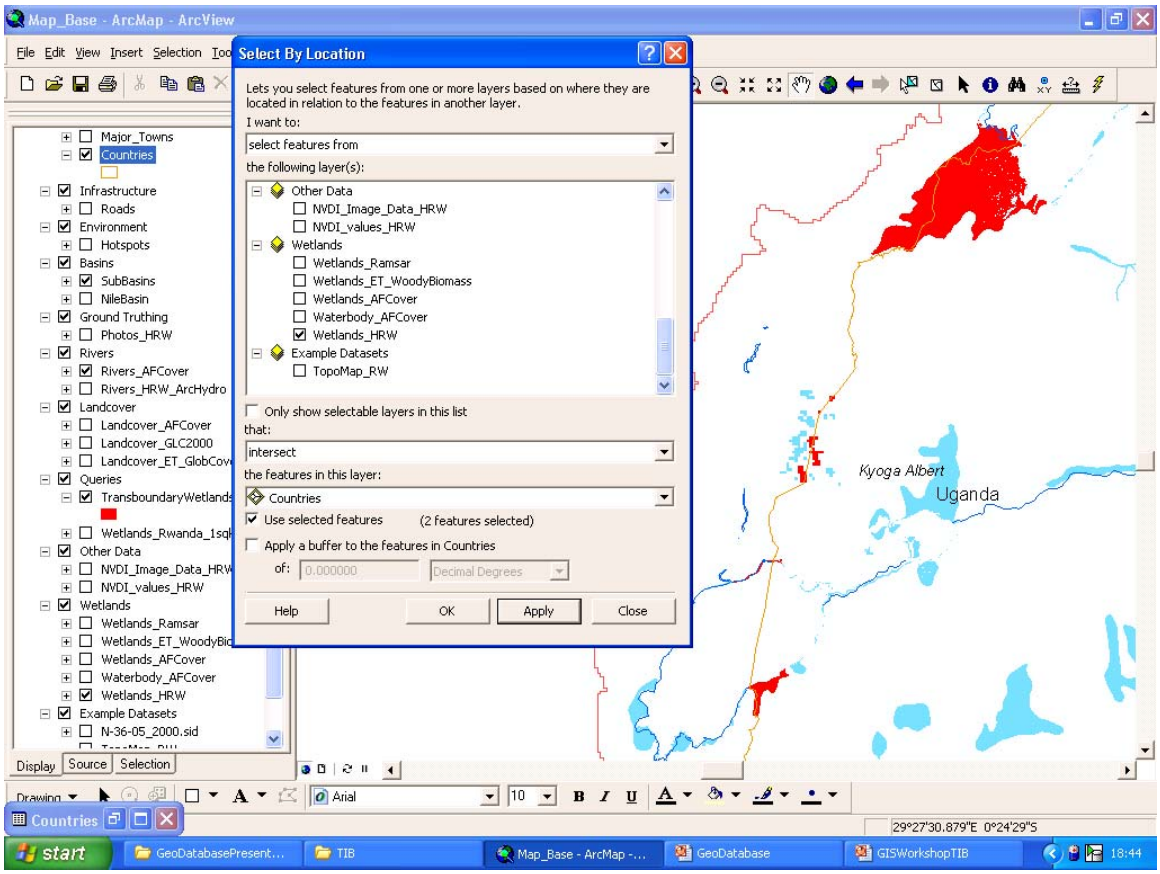

Figure 6 An example of undertaking a spatial query

6.5 UPDATING METHODOLOGY

The methodology that should be used to update the wetland inventory will depend on the specific requirements of the study to be undertaken, the scale, the particularities of the study site and the objectives of the research. As a guideline a generalized methodological approach as used in the baseline study for the whole Nile basin is given in Figure 7.

This methodology was used to generate wetland layers from data captured by earth observation satellites[2]. It may be adapted to the specific needs of any updating or refinement exercise or a more suitable approach may be chosen. It is important to note that selecting an adequate methodology is a main factor for successful mapping. Full details of the processing method followed for the Wetlands Inventory project can be found in Volume I of this report, The Wetlands of the Nile Basin: Baseline Inventory and Mapping.

