CONVENTION ON WETLANDS (Ramsar, Iran, 1971)

11th Meeting of the Scientific and Technical Review Panel
Gland, Switzerland, 8-11 April 2003

DOC. STRP11-8

Agenda item 6.1 i)

Background materials concerning further development of guidance on wetland inventory

1. Attached to this note are:

   i) COP8 Resolution VIII.6 "A Ramsar Framework for Wetland Inventory"; and

   ii) Information Paper COP8 DOC. 35 "Information paper: The use of Earth Observation Technology to support the implementation of the Ramsar Convention"

2. These materials provide the background to the high priority task requested of the Panel for 2003-2005 concerning further review of application of remote sensing data, low-cost GIS and classification systems in wetland inventory.

3. The STRP is requested to familiarize itself with the contents of these materials, as the basis for preparing its Work Plan activities on these matters.

4. Concerning remote sensing (Earth Observation), the work funded by the European Space Agency (ESA) in support of the Ramsar Convention reported in COP8 DOC. 35 has now been completed, and a further ESA project concerning the development of Earth Observation methodologies for different wetland types is now in preparation. An update on this will be provided to the Panel at its 11th meeting.

"Wetlands: water, life, and culture"
8th Meeting of the Conference of the Contracting Parties
to the Convention on Wetlands (Ramsar, Iran, 1971)
Valencia, Spain, 18-26 November 2002

Resolution VIII.6

A Ramsar Framework for Wetland Inventory

1. RECALLING Recommendation 1.5, in which the Contracting Parties stated the need to prepare inventories of their wetlands "as an aid to the formulation and implementation of national wetland policies", and Resolution VII.16, in which the Parties adopted guidelines on these matters;

2. RECALLING ALSO Recommendation 4.6, Resolutions 5.3 and VI.12, and Action 6.1.2 of the Strategic Plan 1997-2002, in all of which the Parties recognized the value of national inventories for identifying sites suitable for inclusion in the List of Wetlands of International Importance (the Ramsar List) under the Convention;

3. AWARE that in Action 6.1.3 of the Strategic Plan 1997-2002 and Resolution VII.20 the Parties also recognized the importance of baseline wetland inventory for quantifying the global wetland resource as the basis for assessment of its status and trends, for identifying wetlands suitable for restoration, and for risk and vulnerability assessments;

4. NOTING that this meeting has adopted *Principles and guidelines for wetland restoration* (Resolution VIII.16); *Wetland issues in Integrated Coastal Zone Management (ICZM)* (Resolution VIII.4); *Additional guidance for identifying and designating under-represented wetland types as Wetlands of International Importance* (Resolution VIII.11); *New Guidelines for management planning for Ramsar sites and other wetlands* (Resolution VIII.14); and *Guidelines for Global Action on Peatlands* (Resolution VIII.17), the implementation of all of which will be substantially assisted by the availability of wetland inventory at national and other scales;

5. RECALLING the findings of the report of Wetlands International entitled *Global Review of Wetland Resources and Priorities for Wetland Inventory* (GRoWI), from which it was indicated to COP7 that few countries, if any, had comprehensive national inventories of their wetland resources, and that it was not possible to provide a clear baseline estimate of the world's wetland resources with any confidence;

6. NOTING that a joint project between Wetlands International and the Institute for Inland Water Management and Waste Water Treatment (RIZA) in the Netherlands has expanded and updated the GRoWI analyses for all European countries;

7. AWARE that the Millennium Ecosystem Assessment (MA) is evaluating the condition, status and trends in global ecosystems including inland wetlands, subterranean (karst), and coastal and marine systems, and that this will include new applications of remote sensing which may enhance information on the global distribution of wetlands and their status;

8. ALSO AWARE that the European Space Agency's project Treaty Enforcement Services using Earth Observation (TESEO) is evaluating the use of remote sensing for wetland inventory, assessment, monitoring and site management, as well as for dryland ecosystems;

9. RECALLING that in Resolution VII.20 the Conference of the Parties urged "all Contracting Parties yet to complete comprehensive national inventories of their wetland resources, including where possible wetland losses and wetlands with potential for restoration, to give highest priority in the next triennium to the compilation of comprehensive national inventories", but NOTING with concern that in their National Reports to this meeting only 51 Contracting Parties have reported the existence of partial inventories or the initiation of national wetland inventory, and only 29 the completion of comprehensive inventories;

10. ALSO RECALLING that in Resolution VII.20 the Contracting Parties requested the Scientific and Technical Review Panel (STRP), in collaboration with Wetlands Intentional, the Ramsar Bureau, and other interested organizations, to review and further develop existing models for wetland inventory and data management, including the use of remote sensing and low-cost and user-friendly geographic information systems, and to report their findings to the 8th Meeting of the Conference of the Contracting Parties with a view to promoting international common standards;

11. FURTHER RECALLING that in Resolution VII.20 the Contracting Parties resolved that their inventory data, where it exists, should be housed and maintained in such a way that the information resource should be available to all decision-makers, stakeholders, and other interested parties;

12. APPRECIATIVE of the financial support of the governments of the United Kingdom and the United States of America for the preparation by the STRP of further guidance on wetland inventory; and

13. RECOGNIZING that various methodologies for national inventory can in general be applied also to local, sub-national (e.g. provincial), and transboundary international scales;

THE CONFERENCE OF THE CONTRACTING PARTIES

14. ADOPTS the *Framework for Wetland Inventory* as annexed to this Resolution;

15. RECOGNIZES that it is appropriate to apply different wetland inventory approaches, methods and wetland classifications for different purposes and objectives, but that common standards can be achieved by ensuring consistency in the collection of a core (minimum) dataset, as provided in the Framework;

16. URGES all Contracting Parties that have yet to complete comprehensive national wetland inventories to continue to give a high priority in the next triennium to the compilation of such inventories, utilizing the *Framework for Wetland Inventory* to ensure that their inventory design appropriately addresses their purpose and objectives, in order that their activities that require the sound basis of wetland inventory, such as policy development and Ramsar site designations, can be carried out on the basis of the best possible information;

17. ENCOURAGES Contracting Parties initiating development of a national wetland inventory to consider the application or adaptation of an existing inventory methodology and data management system, including the updated inventory methodology developed by the Mediterranean Wetlands Initiative (MedWet), the Asian Wetland Inventory and other appropriate methodologies, so as to ensure consistency in inventory data and information collected;

18. CALLS UPON Contracting Parties that have undertaken wetland inventories to ensure that they have appropriate arrangements in place for housing and maintaining their wetland inventory data, both in printed and electronic formats, and, where appropriate, to make this data and information available, including where possible through the World Wide Web and CD-ROM formats, to all decision-makers, stakeholders, and other interested parties;

19. ALSO CALLS UPON all Contracting Parties and others who have undertaken, or are undertaking, wetland inventory to document information about the inventory, its data holdings, management and availability using the standard metadata record provided in the *Framework for Wetland Inventory*, so as to make this information available as widely as possible;

20. REQUESTS the Ramsar Bureau and Wetlands International, working with its Wetland Inventory and Monitoring Specialist Group, to make available, if possible, the standard metadata record for wetland inventory on the World Wide Web so that Contracting Parties and others can report and make fully available the information about their wetland inventories, and so as to assist in the updating by Wetlands International of global information about the status of wetland inventory;

21. ENCOURAGES Contracting Parties and other interested organizations and funding bodies to provide resources to Wetlands International, working with other relevant organizations, to review and update the *Global Review of Wetland Resources and Priorities for Wetland Inventory* (GRoWI) report made available to COP7, and to report on its findings to the 9th Meeting of the Conference of the Contracting Parties, including progress in the implementation of Resolution VII.20;

22. REQUESTS the Scientific and Technical Review Panel, working with Wetlands International, the Ramsar Bureau, remote sensing agencies, and other interested organizations to review further the application of remote sensing data, low-cost geographical information systems, and classification systems in wetland inventory, and to report on its findings to the 9th Meeting of the Conference of the Contracting Parties;

23. CALLS UPON Contracting Parties and other organizations with experience in training and capacity building in wetland inventory, including in the use of remote sensing and geographical information systems, to work with Wetlands International in order to make available this expertise through the Ramsar Training Framework, once established;

24. FURTHER CALLS UPON bilateral and multilateral donors to assign priority to supporting wetland inventory projects in developing countries and countries with economies in transition, noting the importance of such projects in forming the basis for developing and implementing the sustainable use of wetlands; and

25. REQUESTS Contracting Parties to give priority to submitting wetland inventory projects to the Ramsar Small Grants Fund.

Annex

A Framework for Wetland Inventory

Background and context

1. In Resolution VII.20 (1999) the Contracting Parties recognised the importance of comprehensive national inventory as the vital basis for many activities necessary for achieving the wise use of wetlands, including policy development, identification and designation of Ramsar sites, documentation of wetland losses, and identification of wetlands with potential for restoration (see also Resolutions VII.16 and VIII.17). It also encouraged the collection of information for the management of shared wetlands, including those within river basins and/or coastal zones (see also Resolutions VII.18 and VIII.4) as appropriate. Furthermore, Operational Objective 1 of the Convention's Strategic Plan 2003-2008 is devoted to wetland inventory and assessment, with a series of concrete actions to achieve this Operational Objective.

2. The *Global Review of Wetland Resources and Priorities for Wetland Inventory* (GRoWI), prepared in 1999 for the Ramsar Convention by Wetlands International and the Environmental Research Institute of the Supervising Scientist, Australia, indicated that few countries have comprehensive national inventories of their wetland resources, and lack this essential baseline information on their wetlands. In addition, the National Reports submitted to Ramsar COP8 indicated that insufficient progress has been made in wetland inventory.

3. The GRoWI review concluded that a clear identification and statement of purpose and objectives is fundamental to the design and implementation of effective and cost-efficient inventory, but found that the purpose and objectives for many existing inventories were poorly, if at all, stated.

4. In Resolution VII.20 the COP urged Contracting Parties which had yet to complete national inventories of their wetland resources to give the highest priority to the compilation of comprehensive wetland inventories, and requested the Convention's Scientific and Technical Review Panel (STRP) to review and further develop existing models for wetland inventory and data management, including the use of remote sensing and low-cost and user-friendly geographic information systems.

5. This *Framework for Wetland Inventory* has been developed by the STRP, working with the Ramsar Bureau, Wetlands International, the Environmental Research Institute of the Supervising Scientist (Australia) and others, in response to Resolution VII.20. The Framework provides guidance on a standard approach to designing a wetland inventory program. It includes information on determining appropriate remote sensing techniques to apply, wetland classifications and existing standardised inventory methods, and recommends standards for core data fields and data and metadata recording.

6. The Framework provides guidance for designing wetland inventory at multiple scales from site-based to provincial, national and regional. The extent of detail that can be compiled in the inventory will generally decrease as the geographical area of coverage increases, unless large resources can be allocated for the program.

7. The data fields included in any particular inventory will be based on the specific purpose and scale of the inventory. A core data set is recommended as a minimum, but with the option of adding further data fields as required.

8. The Framework uses the definition of "inventory" agreed in Workshop 4 on *Wetland Inventory, Assessment and Monitoring – Practical Techniques and Identification of Major Issues* held during the 2nd International Conference on Wetlands and Development, Dakar, Senegal, 8-14 November 1998 (Finlayson *et al.* 2001). The definition is provided below along with those for the inter-connected concepts of assessment and monitoring:

    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: 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. (Note that the collection of time-series information that is not hypothesis-driven from wetland assessment should be termed *surveillance* rather than monitoring, as outlined in Resolution VI.1.)

9. It is important to distinguish between inventory, assessment and monitoring when designing data gathering exercises, as they require different categories of information. Wetland inventory provides the basis for guiding the development of appropriate assessment and monitoring, but wetland inventories repeated at given time intervals do not constitute 'monitoring'.

A framework for wetland inventory

10. A structured framework for planning and designing a wetland inventory is summarized in Table 1. The framework comprises 13 steps that provide the basis for making decisions in relation to the purpose (and objectives), and the available resources, for an inventory.

11. 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.

12. 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 1. A structured framework for planning a wetland inventory

Step	**Guidance**
1. State the purpose and objective	State the reason(s) for undertaking the inventory and why the information is required, as the basis for choosing a spatial scale and minimum data set.
2. Review existing knowledge and information	Review the published and unpublished literature and determine the extent of knowledge and information available for wetlands in the region being considered.
3. Review existing inventory methods	Review available methods and seek expert technical advice to: a) choose the methods that can supply the required information; and b) ensure that suitable data management processes are established.
4. Determine the scale and resolution	Determine the scale and resolution required to achieve the purpose and objective defined in Step 1.
5. Establish a core or minimum data set	Identify the core, or minimum, data set sufficient to describe the location and size of the wetland(s) and any special features. This can be complemented by additional information on factors affecting the ecological character of the wetland(s) and other management issues, if required.
6. Establish a habitat classification	Choose a habitat classification that suits the purpose of the inventory, since there is no single classification that has been globally accepted.
7. Choose an appropriate method	Choose a method that is appropriate for a specific inventory based on an assessment of the advantages and disadvantages, and costs and benefits, of the alternatives.
8. Establish a data management system	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: a) record information about the inventory datasets; and b) outline details of data custodianship and access by other users.
9. Establish a time schedule and the level of resources that are required	Establish a time schedule for: a) planning the inventory; b) collecting, processing and interpreting the data collected; c) reporting the results; and d) 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. Assess the feasibility & cost effectiveness	Assess whether or not the program, including reporting of the results, can be undertaken within under the current institutional, financial and staff situation. Determine if the costs of data acquisition and analysis are within budget and that a budget is available for the program to be completed.

11. Establish a reporting procedure	Establish a procedure for interpreting and reporting all results in a timely and cost effective manner. The report should be succinct and concise, indicate whether or not the objective has been achieved, and contain recommendations for management action, including whether further data or information is required.
12. Establish a review and evaluation process	Establish a formal and open review process to ensure the effectiveness of all procedures, including reporting and, when required, supply information to adjust or even terminate the program.
13. Plan a pilot study	Test and adjust the method and specialist equipment being used, assess the training needs for staff involved, and confirm the means of collating, collecting, entering, analysing and interpreting the data. In particular, ensure that any remote sensing can be supported by appropriate "ground-truth" survey.

Step 1 State the purpose and objective

13. 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; and
    i) developing networks of experts and cooperation for wetland conservation and management.

14. 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.

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

Step 2 Review existing knowledge and information

16. 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 geographically or to particular wetland habitats or ecosystems in the region under consideration.

17. 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).

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

Step 3 Review existing inventory methods

19. A number of established methods for wetland inventory exist. The characteristics of five examples in current use are summarized in Appendix I. Further sources of information are listed in Appendix VI. The techniques and habitat classifications used in these methods have been successfully adapted for use in a number of locations.

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

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

22. 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.

23. A procedure for determining which remotely sensed datasets are the most appropriate for particular purposes, including their use in GIS, is given in Appendix II. A summary of currently available remote sensing data sets that can be applicable to wetland inventory is provided in Appendix III.

Step 4 Determine the scale and resolution

24. The spatial scale used for wetland inventory is inseparable from its objective and greatly influences the selection of the method to be used.

25. 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.

26. 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.

27. 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.

28. 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 5 Establish a core or minimum data set

29. 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.

30. 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.

31. The core data can be divided into two components:

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

32. 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 wetland(s).

33. Recommended core data fields for the collection of biophysical and management features of wetlands are listed in Table 2.

Table 2. Core (minimum) data fields for biophysical and management features of wetlands

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 values and benefits (goods and services) derived from the wetland – including products, functions and attributes (see Resolution VI.1) and, where possible, their services to human well-being (see 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 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.

Step 6 Establish a habitat classification

34. Many national wetland definitions and classifications are in use (Appendix IV). These have been developed in response to different national needs and take into account the main biophysical features (generally vegetation, landform and water regime, sometimes also water chemistry such as salinity) and the variety and size of wetlands in the locality or region being considered.

35. The Ramsar Classification System for Wetland Type (Resolution VI.5) is increasingly being used as a classification basis for national wetland inventories. However, when it was first developed it was not anticipated that the Ramsar classification would be used for this inventory purpose, so its usefulness as a habitat classification for any specific wetland inventory should be carefully assessed. Whilst the Ramsar Classification System has value as a basic habitat description for sites designated for the Ramsar List of Wetlands of International Importance, it does not readily accommodate description of all wetland habitats in the form and level of description that are now commonly included in many wetland inventories.

36. A classification based upon the fundamental features that define a wetland – the landform and water regime – is considered to be superior to those based on other features (Resolution VII.20). The basic landform and water regime categories within such a classification can be complemented with modifiers that describe other features of the wetland, for example, for vegetation, soils, water quality, and size.

37. As it is unlikely that a single classification can be globally acceptable, not least because different classification systems are required by some national legislations, a classification should be chosen that suits the purpose of the inventory. The core biophysical data recommended to be collected in an inventory (Table 2) may be used to derive a classification that suits individual needs.

Step 7 Choose an appropriate method

38. Many inventory methods are available (see Appendices I and IV for examples). When assessing which method (or methods) is appropriate for an inventory, it is necessary to be aware of the advantages and disadvantages of the alternatives in relation to the purpose and objective of the proposed inventory work. This applies particularly to the use of remotely sensed data (as listed in Appendix III).