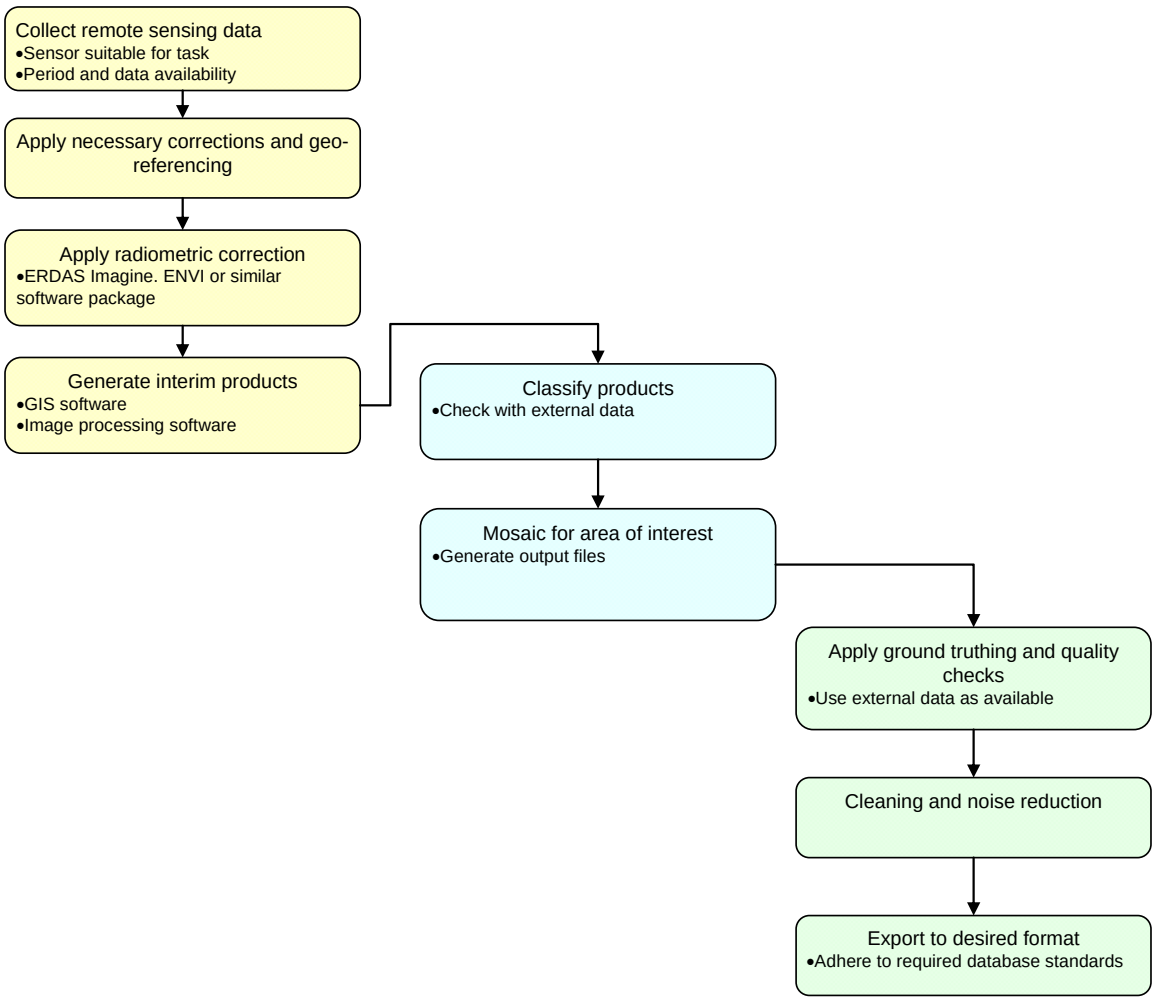

Figure 7 Generalized methodology as guideline for wetland mapping, updating and refinement approaches

[2] The particular method applied in the Wetland Inventory study used multispectral data from a passive optical sensor such as LANDSAT or SPOT.

7. The Ramsar 'Toolkit' of Guidance available to Ramsar Parties for Implementing the Integrated Wetland Inventory, Assessment and Monitoring Framework

A substantial set of Ramsar guidance already exists for wetland inventory, assessment, monitoring, and management. Guidance has been compiled in Ramsar Wise Use Handbooks [(3rd Edition) 12, 13, 15 and 16]. Key guidelines, definitions and other relevant guidance is listed in Table 1. Key aspects and features of the Convention's guidance on wetland inventory, assessment and monitoring are summarized in the following sections of this integrated framework.

7.1 METADATA RECORDS FOR WETLAND INVENTORY

The *Framework for Wetland Inventory* also stresses the importance of establishing a publicly-accessible and standardized metadata record for each inventory undertaken, and it includes a standard model for wetland inventory metadata. Metadata has many elements that can include information describing the age, accuracy, content, currency, scale, reliability, lineage, authorship and custodianship of an individual dataset. Recording and describing this information enables data to be easily located, identified, understood and managed. It also enables data to be used more efficiently and effectively.

Whilst 'metadata' is not a new concept, it has gained added significance through the increasing recognition of data collections and associated information as assets which need to be managed and maintained efficiently. A *metadatabase* can be viewed as the mechanism which links all of these data descriptions together to provide a comprehensive description of the dataset. The metadatabase stores descriptions of the data, not the actual data itself. Where possible, the data fields should be populated with values representing established international standards, to ensure consistency and quality in the data entry. The extent of subjective individual interpretations or descriptions should be minimised where possible, to avoid confusion or inconsistency. This is a particular concern when data are exchanged between organizations. By identifying the fields required for the metadatabase and recommending the parameters and file formats, it is intended that the metadatabase could be produced on a range of database platforms. Using standardized parameters should assist with the transfer of data between platforms

7.2 TYPES OF WETLAND ASSESSMENT

There is a wide range of different types and methods of wetland assessment relevant to different aspects of Convention implementation, with each suited to, and designed for, different purposes and situations. These include:

1. Environmental Impact Assessment (EIA)
2. Strategic Environmental Assessment (SEA)
3. Risk Assessment (RA)
4. Vulnerability Assessment (VA)
5. Change (status and trends) assessment
6. Species-specific assessment

7. Indicator assessment
8. Resource (ecosystem benefits/services) assessment
9. Assessment of values of wetland benefits/services
10. Environmental water requirement (environmental flows) assessment.