39. To assist in determining which remote sensing data is most useful for a particular inventory, a simple decision-tree is provided in Appendix II. The decision-tree is also presented pictorially and contains six steps to assist in determining which data are most suitable. Importantly, the extent of "ground-truth" survey required to validate the remote sense data should be assessed when considering such techniques.

40. Physico-chemical and biological sampling should be undertaken whenever possible by standard laboratory and field methods that are well documented and readily available in published formats. There is a variety of acceptable methods in use. The bibliographical details of those used should be recorded and any departures from standard procedures clearly justified and documented.

41. As a general rule, the inventory method chosen should be sufficiently robust to ensure that the required data can be obtained within the constraints imposed by the terrain, resources, and time period available. Where adequate methods do not exist, well-directed research is needed to develop or identify specific techniques.

42. The use of Geographic Information Systems (GIS) for managing spatial data, in particular, is encouraged, noting that low-cost GIS platforms are increasingly available and widely-used.

Step 8 Establish a data management system

43. 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.

44. 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.

45. 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.

46. In addition, a meta-database should be used to record basic information about individual inventory data sets. These meta-data 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 (Appendix V), and further guidance on the use of this inventory metadata standard will be issued by the Ramsar Bureau.

47. General good practice guidance on meta-data 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).

48. The meta-data 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 Establish a time schedule and the level of resources that are required

49. 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.

50. 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.

51. 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 Assess the feasibility and cost effectiveness of the project

52. Once a method has been chosen and a time schedule determined, it is necessary to assess whether or not it is feasible and cost effective to undertake the project. This assessment is essentially a review of the entire inventory method, including the time schedule and costs.

53. Factors that influence the feasibility and cost effectiveness of the project include:

- availability of trained personnel;
- access to sampling sites;
- availability and reliability of specialized equipment for sample collection or analysis of samples;
- means of analyzing and interpreting the data;
- usefulness of the data and information derived from it;
- means of reporting in a timely manner; and
- financial and material support for any continuation of the project.

Step 11 Establish a reporting procedure

54. The results obtained in the inventory should be recorded and reported in a timely and cost effective manner. The records should be concise and readily understood by others involved in the program or similar investigations. Where necessary the records should be cross-referenced to other documentation from the inventory.

55. It is important to keep in mind that the data may be useful for further analyses in the future – the analysts involved should be able to readily access and interpret the data records and be aware of any constraints on their usefulness for such purposes. In this respect the reporting procedure should incorporate reference to the meta-database and archived data.

56. A report on the inventory should be prepared at pre-determined intervals. It should be succinct and concise and indicate whether or not the purpose and objective of the inventory is being achieved, and whether there are any constraints on using the data (e.g. changes to the sampling regime such as lack of replication or concerns about its accuracy).

57. The core data should be made available to interest groups in appropriate formats along with details of the methods used. Reports may present the data collected and/or contain specific recommendations for further inventory and data collection, or for management action.

58. At the same time, a meta-data record of the inventory should be made and added to a centralized file using a standardized format.

59. All reports should be made available to interested parties and other agencies in the shortest possible time through appropriate electronic and hardcopy formats.

Step 12 Review and evaluate the inventory

60. Throughout the inventory it may be necessary to review progress and make adjustments to the sampling regime, data management, and program implementation. The review and evaluation process should be developed and agreed as part of the planning and design phase of the inventory. The review procedures should establish that when changes are made they should be recorded and made known to all involved in the inventory.

61. The review procedures should also establish that at the end of the inventory, or after a predetermined time period, the entire process should be re-examined and necessary modifications made and recorded. The evaluation procedures should be designed to illustrate both the strengths and the weaknesses of the inventory, including necessary reference to the sampling regime and/or the data quality.

62. The evaluation can also be used to justify a request for ongoing funding. If the inventory has been a success and achieved its purpose and objective, this should be clearly stated and the program brought to an end. Conversely, if the inventory has not achieved its purpose and objective, this also should be clearly stated along with a recommendation as to whether it should continue, possibly in a revised form, or halted.

Step 13 Plan a pilot study

63. Before launching an inventory a pilot study is essential. The pilot study provides the mechanism through which to confirm or alter the time schedule and the individual steps within the chosen method. It also provides the opportunity to develop individual workplans for all personnel.

64. The pilot study phase is the time to fine-tune the overall method and individual steps and test the basic assumptions behind the method and sampling regime. Specialist field equipment should be tested and, if necessary, modified, based on practical experience. It is also the opportunity to assess training needs. The amount of time and effort required to conduct the pilot study will vary considerably – its importance will be shown by the improvements made to the schedule and design of the inventory.

65. The pilot study provides the final step before commencing the wetland inventory itself. Lessons learnt during the pilot study should be incorporated into the inventory method.

Implementation of the inventory

66. 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.

67. 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.

68. 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.

69. 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.

70. 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.

Appendix I

Inventory methods

71. Standardized inventory methods are available and have been successfully used in different circumstances, countries or regions. Notable amongst these are the Mediterranean Wetlands Initiative (MedWet) inventory, the United States Fish and Wildlife Service national wetland inventory, the Ugandan national wetland inventory, the Asian wetland inventory, and the Ecuador national wetland inventory.

72. The characteristics of these examples are summarised below in terms of each of the 13 Framework steps. These examples have been chosen principally as they were considered comprehensive examples of existing methods, but also because they illustrate differences in approaches that could be used in different locations, for different purposes, and at different scales. The need for different methods and wetland classifications (see also Appendix IV) that enable local and national needs to be met must be stressed: this is illustrated by the range of examples below.

Mediterranean Wetlands Initiative (MedWet) inventory

73. This is a set of standard but flexible methods and tools, including a database for data management, for inventory in the Mediterranean region. Although not intended as a pan-Mediterranean wetland inventory, it has provided a common approach that has been adopted, and adapted, for use in several Mediterranean countries and elsewhere.

1. Purpose and objective	To identify where wetlands occur in Mediterranean countries and ascertain which are priority sites for conservation; to identify the values and functions for each wetland and provide a baseline for measuring future change; and to provide a tool for planning and management and permit comparisons between sites.
2. Information review	A process of consultation with an advisory group of experts from the Mediterranean and elsewhere. This group considered the experience and knowledge gained from other inventory and various Ramsar guidelines on managing wetlands.
3. Review methods	Considered database methods used elsewhere in Europe, United States and Asia. Compatibility with wetland databases being used in Europe was a key consideration, e.g. the CORINE Biotopes program. The method was designed to include both a simple and a complex data format.
4. Scale and resolution	Multiple scales for river basins, wetland sites and habitats have been adopted.
5. Core data set	Standard data sheets have been established for river basins, wetland sites (identification, location, description, values, status), habitat, flora, fauna, activities and impacts, meteorological data, and references.
6. Habitat classification	Ramsar classification can be used at a broad scale. For detailed information on sites the United States National Wetland Inventory classification has been adapted.
7. Method	Five steps: i) site selection; ii) Site identification through cartographic means or remote sensing with field assessment; iii) habitat

	classification; iv) data collection and management through standard data sheets and database; and v) map production using standard conventions.
8. Data management	Based on a standard database, initially developed in FoxPro in MS-DOS, and updated in 2000 in Microsoft Access. [Note. A further updated database, using MS Visual Basic software, and including mapping/GIS capability, due for release 2002.]
9. Time schedule and resources	Dependent on the complexity of the inventory. A simple inventory can be done with minor resources while a detailed inventory requires greater human and financial resources.
10. Feasibility & cost effectiveness	Assessed in France before being made available for on-ground pilot studies. The feasibility of the program is built around having a flexible approach that reflects the resources that are available for the inventory.
11. Reporting	Standardized data sheets provided for storing information and a database for ease of reporting. Specific formats for reports can be determined and included.
12. Review and evaluation	An inventory working group has been established to assess progress with undertaking and using the information from inventories using this approach, and to update the information and methods as necessary.
13. Pilot study	Undertaken in Portugal, Morocco, Greece, Spain and France.
Further information	Costa, Farinha, Tomas Vives & Hecker 1996 & 2001; Hecker, Costa, Farinha & Tomas Vives 1996. http://www.wetlands.org/pubs&/wetland_pub.html

United States national wetland inventory

74. A long running national program that has developed a classification and methodology for producing a map-based inventory.

1. Purpose and objective	To conduct a natural resource inventory of wetlands for use in wetland planning, regulation, management and conservation.
2. Information review	Reviewed the extent of wetland survey and inventory to determine the status of wetland protection and the availability of maps of wetlands.
3. Review methods	Reviewed existing wetland inventory and consulted with state and federal agencies to determine what inventory techniques were being used.
4. Scale and resolution	Maps produced at a scale of 1:80 000 or 1:40 000.
5. Core data set	Standardized data collection is undertaken in line with the information required for the habitat classification and production of standard maps for each state.
6. Habitat classification	Hierarchical classification developed as an integral part of the inventory to describe ecological units and provide uniformity in concepts and terms.
7. Method	Based on interpretation of color infrared aerial photographs, initially at 1:24 000 and more recently at 1:40 000 to 1:80 000 scale. The mapping unit varies according to the region and ease of identifying

	wetlands. The method includes field checking and stereoscopic analysis of photographs. Other remote sensing techniques are being tested.
8. Data management	Maps and digital data are made available online at www.nwi.fws.gov. Data is analyzed through GIS using ARC-INFO.
9. Time schedule and resources	Ongoing program since 1974. Maps are updated as needed and when funding is available.
10. Feasibility & cost effectiveness	Large scale program was extensively funded and a large proportion of the country is now mapped. A statistical design was incorporated to provide valid representative figures for selected areas.
11. Reporting	National wetland trends are produced periodically, based on statistical sampling. Mapping targets have been set through legislation that has periodically been revised.
12. Review and evaluation	The inventory has been under regular review and its outputs evaluated and new targets and priorities established.
13. Pilot study	An extensive phase of method development was undertaken before the inventory was considered operational. The classification system which underpins the inventory was extensively tested in the field.
Further information	Cowardin, Carter, Golet & LaRoe 1979; Cowardin & Golet 1995; Wilen & Bates 1995 www.nwi.fws.gov

Uganda National Wetlands Programme

75. The inventory is a component of an ongoing National Wetlands Program. It is largely carried out at the local level, using standard formats, and includes a training component.

1. Purpose and objective	To survey, describe, quantify and map all wetlands and provide decision-makers and planners, especially at district level, with information for management planning; to support policy implementation; to support economic valuation; and to support overall natural resource management planning.
2. Information review	Undertook literature review prior to the onset of the inventory.
3. Review methods	Carried out a review prior to the onset of the inventory process.
4. Scale and resolution	Uses SPOT imagery at 1:50 000 to cover the country.
5. Core data set	Bio-physical data encompassing site name, area, location, general description, seasonality, biota (vegetation types and animals present) and management data covering land-use, land tenure, conservation status, values, threats.
6. Habitat classification	Derived from landform, water regime and vegetation.
7. Method	GIS-based map analyses based on remotely sensed data alongside topographic maps of similar scale (1:50 000) as well as ground surveys. Uses standard data sheets. All wetlands are coded. Methods are documented in a wetland inventory guide. Activity is carried out on district basis with personnel from the district being designated to carry out the fieldwork and compile reports.

8. Data management	A computerized database using Microsoft Access was based on the standardized field data sheets. This database will be linked to the ArcView map database using wetland codes. The linkage between the two databases forms the National Wetland Information System (NWIS) which is already developed with ongoing data entry.
9. Time schedule and resources	An ongoing process with regular updates. The inventory is one of the main activities of a donor-funded National Wetlands Program with a number of partners.
10. Feasibility & cost effectiveness	Feasibility assessed through pilot studies. Cost effectiveness related to the complexity of the wetland systems, extent of areas being assessed, availability of remotely sensed images and capacity.
11. Reporting	Standardized data sheets used for storing information in a database for ease of reporting. Individual reports prepared at district level. These will be consolidated into a National Wetland Inventory.
12. Review and evaluation	Done within the project in consultation with a few external experts.
13. Pilot study	Undertaken in a few wetlands and then districts..
Further information	National Wetlands Programme 1999; Pabari, Churie & Howard 2000. www.iucn.org/themes/wetlands/uganda.html

Asian Wetland Inventory (AWI)

76. This approach has been developed in response to the recommendations contained in the *Global Review of Wetland Resources and Priorities for Wetland Inventory* report and presented in Resolution VII.20. The method is a hierarchy that can be implemented at four spatial scales. The method is based largely on a draft protocol developed in Australia, and has been tested in a pilot study in Japan. The pilot study has resulted in a manual being produced.

1. Purpose and objective	To provide a hierarchical database on coastal and inland wetlands in Asia
2. Information review	Undertaken in the extensive global review of wetland inventory conducted on behalf of the Ramsar Convention (see Resolution VII.20)
3. Review of methods	Undertaken in the extensive global review of wetland inventory conducted on behalf of the Ramsar Convention and refined through the development of a manual.
4. Scale and resolution	Hierarchical multi-scalar approach with four levels of analysis: level 1 at 1:10 000 000 to 1:5 000 000; level 2at 1:1 000 000 to 1:250 000; level 3 at 1: 250 000 to 1:100 000; and level 4 at 1:50 000 to 1:25 000.
5. Core data set	Hierarchical multi-scalar minimum data at each level of analysis: level 1 – broad geology, land cover and climate for river basins; level 2 – geology, landforms, climate for wetland regions; level 3 – hydrological, climate, landform, physico-chemical, and biological detail for wetland complexes; and level 4 information on management issues and procedures included, in addition to site descriptions as per level 3
6. Habitat classification	Derived from minimum data on landform and water regimes and possibly supplemented with information on vegetation, areal size and water quality.

7. Method	GIS-based map analyses using remotely sensed imagery and maps augmented with ground surveys that are more intensive at levels 3 and 4. Prescribed data sheets and fields with agreed codes are available for each level of analysis.
8. Data management	The data management system is built on a computerized database engine with web, user/data interface and GIS capabilities. This serves as the primary data management/storage/retrieval component of the project. The system is based on the Windows platform using MS Visual Basic and Access 97 software. The website (www.wetlands.org/awi) serves as the main communication node for data collection, announcements and discussions.
9. Time schedule and resources	An ongoing process with regular updates of information obtained through national or local analyses. The program has been devolved through the regionalized structure of Wetlands International and its partners.
10. Feasibility & cost effectiveness	Feasibility assessed through project meetings and submission of funding applications that required targeted outputs etc. Cost effectiveness related to the extent of the areas being assessed and the extent of pre-existing inventory information, maps and remotely sensed images. The procedure was based on the Ramsar Convention's review of wetland inventory that found many inventories did not achieve their purpose through being over-ambitious and/or not applying tight data management and reporting procedures – all features that have been addressed.
11. Reporting	Standardized data sheets provided for storing information in a database for ease of reporting. Individual reports are provided through the devolved projects and where appropriate copies filed by Wetlands International on its web page (www.wetlands.org/awi/).
12. Review and evaluation	Provided at the Wetlands International seminar "Wetlands in a Changing World" held in Wageningen, The Netherlands, 30 November 2001.
13. Pilot study	Undertaken in Japan – Hokkaido and Kushiro Marsh with maps produced in a GIS format.
Further information	Finlayson, Howes, Begg & Tagi 2002; Finlayson, Howes, van Dam, Begg & Tagi 2002 www.wetlands.org/awi/

Ecuador wetland inventory

77. This is a national wetland inventory nearing completion that has been developed by the Ministry of the Environment, the Ramsar Bureau, and the EcoCiencia Foundation, and is designed to support Ecuador's implementation of the Ramsar Convention and the wise use of wetlands.

1. Purpose and objective	To provide information to assist in the management of globally important biodiversity in Ecuadorian wetlands, supporting Ecuadorian wetlands conservation through the identification, characterization and prioritization of wetlands for management and conservation.

2. Information review	Published documents and material on the internet and held by universities, research organisations and from a national workshop on the identification and status of wetlands was assessed.
3. Review of methods	Inventory methods used in Canada, Venezuela, Brazil and parts of Argentina were reviewed. Each method was considered to have limitations for application in Ecuador, including too resource and capacity demanding, too little background information available in Ecuador, lacking an ecosystem (catchment)-scale approach, or only reliant on secondary information sources.
4. Scale and resolution	Information was collected at 1:50,000 scale. As some wetlands were too large to use maps at this scale, large individual sites are presented at different scales but information on them held in the database at 1:50,000 scale.
5. Core data set	The data was collected using a quadratical-based matrix that included five selected general criteria, each validated through a series of analysed variables. Information was gathered on social, economic, zoological, botanical, limnological, ecological (including aquatic and terrestrial) features.
6. Habitat classification	The habitat classification followed two existing systems being used in Ecuador.
7. Method	The method includes the following steps: information collected using remote sensing; validation and delineation of zones using a numerical matrix; information on socio-economical and ecological aspects of wetlands derived from interviews; published information reviewed; primary information on ecological and social aspects of wetlands generated. Data was entered into a GIS containing physiographic layers so as to permit the production of recommended land-use strategy and management proposals for the wetlands within their catchments.
8. Data management	Cartographic information is managed by the department of Geographical Information Systems (GIS). Other information is maintained in digital formats by individual researchers. A database of wetland photographs is also maintained.
9. Time schedule and resources	The project began in 1996 with pilot studies in two provinces. Nation-wide coverage was intended to be completed by July 2002 but has now been extended to early 2003 for financial reasons. The total project cost is US$ 1 million over the seven years of the project, with funding from the Ramsar Bureau, the World Bank, the Global Environment Fund, the MacArthur Foundation and the Ecuadorian Government.
10. Feasibility & cost effectiveness	Feasibility and cost effectiveness was assessed in the project development phase through the World Bank's incremental costs assessment procedures.
11. Reporting	Published reports will be produced, and data held electronically in the GIS database.
12. Review and evaluation	Six-monthly World Bank evaluation of the process and progress in achievements of targets. Final report will have pre-publication review by the Ramsar Bureau. The Ecuador National Wetlands Working Group will consider the final publication.