The Ramsar Convention has adopted guidance on a number of these types of assessments and is being prepared for publication as *Ramsar Technical Reports*. Details about these assessments are described in the Ramsar handbook 11, provided in the annex of this manual.

7.3 THE RELATIONSHIPS AMONG THE DIFFERENT WETLAND ASSESSMENT TOOLS AVAILABLE THROUGH THE CONVENTION

Figure 8 illustrates the relationships among various assessment tools as a flow diagram that shows the linkages between the tools and the choices that may need to be made when assessing the condition of or change in a wetland.

It is important to recognize that whilst each assessment tool has a specific application there can exist considerable overlaps between tools under some circumstances. In some instances, one or more specific tools can be used as part of a broader form of assessment. Practitioners need to consider the choice of tool or tools in relation to the specific purpose of the assessment they need to undertake.

The assessment tools and approaches shown in Figure 8 are relevant to assessing change or potential change in wetlands. These can be effectively integrated in a hierarchical decision-making framework, so that there is an efficient flow of information and influence from one to the other. Some of the ways in which this can occur are:

- *Strategic Environmental Assessment* can provide a framework or context which helps to determine the need for, and the parameters of, relevant project-specific *Environmental Impact Assessments*, focusing on key issues, priority risks and opportunities.
- *Environmental Impact Assessment* can help determine the need for, and the parameters of, *Vulnerability and Risk Assessments* and *Wetland Valuations*.
- *Vulnerability and Risk Assessments* help define baselines, tolerance limits and other elements to feed in to *Environmental Impact Assessment*, as well as potential measures for reducing the risk of wetland degradation.
- *Risk Assessment* can also quantify the magnitude and likelihood of impacts, as part of an *Environmental Impact Assessment*.
- *Wetland Valuation* (of ecosystem provisioning, regulating, cultural and supporting benefits/services) can provide information to assist in articulating the benefits obtained from a wetland and hence support the concepts provided in *Vulnerability and Risk Assessments*.
- Information on impacts collected in the *Environmental Impact Assessment* process and through subsequent monitoring activities can feed into the *Strategic Environmental Assessment* process, as well as informing *Vulnerability and Risk Assessments* and *Wetland Valuations*
- *Rapid Assessment* of biodiversity provides information that can guide *Environmental Impact Assessment* and support *Vulnerability and Risk Assessment*, and identify elements of biodiversity that could be used within *Wetland Valuation.*