13. Pilot study	A pilot study was undertaken in 1996 of the lentic wetlands, in the Provinces of Esmeraldas and Manabí.
Further information	Briones, E., Flachier, A., Gómez, J., Tirira, D., Medina, H., Jaramillo, I., & Chiriboga, C. 1997. Inventario de Humedales del Ecuador. Primera parte: Humedales Lénticos de las Provincias de Esmeraldas y Manabí. EcoCiencia/ INEFAN/ Convención de Ramsar. Quito, Ecuador. Briones, E., Gómez, J., Hidalgo, A., Tirira, D., & Flachier, A. 2001. Inventario de Humedales del Ecuador. Segunda parte: Humedales Interiores de la Provincia de El Oro. Convención de Ramsar/ INEFAN/ EcoCiencia. Quito, Ecuador.

Appendix II

Determining the most appropriate remotely sensed data for a wetland inventory

78. The following steps provide an outline procedure for assessing which is the most appropriate remote sensing technique for a particular inventory. The procedure is summarized graphically in Figure 1. Available remote sensing data sets applicable to wetland inventory are listed in Appendix III.

79. Much of the information required for this specific determination concerning use of remote sensing can be acquired by following the inventory Framework steps that lead to the choice of an inventory method.

I. Define the purpose and objective

80. Explicitly define the purpose and objective for the inventory (e.g., distribution of specific plant species on a floodplain wetland, baseline data for areas inundated by floodwaters, type of habitats to be mapped, etc.).

II. Determine if remote sensing data is applicable

81. Assess whether remote sensing technology can be applied successfully as a tool to the wetland issues defined previously. This decision will be based on a combination of wetland habitat structure and sensor characteristics and explicitly relates to the spatial and spectral resolution of the remote-sensing device. Expert advice may be needed.

III. Define the wetland characteristics within a remote sensing context

82. Determine the spatial scale most suitable for the habitat structure, the season for data collection, the spectral characteristics and resolution that are critical to sensor choice, and what data and sensors are already available. If multiple surveys are required, determine at the outset the most appropriate temporal scale (e.g., annually or over much longer time periods).

IV. Choose appropriate sensor(s)

83. Assess the spatial and spectral resolution of likely sensors and ensure that they can obtain the environmental information that is required for the defined problem/issue. In some cases several sensors may be required (e.g., Landsat TM fused with polarimetric AirSAR for the identification of salt-affected areas on floodplains dominated by tree species).

84. For each sensor ascertain whether or not it can revisit the site at necessary intervals and whether its application is dependent on seasonal conditions (e.g. optical or RADAR sensors) and that the costs of the image and its analysis are within the allocated budget.

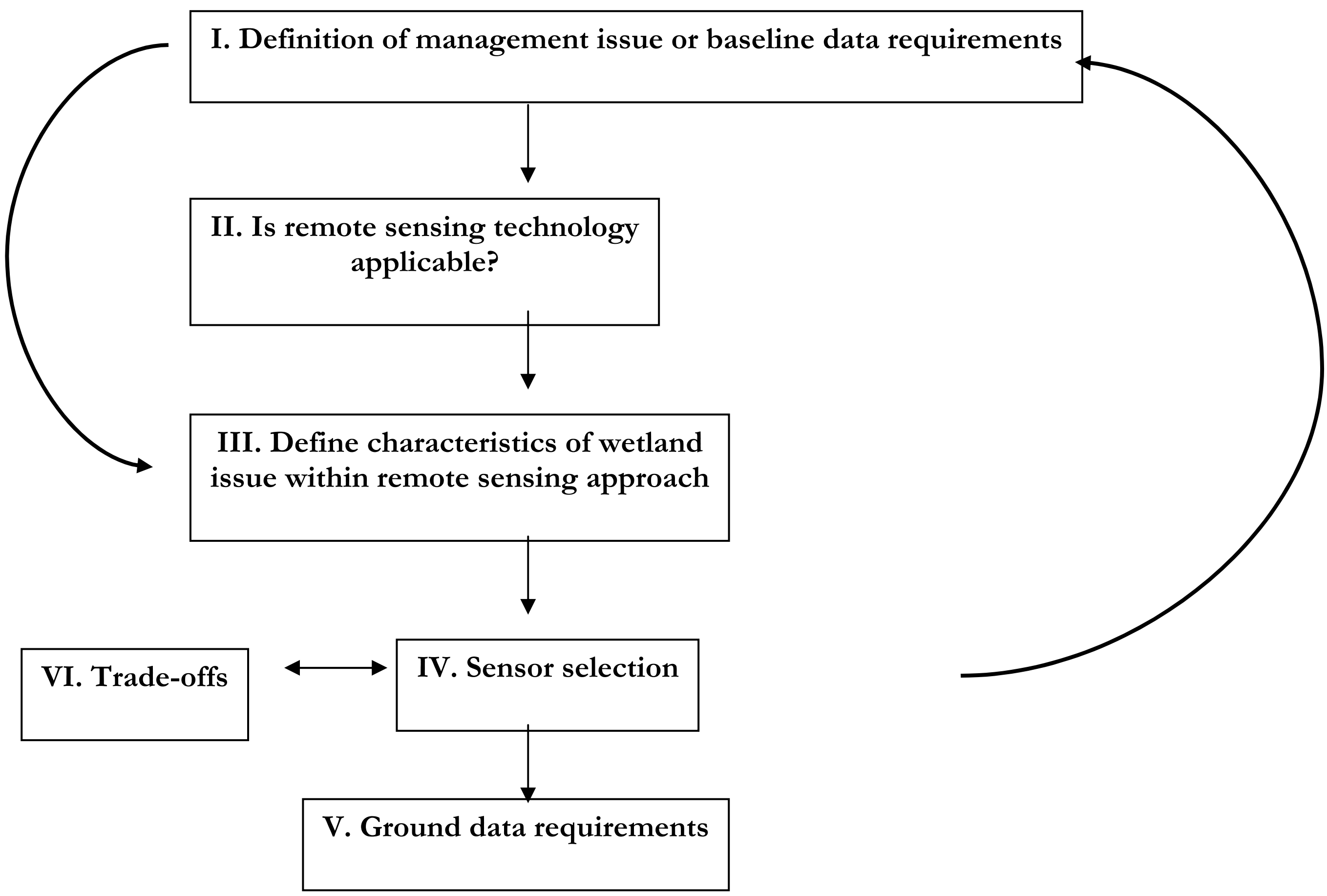
V. Ground data requirements

85. Determine a ground sampling strategy suitable for the sensor selected, including whether or not the collection of ground data should be done simultaneously with the acquisition of data from the sensor. Also determine any potential issues that may influence extrapolation from the ground data, such as scaling-up.

VI. Trade-offs

86. Ascertain if there are any trade-offs when using particular sensors (e.g., what advantages and disadvantages does one data source offer?) and whether these will affect the study (as defined at step I above).

Figure 1. Recommended steps in determining the most appropriate remotely sensed data for use in a wetland inventory.