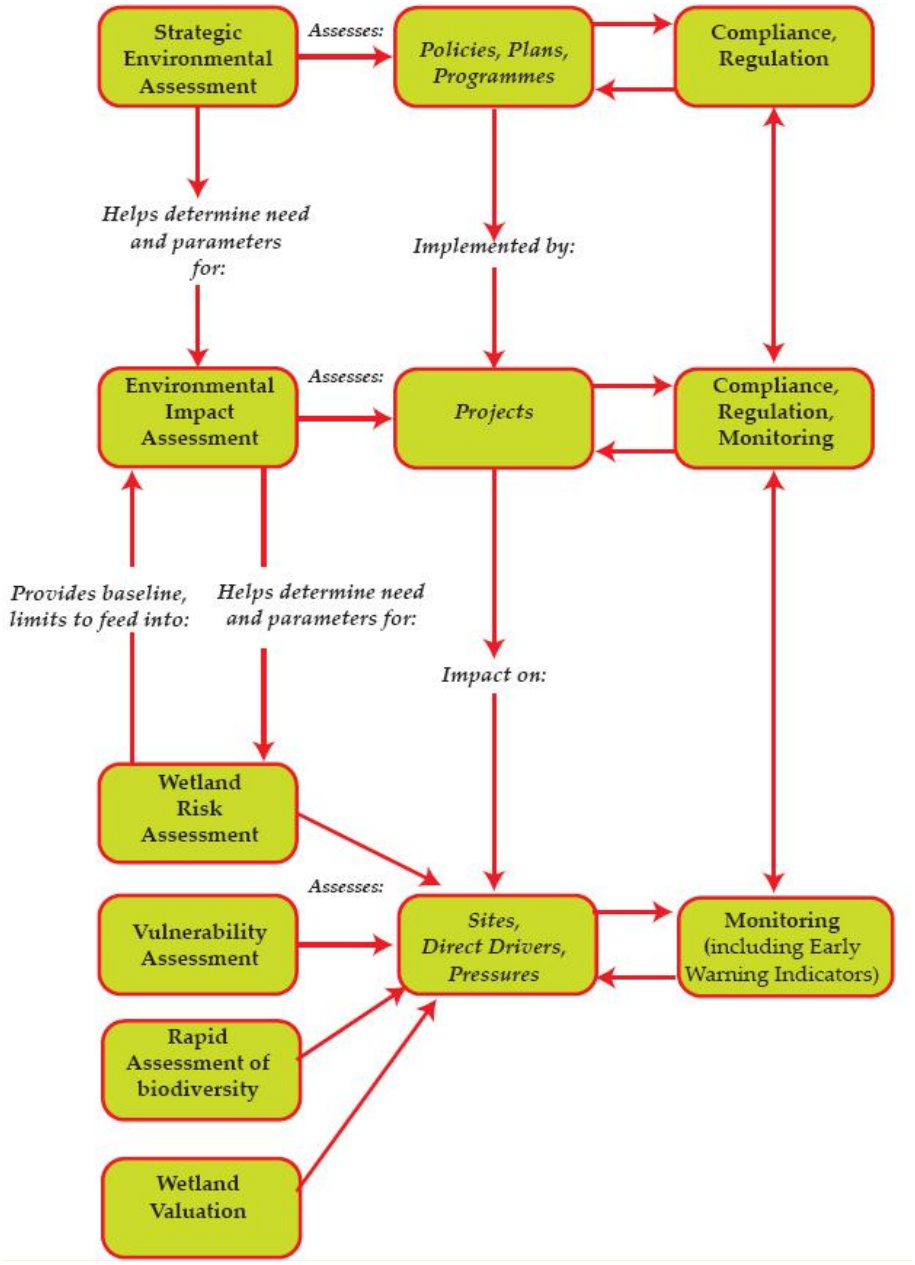

Figure 8 The relationships among the different wetland assessment tools available through the Convention [3]

Thus Strategic Environmental Assessment, Environmental Impact Assessment, and Vulnerability and Risk Assessment will help define the scope of monitoring for policies/plans/programmes, for projects and for site management, respectively.

The Convention's *Wetland Risk Assessment Framework* (Ramsar Resolution VII.10; Ramsar Handbook 8) includes a substantial component addressing early warning indicators. Measurement of these indicators will draw on data from site management and monitoring and will feed back to adjustments in that management. Rapid Assessment of biodiversity can also provide early warning of impending change, but there is an inverse relationship between the extent of the ecological relevance of an

[3] from Ramsar Handbook 11, 2007

indicator and the extent of early warning. Early warning indicators can also provide data to the monitoring stimulated in relation to projects by Environmental Impact Assessment.

7.4 WETLAND MONITORING

A framework for designing a wetland monitoring programme was adopted by COP6 (Ramsar Resolution VI.1) in 1996 and is incorporated into Ramsar Wise Use Handbook [16, *Managing wetlands*, 3rd edition].

The framework is not a prescriptive recipe for any particular monitoring programme. It simply provides a series of steps that can be used by wetland managers and planners, working in partnership with local users and managers, to design a monitoring programme based on their particular circumstances and needs.

When designing a monitoring program it is necessary to consider a number of principles that ensure valid results, analysis and interpretation.

Many monitoring techniques are also available in the MedWet monitoring manual, which provides a listing and guidance on specific approaches (Tomas Vives, P. (ed). 1996 *Monitoring Mediterranean Wetlands: A Methodological Guide*. MedWet Publication, Wetlands International, Slimbridge, U.K. & ICN, Lisbon, Portugal) (downloadable from: http://www.medwet.org/medwetnew/en/04.RESOURCE/04.3.publications15.htm).

7.5 APPLYING WETLAND INVENTORY, ASSESSMENT AND MONITORING TOOLS IN THE CONTEXT OF THE WISE USE OF WETLANDS

This integrated framework for wetland inventory, assessment and monitoring, and the tools and methodologies it covers, forms one of several framework guidances developed by the STRP to assist Contracting Parties and others in more readily selecting and applying each of the increasing range of the Convention's wetland conservation and wise use guidelines.

The STRP has also recognized the significance of the Millennium Ecosystem Assessment's Conceptual Framework for Ecosystems and Human Wellbeing in providing an overarching framework for the delivery of Ramsar's wise use of wetlands (Ramsar Resolution IX.1). It provides a multiscalar approach which indicates how and where policy and management interventions, including the different components of the Convention's toolkit of Wise Use Handbooks, can be made (Ramsar Resolution IX.1).

Within this conceptual framework, most of the Convention's tools for inventory, assessment and monitoring concern the maintenance of the ecological character of wetlands through interventions within wetland ecosystems themselves – between the components and processes of wetlands and the ecosystem benefits/services these deliver. Others, notably Environmental Impact Assessment, Risk Assessment, and Vulnerability Assessment concern addressing the interactions between "Direct Drivers of Change" to wetlands and the wetlands themselves. However, since Strategic Environmental Assessment is concerned with policies, plans and programmes, it acts as an intervention between Indirect and Direct Drivers of Change.

8. Gaps in Ramsar's Toolkit of Inventory, Assessment and Monitoring Guidance

Although this *Integrated Framework for wetland inventory, assessment and monitoring* now includes a large number of different tools and approaches, a number of gaps in methodological guidance remain before it provides a comprehensive Ramsar framework for implementation by Contracting Parties and others. These are identified in the schedule of actions for the scientific and technical implementation of the Ramsar Convention, 2006-2011. They include:

1. development and testing of a hydro-geomorphically-based system of classification of wetland types, including an evaluation of how this relates to other possible systems and to the current Ramsar classification system
2. further development of the Web-based wetland inventory metadatabase
3. a review of data and information needs for Ramsar sites and other wetlands, including guidance for the description of the ecological character of wetlands, and harmonisation of the Information Sheet on Ramsar Wetlands (RIS) with the wetland inventory core data fields and the description of ecological character
4. advice on delineating and mapping wetlands (in conjunction with the description of ecological character
5. further consolidated guidance on detecting, reporting and responding to change in the ecological character of wetlands
6. establishment and implementation of mechanisms for the ecological 'outcome-oriented' indicators of effectiveness of the implementation of the Convention and development of further such indicators

In addition to these methodological developments, Resolution IX.2 also recognizes that regular assessment and reporting on the status and trends of the ecological character of Ramsar sites and other wetlands will need to ensure that the results of national wetland inventory and assessments are made fully accessible, as is called for in Resolution VIII.6.

There is also a need, recognized in the work of the Millennium Ecosystem Assessment (see Finlayson, D'Cruz & Davidson. 2005. *Ecosystems and Human Well-being: Wetlands and Water. Synthesis.* World Resources Institute, Washington D.C.), for more case studies and more widespread and comprehensive assessments of the socio-economic value of wetland ecosystem benefits/services, particularly in relation to the potential conversion of wetlands to other land uses, as the basis for sound decision making.

9. Practical Inventory Considerations

A structured framework for planning and designing a wetland inventory is summarized in Table 2. The framework comprises a series of steps that provide the basis for making decisions in relation to the purpose (and objectives), and the available resources, for an inventory.

All steps in the Framework are applicable to the planning and implementation of any wetland inventory, and all steps should therefore be followed during the design and planning process. The framework does not provide prescriptive guidance on particular inventory methods; rather it provides guidance to the Contracting Parties and others who are planning to undertake wetland inventory by drawing attention to different methods and wetland classifications already in use and of proven utility under different circumstances.

The framework should be used as a basis for making decisions for undertaking a wetland inventory under the circumstances particular to each inventory program. Guidance on the application of each step is provided.

Table 2 Structured framework for planning a wetland inventory

Step	Guidance
1. Problem statement, why is new information required	What is the problem that shall be tackled? Identify the problem in order to be able to define the needs and objectives of the study.
2. State the purpose and objective, what shall be achieved	State the reasons for undertaking the inventory and why the information is required, as the basis for choosing a spatial scale and minimum data set. What shall be achieved with the study and why.
3. Contact master wetland dataset administrator for overview of current knowledge and metadata of existing data	There may be baseline or updated knowledge available in the master database that can contribute to a successful start of the study.
4. Review other existing knowledge and Information regarding the area of interest	Review the published and unpublished literature and determine the extent of knowledge and information available for wetlands in the region being considered.
5. Review technical requirements, what is needed to obtain comparable and overall compatible data	Data exchange protocols should be agreed and standards adhered to in order to work with compatible products and assure easy data exchange.
6. Review existing methods and select method appropriate to objective based on study area extent, required accuracy, desired resolution, timeframe, skills and budget	Review available methods and seek expert technical advice to choose the methods that can supply the required information and ensure that suitable data management processes are established.

Step	Guidance
7. Establish dataset including spatial, tabular and narrative information. Fitting the date, resolution and spatial extent required for the purpose of the study	Identify the core, or minimum, data set sufficient to describe the location and size of the wetlands and any special features. This can be complemented by additional information on factors affecting the ecological character of the wetlands and other management issues if required. The assessment should also result in the definition of the spatial extent of the study area.
8. Establish a data management system for base dataset and generated data	Establish clear protocols for collecting, recording and storing data, including archiving in electronic or hardcopy formats. This should enable future users to determine the source of the data, and its accuracy and reliability. At this stage it is also necessary to identify suitable data analysis methods. All data analysis should be done by rigorous and tested methods and all information documented. The data management system should support, rather than constrain, the data analysis. A meta-database should be used to record information about the inventory datasets and outline details of data custodianship and access by other users.
9. Setup schedules, responsibilities resources and coordination as well as reporting and review needs	Establish a time schedule for planning the inventory, collecting, processing and interpreting the data collected, reporting the results and regular review of the program. Establish the extent and reliability of the resources available for the inventory. If necessary make contingency plans to ensure that data is not lost due to insufficiency of resources.
10. Fulfil administrative requirements	Field studies may require permissions, data may need to be ordered and other permissions obtained especially in data sharing situations. The requirements should be fulfilled for a successful study start
11. Implement study	The study should be carried out in accordance with the project schedule and budget. Coordination may be necessary where the study is carried out by multiple partners. Mid term reviews and resulting adjustments may be useful for maximizing the study results.