Appendix III

Summary of remotely sensed data sets applicable to wetland inventory

SATELLITE DATA

Data Type	Spatial Resolution	Coverage	Spectral Resolution	Temporal Resolution	Contact
IKONIS	1m panchromatic 4m multispectral	100km2 (minimum)	Band 1 (blue) = 0.45-0.53µm Band 2 (green) = 0.52-0.61µm Band 3 (red) = *0.64-0.72µm* Band 4 (NIR) = *0.77-0.88µm*	1-3 days Not routinely collected Data capture must be ordered	**Space Imaging** http://www.spaceimaging.com/
Landsat 7 ETM	Bands 1-5 & 7 = 30 m Band 6 = 60m Band 8 = 15m	Typical full scene = 184 x 185km (Super scenes up to 60,000km2 and small scenes 25 x 25km are available)	Band 1 (blue) = 0.45-0.52µm Band 2 (green) = 0.52-0.60µm Band 3 (red) = 0.63-0.69*µm* Band 4 (NIR) = 0.76-0.90*µm* Band 5 (MIR) = 1.55-1.75µm Band 6 (TIR) = 10.40-12.50µm Band 7 (MIR) = *2.08-2.35µm* Band 8 (pan) = *0.52-0.90µm*	Every 16 days Data available since April 1999	**EROS Data Center** of the **U.S. Geological Survey** http://landsat7.usgs.gov/
Landsat 5 TM Due to be decomm-issioned	Bands 1-5 & 7 = 30m Band 6 = 120m	Typical full scene = 184 x 185km (Super scenes up to 60,000km2 and small scenes 25 x 25km are available)	Band 1 (blue) = 0.45-0.52µm Band 2 (green) = 0.52-0.60µm Band 3 (red) = 0.63-0.69*µm* Band 4 (NIR) = 0.76-0.90*µm* Band 5 (MIR) = 1.55-1.75µm Band 6 (TIR) = 10.40-12.50µm *Band 7 (MIR)* = 2.08-2.35*µm*		**U.S. Geological Survey** http://edcsns17.cr.usgs.gov/EarthExplorer/

SPOT	Multispectral = 20m PAN = 10m	60 x 60km	Band 1 (green) = 0.50-0.59µm Band 2 (red) = 0.61-0.68μm Band 3 (NIR) = 0.79-0.89μm Band 4 (SWIR) = 1.58-1.75µm* <u>PAN</u> = 0.51-0.73µm/0.61-0.68* *= SPOT4 only	Every 26 days Data available since 1990	**SPOT Image** http://www.spot.com/

RADAR-SAT	10 – 100m (varies with angles and # of looks)	50 x 50km – 500 x 500km (varies with angles and # of looks)	Single frequency C Band 56 nm HH polarisation variety of beam selections	Data available since 1995 revisit times approx. 6 days at mid-latitudes	Canadian Space Agency (CSA) Canadian Center for Remote Sensing (CCRS) distributed by **Radarsat International** http://www.rsi.ca/
JERS 8 optical bands SAR L band Bands 3 and 4 provide stereo coverage	18m pixels	75 x 75km	<u>Eight optical bands</u> Band 1 (green) = 0.52-0.60µm Band 2 (red) = 0.63-0.69μm Bands 3 & 4 (NIR) = 0.76-0.86μm Band 5 (MIR) = 1.60-1.71µm Band 6 (MIR) = 2.01-2.12µm Band 7 (MIR) = 2.13-2.25µm Band 8 (MIR) = 2.27-2.40µm SAR BAND = L band235nm <u>HH polarisation</u>	Data available covering years 1992-1998	**EOC Earth Observation Centre, National Space Development Agency of Japan** http://hdsn.eoc.nasda.go.jp/
ALI	10 m – PAN 30 m – MSS	37 km swath	PAN – 0.48-0.69µm Band 1 – 0.48 – 0.69µm Band 2 – 0.433 – 0.453µm Band 3 – 0.45 – 0.515µm Band 4 – 0.525 – 0.606µm	Data captured since November 1990 Captures must be requested Operation	**GSFC NASA's Goddard Space Flight Center** http://eo1.gsfc.nasa.gov/

			Band 5 - 0.63 – 0.69µm Band 6 – 0.775 – 0.805µm Band 7 – 0.845 – 0.89µm Band 8 – 1.2 – 1.3µm Band 9 – 1.55 – 1.75µm Band 10 – 2.08 – 2.35µm	expected until 2002(?)	

HYPER-ION	30 m resolution	7.5 km x 100 km	220 spectral bands covering 0.4 – 2.5µm	Data captured since November 1990 Captures must be requested Operation expected until 2002(?)	**GSFC NASA's Goddard Space Flight Center** http://eo1.gsfc.nasa.gov/

ASTER Advanced Spaceborne Thermal Emission and Reflection Radiometer	VNIR (bands 1-3) 15m pixels SWIR (bands 4-9) 30m pixels TIR (bands 10-14) 90m pixels	60 km swath	Band 1 - 0.52 - 0.60µm Band 2 - 0.63 - 0.69µm Band 3N - 0.78 - 0.86µm Band 3V - 0.78 - 0.86µm Band 4 - 1.600 - 1.700µm Band 5 - 2.145 - 2.185µm Band 6 - 2.185 - 2.225µm Band 7 - 2.235 - 2.285µm Band 8 - 2.295 - 2.365µm Band 9 - 2.360 - 2.430µm Band 10 - 8.125 - 8.475µm Band 11 - 8.475 - 8.825µm Band 12 - 8.925 - 9.275µm Band 13 - 10.25 - 10.95µm Band 14 - 10.95 - 11.65µm	Coverage is sporadic Data can be downloaded free of charge	**NASA / Earth Observing Data Gateway** http://edcimswww.cr.usgs.gov/pub/imswelcome/
AVHRR Advanced Very High Resolution Radiometer	1.1km pixel	2700km swath width	**5 bands** 0.58-12.50um (varying bandwidths)	daily images	NOAA: Online requests for these data can be placed via the **U.S. Geological Survey Global Land Information System** (GLIS) http://edc.usgs.gov/Webglis/glisbin/glismain.pl
Orbview-4 Due for launch in 2001	**Multispectral** 4m pixel **Hyperspectral** 8m pixel **Panchromatic** 1m pixel	**Multispectral** 8km swath width **Hyperspectral** 5km swath width **Panchromatic** 8km swath width	**Multispectral** 4 bands VIS/NIR **Hyperspectral** 200 bands 0.4-2.5um **Panchromatic** 1 band in VIS	revisit 2-3 days	Orbital Science Corporation Army,Navy,Airforce, **NASA** http://www.orbimage.com/

ERS-1 SAR	12.5m pixel	100 km x 102 km	Single frequency C Band (5.3 GHz), Wave length: 5.6 cm; VV polarisation	Data available since 1991 to 1999 revisit times approx.: 3-day, 35-day and 176-day depending on the mode of operation	**European Space Agency (ESA)** http://www.esa.int
ERS-2 SAR	12.5m pixel	100 km x 102 km	Single frequency C Band (5.3 GHz), Wave length: 5.6 cm; VV polarisation	Data available since 1995 revisit times approx.: 3-day, 35-day and 176-day depending on the mode of operation	**European Space Agency (ESA)** http://www.esa.int
ERS-1 ATSR	1 km pixel	512 km x 512 km	4 bands: 1.6μm (visible) and three thermal bands at 3.7μm, 11μm, and 12μm.	Data available since 1991 to 1999 revisit times approx.: 3-day, 35-day and 176-day depending on the mode of operation	**European Space Agency (ESA)** http://www.esa.int

ERS-2 ATSR2	1 km pixel	512 km x 512 km	7 bands: four bands in the visible: 0.55μm, 0.67μm, 0.87μm; 1.6μm and three thermal bands at 3.7μm, 10.8μm, and 12μm.	Data available since 1995 revisit times approx.: 3-day, 35-day and 176-day depending on the mode of operation	**European Space Agency (ESA)** http://www.esa.int
ENVISAT ASAR	30 m, 150 m or 1km depending on the operational mode	Swat with of < 100km, > 400km and in 5km x 5km vignette, pedending on the operational mode	Single frequency C Band (5.3 GHz), HH and VV polarisation	Data available in 2002	**European Space Agency (ESA)** http://www.esa.int
ENVISAT MERIS	300 m (full reesulution) and 1200 m (reduced resolution)	1150km wide swath	15 spectral bands in the 390 - 1040 nm range of the electromagnetic spectrum	Data available in 2002	**European Space Agency (ESA)** http://www.esa.int
ENVISAT AATSR	1 Km	512 km x 512 km	7 bands: four bands in the visible: 0.55μm, 0.67μm, 0.87μm; 1.6μm and three thermal bands at 3.7μm, 10.8μm, and 12μm.	Data available in 2002	**European Space Agency (ESA)** http://www.esa.int

AIRBORNE DATA

HyMap	Typically 2.5m or 5m	Varies with pixel size 5m = 2.5km swath 2.5m = ~1.3km swath	124 bands covering 0.44-2.4µm	Unreliable – user defined and sensor availability	**Integrated Spectronics Pty Ltd** http://www.intspec.com/
HyMap MK1 (AIS)	Usually 5m	Varies with pixel size 5m = 2.5km swath	98 bands covering 0.50-1.1µm, 1.45-1.80µm, 1.95-2.45µm	Unreliable – user defined and sensor availability	**Integrated Spectronics Pty Ltd** http://www.intspec.com/
CASI Compact Airborne/ Spectrograp -hic Imager	Typically 1m	Depends on spatial resolution 1m pixel = ~500m swath	**Variable bands (~19-288)** (~2-12nm wide) 0.40-1.0um Typically 96 bands covering visible to NIR	Unreliable – user defined and sensor availability	Manufactured by **Itres Research Ltd.** http://www.itres.com/ **BallAIMS** www.ballaerospace.com.au
Daedalus	Spatial resolution determined by aircraft flying height. A 1000 metre increase in flying height = 2.5 metre pixel size increase.	Image swath = Flying Height x 1.6	Band 1 – 0.42-0.45µm. Band 2 – 0.45-0.52µm. Band 3 – 0.52-0.60µm. Band 4 – 0.605-0.625µm. Band 5 – 0.63-0.69µm. Band 6 – 0.695-0.75µm. Band 7 – 0.76-0.90µm. Band 8 – 0.91-1.05µm. Band 9 – 1.55-1.75µm. Band 10 - 2.08-2.35µm. Band 11 - 8.5-13.0µm. Band 12 Band 11 X0.5 or X2 Gain.	Unreliable – user defined and sensor availability	**Air Target Services** http://www.airtargets.com.au/index.html
AIRSAR Airborne Synthetic Aperture Radar	Slant range resolution of 10m Azimuth resolution of 1m	Ground swath = 10-15km	P, L, C bands Interferometric with L and C Runs in several modes including high resolution 80MHz SAR, TOPSAR (data coregistered with DEMs, ATI mode (C and L bands along track)	Unreliable, see PACRIM missions	**JPL/NASA** http://airsar.jpl.nasa.gov/