Step	Guidance
12. Contact master wetland dataset administrator for data exchange and potential provision with upgraded wetland information product based on the submitted data	After the study has yielded results, the master wetlands database administrator should be contacted to feed the results back into the master database and to potentially use the query possibilities on the full dataset for obtaining additional study results.

Step 1 – Problem statement, why is new information required

Identification of a problem includes

a. which area is studied
b. what are the conceptional processes in the study area
c. what has triggered the need for studying the area
d. are the research questions comprehensive or may more be needed?

Step 2 - State the purpose and objective, what shall be achieved

Wetland inventory has multiple purposes. These include:

a. listing particular types, or even all, wetlands in an area
b. listing wetlands of local, national and/or international importance
c. describing the occurrence and distribution of wetland taxa
d. describing the occurrence of natural resources such as peat, fish or water
e. establishing a baselines for measuring change in the ecological character of wetlands
f. assessing the extent and rate of wetland loss or degradation
g. promoting awareness of the value of wetlands
h. providing a tool for conservation planning and management
i. developing networks of experts and cooperation for wetland conservation and management

An inventory should contain a clear statement of its purpose and objective. This should identify the habitats that will be considered, the range of information that is required, the time schedule, and who will make use of the information.

A clear statement of the purpose(s) will assist in making decisions about the methods and resources needed to undertake the inventory.

Step 3 - Contact master wetland dataset administrator for overview of current knowledge and metadata of existing data

Agree on:

a. what data for the area of interest can be provided
b. what can be queried based on the data contained in the master database
c. is there information about other studies concerning the area of interest that could potentially have already generated useful information?
d. How does the existing data look like, what are requirements for data use?

Step 4 - Review other existing knowledge and information regarding the area of interest

Past investigations have resulted in the provision of broad-scale wetland inventory information for many parts of the world. Other, more detailed, but localized inventory may have been undertaken, restricted either under consideration.

Valuable information may be held in many different formats and/or by many different organizations (e.g., waterbird, fisheries, water quality and agricultural information bases, and local peoples' information and knowledge).

A comprehensive review of existing data sources may be necessary and its relevance to the proposed inventory work ascertained.

Step 5 - Review technical requirements, what is needed to obtain comparable and overall compatible data

Compare the technical requirements as discussed with the master database administrator with the own setup and existing data. Do reference systems match? Are the same protocols used? Adjust where necessary. The review should include requirements regarding the classification systems and definitions used by the master database.

Step 6 - Review existing methods and select method appropriate to objective based on study area extent, required accuracy, desired resolution, timeframe, skills and budget

A number of established methods for wetland inventory exist. The characteristics of five examples in current use are summarized in RAMSAR Handbook 12. The techniques and habitat classifications used in these methods have been successfully adapted for use in a number of locations.

The review should determine whether or not existing established inventory methods are suitable for the specific purpose and objectives of the inventory being planned.

Some inventory methods use a linked hierarchical approach, in which inventory may be designed at different spatial scales for different purposes.

Many inventories have been based on ground-survey, often with the support of aerial photography and topographical maps and, more recently, satellite imagery. The development of Geographic Information Systems (GIS) and the enhanced resolution of satellite imagery have resulted in greater use of spatial data.

A procedure for determining which remotely sensed datasets are the most appropriate for particular purposes, including their use in GIS, is given in RAMSAR Handbook 12.

The spatial scale used for wetland inventory is inseparable from its objective and greatly influences the selection of the method to be used.
Wetland inventory has been carried out at a number of spatial scales, with specific objectives at each scale. When choosing the scale it is necessary first to determine the objective and then assess how this can be achieved through a chosen scale.

Suitable scales for wetland inventory within a hierarchical approach are:

a. wetland regions within a continent, with maps at a scale of 1:1,000,000 – 250,000
b. wetland aggregations within each region, with maps at a scale of 1:250,000 – 50,000
c. wetland sites within each aggregation, with maps at a scale of 1:50,000 – 25,000.

The choice of scale is also related to the size of the geographic area involved and to the accuracy required and achievable with available resources.

Each of the scales needs a minimum mapping unit that reflects the minimum acceptable accuracy for that scale. This is done by first determining what is the minimum size of feature that can be clearly delineated at that scale, to acceptable standards, and by then determining what measures are required to describe the accuracy/confidence of defining the unit. For example, a land systems map compiled to a scale of 1:250,000 typically involves taking one on-the-ground site observation for every 600 ha surveyed.

Step 7 - Establish dataset including spatial, tabular and narrative information. Fitting the date, resolution and spatial extent required for the purpose of the study

A core or minimum data set sufficient to describe the wetland(s) should be determined. The specific details of this data set are inseparable from the level of complexity and the spatial scale of the inventory.

It is recommended that sufficient information (the core, or minimum, data set) should be collected so as to enable the major wetland habitats to be delineated and characterized for at least one point in time.