MASTER Modis ASTER airborne simulator	5-50m pixel (depending on flight height)	Swath varies with flying height	**50 bands** 0.40-13.0um	Unreliable, see PACRIM missions	**JPL/NASA** http://masterweb.jpl.nasa.gov/
AVIRIS Advanced Visible/ Infra-Red Imaging Spectrom_r	20m pixel	11.5km swath width	**224 bands**(10nm wide) 0.40-2.50um		**NASA-JPL** http://makalu.jpl.nasa.gov/
Airborne Digital Cameras	Spatial resolution determined by aircraft flying height. Typically 0.5 – 1 m resolution.	Swath of image depends on aircraft flying height	Typically colour (RGB) or colour infrared (IR, R, G)	Unreliable – user defined	Contact local companies. Example **Specterra Systems Pty Ltd** http://www.specterra.com.au/
Airborne CIR / Colour / Black and White photos	Spatial resolution determined by aircraft flying height.	Swath of image depends on aircraft flying height	Typically colour (RGB), colour infrared (IR, R, G), or black and white	Unreliable – user defined	Contact local companies. Example **FUGRO Airborne Surveys** http://www.fugro.com/
LIDAR	Absolute elevation accuracy of 15 cm.	User defined	Varies, depending on type of laser selected.	Unreliable – user defined.	A number of different LIDAR systems made by different manufacturers.

FIELDBASED

Spectro-meters	Varies – typically nanometres - metres	Varies – typically millimetres - metres	Continuous spectral curve. Range varies from UV-SWIR Typically 0.4 - 2.5μm	Unreliable – user defined and sensor availability	**For hire** contact local companies. **For purchase** contact **Analytical Spectral Devices Inc** http://www.asdi.com/

Appendix IV

Wetland classifications

87. A wide range of different wetland classifications are in use around the world. An annotated summary of some of these wetland classifications is given below, listed in order of their date of publication.

88. No single classification is likely to meet all needs of different wetland inventories. Rather it is recommended that a classification suited to the purposes of a particular inventory should be chosen or developed.

89. In some cases it may be possible to derive a classification from the core information collected in the inventory, such as proposed for the Asian Wetland Inventory, or to establish a mechanism to compile and present information on wetland types under several different classifications, as has been done for the MedWet inventory. However, it should not be assumed that an existing classification will suit all inventory purposes.

Name/title	**USA national wetland classification**
Description	Hierarchical classification containing 5 levels that describe the components of a wetland, namely, vegetation, substrate composition and texture, water regime, water chemistry and soil. It contains vegetated and non-vegetated habitats.
Reference	Cowardin, Carter, Golet & LaRoe 1979; Cowardin & Golet 1995
URL	wetlands.fws.gov/Pubs_Reports/Class_Manual/class_titlepg.htm and www.nwi.fws.gov/atx/atx.html

Name/title	**Hydrogeomorphic classification – Australia**
Description	Based on landforms and water regimes with further sub-divisions based on areal size, shape, water quality and vegetation features. A binary format for describing wetland habitats is provided.
Reference	Semeniuk 1987; Semeniuk & Semeniuk 1997.

Name/title	**Classification of wetlands in the countries of Western European: CORINE BIOTOPES** (1991) **Classification of Palearctic Habitats** (1996) **EUNIS Habitats Classification** (2002) (EUropean Nature Information System)
Description	European standard for hierarchical description of natural or semi-natural areas, including wetland habitats. Habitats are identified by their facies and their flora. EUNIS Habitat classification (2002) integrates earlier classifications (CORINE-Biotopes, Palearctic Habitat Classification) and establishes links with other Classification types (CORINE-Land-Cover typology, Habitats Directive Annex I, Nordic classification system, and other national systems).
Reference	European Communities 1991; Devillers, & Devillers-Terschuren 1996; Davies & Moss 2002.
URL	http://nature.eionet.eu.int/activities/EUNIS/harmo/eunis_habitat http://mrw.wallonie.be/dgrne/sibw/EUNIS/home.html

Name/title	**Ramsar Classification System for Wetland Type**
Description	Hierarchical listing of wetland habitats loosely based on the USA national wetland classification. It has been modified on several occasions since introduction in 1989 so as to accommodate further habitats of interest to the Contracting Parties to the Ramsar Convention.
Reference	Scott & Jones 1995; Ramsar Bureau 2000.
URL	http://www.ramsar.org/key_ris_types.htm

Name/title	**MedWet Mediterranean wetland classification**
Description	Hierarchical listing of wetland habitats loosely based on the USA national wetland classification with modifications made to reflect the range of wetland habitats around the Mediterranean. Software that accompanies the methodology enables other classifications commonly used in the region to be generated from the database.
Reference	Hecker, Costa, Farinha & Tomas Vives et al 1996
URL	http://www.wetlands.org/pubs&/wetland_pub.html

Name/title	**Canadian wetland classification**
Description	Hierarchical listing of habitats based on broad physiognomy and hydrology, surfae morphology and vegetation physiognomy. Further characterisation is based on the chemical features of the habitat.
Reference	National Wetlands Working Group 1997; Zoltai & Vitt 1995.
URL	www.fes.uwaterloo.ca/research/wetlands/Publications.html

Name/title	**South African wetland classification**
Description	Adaptation of the "Cowardin" wetland classification developed in the USA. Includes adaptations to reflect the functional aspects of wetlands based on geomorphic and hydrologic features. It is hierarchical and able to accommodate all wetland types in the region.
Reference	Dini & Cowan 2000
URL	www.ccwr.ac.za/wetlands/inventory_classif.htm

Name/title	**Asian wetland classification**
Description	Based on landforms and water regimes. Classification can be derived from the core data fields and augmented with information on vegetation, areal size, and water quality.
Reference	Finlayson, Howes, Begg & Tagi 2002 Finlayson, Howes, van Dam, Begg & Tagi 2002.
URL	Web-based information not yet available

Appendix V

Recommended standard metadata record for the documentation of wetland inventories

90. The following figure and table summarize the standard structure of a wetland inventory metadata record, designed to assist all those undertaking wetland inventory in documenting and making publicly available information about their inventory, in line with Resolution VII.20.

91. The inventory metadata record is based on, and consistent with, global standards for metadata recording, (e.g. ISO/DIS 9115 Geographic Information Metadata), and has been prepared for the Ramsar Convention by the Environmental Research Institute of the Supervising Scientist, Australia, with the financial support of the government of the United Kingdom, to support the development of the next phase of the *Global Review of Wetland Resources and Priorities for Wetland Inventory (GRoWI 2).*

92. Further guidance on the application and use of this inventory metadata standard record for reporting wetland inventory has been prepared and will be issued by the Ramsar Bureau.

Figure 2. Diagrammatic representation of the wetland inventory metadatabase framework.