The core data can be divided into two components:

a. that describing the biophysical features of the wetland
b. that describing the major management features of the wetland

The decision whether to undertake an inventory based only upon core biophysical data or also to include data on management features will be based on individual priorities, needs, and resources. The second component is likely to provide information that can immediately be used for assessment purposes, but it may require more extensive data collection and analyses. Care should be exercised to ensure that the inclusion of this information does not detract from the primary purpose of obtaining sufficient information to enable the delineation and characterization of the wetlands.

Recommended core data fields for the collection of biophysical and management features of wetlands are listed in Table 1.

Step 8 - Establish a data management system for base dataset and generated data

Increasing use of databases and Geographic Information Systems ensure that a large amount of data can be stored and displayed, but these capabilities will be undermined if the data are not well managed and stored in formats that are readily accessible.

Potential data management problems can be overcome by establishing clear protocols for collecting, recording and storing data, including archiving data in electronic and/or hardcopy formats. The protocols should enable future users to determine the source of the data, as well as its accuracy and reliability. The protocols should also ensure effective recording and reporting of data and information. The data management system should support analysis of the data. Details of all analytical methods should be recorded along with the data and made available to all users. This includes details of statistical techniques and any assumptions about the data.

In addition, a meta-database should be used to record basic information about individual inventory data sets. These metadata records should include a description of the type of data and details of custodianship and access. A standard metadata format has been developed specifically for recording wetland inventory, and further guidance on the use of this inventory metadata standard will be issued by the Ramsar Secretariat.

General good practice guidance on metadata and data custodianship, ownership and access is also available in a handbook produced for the Biodiversity Conservation Information System (BCIS) (Biodiversity Conservation Information System 2000).

The metadata records should be an integral part of the data management system and not treated as a separate entity from the data files, even if these have been archived.

Step 9 - Setup schedules, responsibilities resources and coordination as well as reporting and review needs

It is necessary to determine the time schedule for planning the inventory, as well as for collecting, processing and interpreting the data collected during an inventory. This is particularly important if field sampling is required, in which case a sampling schedule that takes into account any special features of the terrain and sampling techniques will be necessary.

The schedule should be realistic and based on firm decisions about funding and resources. This will determine the extent and duration of the inventory. The schedule should also include time to prepare for the inventory, especially if a team of experts needs to be gathered, and extensive background investigation and review has to be undertaken.

The extent and reliability of the resources available for the inventory will eventually determine the nature and duration of the inventory. The funding to secure and train suitable personnel and obtain appropriate technical resources, such as field equipment and remote sensing data, should be confirmed and steps taken to ensure that these are available when required.

Step 10 – Fulfil administrative requirements

Administrative requirements may include

a. permissions for field studies
b. transboundary data exchange protocols
c. registration of study depending on administrative requirements
d. country specific requirements

Step 11 – Implement study

Once the method has been agreed by following all steps in the above Framework the inventory can be implemented with some confidence. Importantly, that confidence is dependent upon a suitable pilot study being undertaken and confirmation of all individual sampling and data management protocols. Any further changes to the agreed protocols should be recorded and, where necessary, discussed and formalized.

It should be expected that collection of the data for the full inventory will consume most of the time and resources available for the inventory. The steps in the Framework are designed to guide development an overall method and ensure that the inventory can be competently implemented.

All data collected during the inventory should be contained within the agreed data management system, which may include both hardcopy and electronic files and records. Steps should be taken to ensure that the data records are secure and duplicate copies kept in safe locations.

Whilst the steps in the Framework provide the basis for designing an inventory project for specific purposes and with specified resources available, it does not ensure that an inventory will be effective. This can only be done by the personnel engaged to undertake the inventory – the Framework provides an outline of the method, including necessary training and contingency in support of the method.

It must be stressed that all steps in the Framework are necessary, with the pilot study step providing an important feedback and an opportunity to refine the inventory before the main sampling effort commences. Similarly, the review and evaluation step provides an important check on progress and a formal opportunity to adjust or even halt the inventory.

More details and examples are given in Ramsar Handbook 12.

Step 12 - Contact master wetland dataset administrator for data exchange and potential provision with upgraded wetland information product based on the submitted data

After a study has been concluded the master database administrator should be contacted and newly generated data fed back into the master database. The generated data needs to be carefully checked regarding its accuracy and respective statements be included with the uploaded data. Data exchange protocols as advised by the database administrator need to be adhered to in order to fulfil structural integrity requirements for the database. Issues here will include the definition of the reference system that has been used, classification information, estimated accuracy, naming of layers, etc. Respective information will be available with the master database administrator.

10. Priorities for Improving Integrated Wetland Inventory, Assessment and Monitoring

The following practical steps for improving integrated wetland inventory, assessment and monitoring are recommended:

1. All countries that have not yet conducted a national wetland inventory should do so, preferably using an approach that is comparable with other large-scale wetland inventories already underway or complete. These should focus on a basic data set that describes the location and size of the wetland and the major biophysical features, including variation in the areas and the water regime – see the further guidance in the Convention's *Framework for Wetland Inventory* (Ramsar Resolution VIII.6).
2. Once the baseline data have been acquired and adequately stored, more management-oriented information on wetland threats and uses, land tenure and management regimes, benefits and values should be added. When such assessment information is recorded, it should be accompanied by clear records that describe when and how the information was collected and its accuracy and reliability.
3. Each inventory and assessment program should contain a clear statement of its purpose and the range of information that has been collated or collected. This extends to defining the habitats being considered and the date the information was obtained or updated.
4. Priority should be given to improving the global inventory for wetland habitats that are currently poorly covered in most parts of the world, i.e. seagrasses, coral reefs, saltmarshes and coastal tidal flats, mangroves, arid-zone wetlands, rivers and streams, and artificial wetlands.
5. The effectiveness of all aspects of wetland inventory and assessment should be increased through the use of a standardised framework and a generic wetland inventory core dataset (as provided in Resolution VIII.6), designed to be as flexible as possible for use in all regions of the world and to accommodate various inventory and assessment objectives.
6. Models for effective wetland inventory, assessment and monitoring, using appropriate remote sensing and ground techniques, should be compiled and widely disseminated. These should outline useful habitat classifications (e.g., those based initially on landform and not vegetation parameters) and methods and means of collating and storing the information, in particular Geographic Information Systems (GIS) for spatial and temporal data that could be used for monitoring purposes.
7. Wetland monitoring systems should build upon the information provided in wetland inventory and assessment activities. Specific monitoring should be based on a hypothesis derived from the assessment data and be contained within a suitable management structure.

11. Conclusions and Recommendations

Inventory and mapping of wetlands is an important task for the sustainable management of wetlands. This manual has condensed the information available in the Ramsar handbooks focusing on those sections important for the situation in the Nile Basin. It is anyhow important to read the chapters in line with the original Ramsar handbooks that are provided in the Annex, specific points for consideration and practical concern have also been summarized in the main report of this project.

12. Further Reading

Handbooks on the Wise Use of Wetlands http://www.ramsar.org/lib/lib_handbooks2006_e.htm
Wetland Values and Functions http://www.ramsar.org/info/values_intro_e.htm
Towards the Wise Use of Wetlands http://www.ramsar.org/lib/lib_wise.htm
Economic valuation of wetlands: a guide for policy makers and planners http://www.ramsar.org/lib/lib_valuation_e.htm
The Criteria for Identifying Wetlands of International Importance http://www.ramsar.org/key_criteria.htm
Guidelines for the management of groundwater to maintain wetland ecological character http://www.ramsar.org/key_guide_groundwater_e.htm
Wetlands and Integrated Coastal Zone Management (ICZM) http://www.ramsar.org/key_guide_iczm_e.htm
An Integrated Framework for wetland inventory, assessment and monitoring http://www.ramsar.org/key_guide_framework_inventory_e.htm
A Framework for Wetland Inventory http://www.ramsar.org/key_guide_inventory_e.htm
Guidelines for reviewing laws and institutions to promote the conservation and wise use of wetlands http://www.ramsar.org/key_guide_laws_e.htm
New Guidelines for management planning for Ramsar sites and other wetlands http://www.ramsar.org/key_guide_mgt_new_e.htm
Guidelines on Management Planning for Ramsar Sites and Other Wetlands http://www.ramsar.org/key_guide_mgt_old_e.htm
Guidelines for developing and implementing National Wetland Policies http://www.ramsar.org/key_guide_nwp_e.htm
Guidelines for establishing and strengthening local communities' and indigenous people's participation in the management of wetlands http://www.ramsar.org/key_guide_indigenous.htm
Guidelines for the rapid assessment of inland, coastal and marine wetland biodiversity http://www.ramsar.org/key_guide_rapidassessment_e.htm
Principles and guidelines for wetland restoration http://www.ramsar.org/key_guide_restoration_e.htm
Wetland Risk Assessment Framework http://www.ramsar.org/key_guide_risk_e.htm
Guidelines on river basin management http://www.ramsar.org/key_guide_basin_e.htm
River basin management: additional guidance and a framework for the analysis of case studies http://www.ramsar.org/key_guide_riverbasins_e.htm
Identifying and designating under-represented wetland types as Wetlands of International Importance http://www.ramsar.org/key_guide_under-represented_e.htm
Integrated Framework for the RAMSAR Convention's water-related guidance http://www.ramsar.org/key_guide_framework_water_e.htm
Guidelines for the allocation and management of water for maintaining the ecological functions of wetlands http://www.ramsar.org/key_guide_allocation_e.htm
A Conceptual Framework for the wise use of wetlands http://www.ramsar.org/key_guide_framework_wiseuse_e.htm
Guidelines for the Implementation of the Wise Use Concept http://www.ramsar.org/key_guide_wiseuse_e.htm
Additional Guidance for the Implementation of the Wise Use Concept http://www.ramsar.org/key_guide_wiseuse_add_e.htm

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