Table 3. Description of the fields of the wetland inventory metadatabase

FIELDNAME	FIELD DESCRIPTION
UNIQ_ID	Unique identifier for each wetland inventory dataset
TITLE	Title of Inventory/ Dataset
AUTHOR	Author / dataset creator
CUSTOD	Organisation/ individual with custodial rights to the data
ABSTRACT	Abstract – summary or short description of the contents of dataset / inventory activity
KEYWORD	Words that may be used to search for a particular dataset. Choose three-five words that describe the key inventory activities i.e. remote sensing – vegetation, and which can be used to search on in database;
CAT_REF	Library catalog reference – e.g. ISBN number – if applicable to dataset
WETL_TYP	Type(s) / nature of wetland(s) being described in inventory
RAMSAR_R	Ramsar region – choose from standard Ramsar 4 letter codes i.e. EEUR; AFRI; etc
COUNTRY	Countries in area of inventory dataset – choose from standard 3-letter ISO country code http://www.bcpl.net/~jspath/isocodes.html
SUB_COUN	Intra-national regions, described in free text; corresponds with sub_nation field in Wetland Inventory metadatabase
COORDS	Bounding coordinates of area – entered as degrees-minutes-seconds for upper left hand, and lower right hand areas; alternatively, could put in series of coordinates which define the perimeter of the inventory area
LOC_DESC	Freehand description of area
RAMSAR_L	Name of Listed Ramsar sites in area – if appropriate
INV_AREA	Total area covered by inventory i.e. a few hectares; '000s of kilometres^2
SCALEINV	Textual descriptions to complement the inventory area values – for example, "large scale"; "small scale" inventory, which could be used as search features to locate particular datasets.
REL_DATA	Related datasets. Names of related files / datasets within the overall inventory.
INV_START	First date of information in the inventory dataset
INV_END	Last date of information in the inventory dataset
INV_STAT	Status of progress on the process of creation of the inventory dataset – complete / incomplete
FREQ_MAIN	Frequency of maintenance / changes / updates to the dataset – regular / irregular/ none planned
LANG_RES	The language in which the dataset was created in i.e. English; Spanish; Vietnamese
AV_FORM	The formats in which the inventory dataset is available in, specifically identifying whether the data is available in digital and/or hard copy formats; in the former case, including a list of forms it is available in i.e. Access database; ArcInfo coverage; Text file etc.
STORFORM	The form or formats in which the dataset is stored by the custodian.
ACC_CONS	Access constraints – e.g. may not be available to general public; use may require a license agreement to be signed
USR_CONS	User constraints – e.g. may not reproduce data without payment of royalty or signing of a license that outlines agreed usage of information
NFS_LOC	Dataset network file system locations – may be entered as a URL address

ACC_INST	Data Access instructions on how to access dataset
IMG_LOC	The location of a browseable image – if applicable to dataset
DIR_LOC	Locations on network from which dataset may be directly accessed – if applicable
DATA_LIN	Data quality – lineage. A brief description of the source(s) and processing / analytical steps and methodology which were used in the creation of the dataset.
POS_ACC	Positional accuracy – a brief assessment and description of the location of spatial features in the dataset relative to their true position on the earth. Information could include whether a differential GPS was used, for instance.
ATTRIB_ACC	Attribute accuracy – a brief assessment of the reliability assigned to features in the dataset, relative to their real world values. For example, was a particular sampling intensity utilized in mapping an area
LOGIC_CON	Logical consistency. A brief description of the logical relationships between items in the dataset. For spatial datasets, this may take the form of a topological consistency check, to ensure that all polygons are closed, nodes are formed at the end of lines, and that there is only one label within each polygon.
DATA_COM	Completeness. A brief assessment of the completeness of the dataset, classification, and verification.
CONT_ORG	Contact organisation (option of adding new organisation, or choosing from existing list of organisations)
CONT_POS	Contact position
MAIL_ADD	Mailing / Postal address for contact position and organisation
POSTCODE	Postcode of mailing address
CONT_PH	Phone number of contact position – should include international direct dial code (IDD), and specify whether local code includes a zero or not when using IDD (e.g. ++ (IDD) (0) xx xxxx xxxx)
CONT_FAX	Facsimile of contact position – should include international direct dial code(IDD), and specify whether local code includes a zero or not when using IDD
CONT_EM	Electronic mail address of contact position.
CONT_STA	State / Province in which contact organisation located.
CONT_COU	Country of contact organisation.
META_NEW	Date metadata was created (automatically generated when file created)
META_MOD	Date metadata last modified (automatically generated when file modified)
META_CIT	Citations for metadata; list of other documents, products which cite or use the products described in the metadata record
ADD_META	Additional metadata – reference to other directories or systems that contain additional information about the dataset.; links to additional metadata records, particularly for GIS and remotely sensed products.

Appendix VI

Reading list

Biodiversity Conservation Information System 2000. *Framework for Information Sharing: Executive Overivew.* Busby, JR (Series Editor). Includes CD-ROM with full text of 8 Handbooks. Available from BCIS Program Manager (for contact details see: http://www.biodiversity.org)

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National Wetlands Working Group 1997. The Canadian Wetland Classification System. 2nd Edition. In BG Warner & CDA Rubec (eds), Wetlands Research Centre, University of Waterloo. Waterloo. 68 pp.

National Wetlands Programme. 1999. Uganda Wetlands Inventory Guide, version 4. Ministry of Water, Lands and Environment, Kampala, Uganda.

Pabari, M., Churie, A. & Howard, G. (eds) 2000. Wetland inventory training workshop, 6-9 December 2000, Kampala, Uganda. Ramsar Convention on Wetlands, IUCN- The World Conservation Union & National Wetlands Programme, Kampala, Uganda.

Phinn S, Hess L & Finlayson CM 1999. An assessment of the usefulness of remote sensing for wetland monitoring and inventory in Australia. In CM Finlayson & AG Spiers (eds), *Techniques for Enhanced Wetland Inventory, Assessment and Monitoring*. Supervising Scientist Report 147, Supervising Scientist Group, Canberra. pp 44-82.

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"Wetlands: water, life, and culture"
8th Meeting of the Conference of the Contracting Parties
to the Convention on Wetlands (Ramsar, Iran, 1971)
Valencia, Spain, 18-26 November 2002

COP8 DOC. 35
Information Paper
English only

The use of Earth Observation technology to support the implementation of the Ramsar Convention

1. This information paper, prepared by the Earth Observation Applications Department of the European Space Agency (ESA-ESRIN, Frascati, Italy), presents the preliminary results of the Treaty Enforcement Services using Earth Observation (TESEO) project on wetlands, carried out by the European Space Agency (ESA) within the framework of the ESA's General Studies Programme (GSP). It is summarised from the preliminary report of this project[1], due to be completed in late 2002, and addresses the following questions:

   i) how can EO contribute to the achievement of the objectives of the Ramsar Convention?
   ii) what are the information needs of the international and national bodies involved in the implementation of the Ramsar Convention? and
   iii) how can EO contribute to fulfil those needs?

2. The paper also includes information on availability, uses, advantages and drawbacks of different Earth Observation sensors for application to wetland issues, which supplements that provided in COP8 DR 6 on a Framework for Wetland Inventory.

3. The TESEO project is intended to the capabilities of existing and near-future Earth Observation (EO) technology to support the implementation of four international treaties of critical importance for the environment: the Convention on Wetlands (Ramsar, Iran, 1971), the UN Convention to Combat Desertification, the Kyoto Protocol to the UN Framework Convention on Climate Change, and the Convention for the Prevention of Marine Pollution from Ships (MARPOL 73/78).

4. With this effort, ESA hopes to gain a better understanding of the user requirements in terms of information products and services, so as to prepare future user-driven activities and Earth Observation missions.

5. The TESEO wetlands project has undertaken an analysis of the information needs of the Convention, and those users who implement it; a review of the ways in which existing Earth Observation technology and sensors can contribute to these user needs, and how upcoming technologies and information from EO sensors may enhance this contribution;

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[1] B. Ryerson, F. Ahern, C. Gosselin, O. Miralles, D. Ball and A. Goldsmith, *Preliminary Analysis Report*, TESEO study on Wetlands, Technical Report, April, 2002.

and it is developing and testing novel applications of EO data and information for wetland assessment, monitoring and management. These novel applications are being trialled on three Ramsar sites: Coto de Doñana (Spain), Mer Bleu (Canada) and Djoudj National Park (Senegal).

The Ramsar Convention and Earth Observation

6. Achieving the Vision of the Ramsar Convention ("the conservation and wise use of wetlands by national action and international cooperation as a means to achieving sustainable development throughout the world") through the application of the Convention's *wise use* concept, the identification, designation and sustainable management of Wetlands of International Importance (Ramsar sites) and international cooperation is a complex and challenging task. It requires that all the national and international bodies involved in the implementation of the Convention have access to suitable information to better understand wetland areas, their processes and their significance in the global environment, to manage efficiently wetland areas so that they may yield the greatest continuous benefit to present and future generations, to inform the general public and policy makers of the importance of wetlands and promote their conservation and protection worldwide. Existing and future Earth Observation technology may play an increasingly important role in supporting these activities.

7. Over the past few decades, Earth Observation technology has proved to be an increasingly powerful tool to monitor and assess the Earth surface and its atmosphere on a regular basis. EO satellites, with increasing capabilities in terms of spatial, temporal and spectral resolution, allow, day-by-day, a more efficient, reliable and affordable monitoring of the environment over time at global, regional and local scales. This makes EO technology a fundamental support to the Convention's Contracting Parties and other related national and international bodies involved in the implementation of the Ramsar Convention.

8. Three main areas where EO technology may contribute particularly significantly to achieving the objectives of the Ramsar Convention can be highlighted:

   i) **Increasing scientific and technical knowledge about wetlands.** The collection and analysis of short-term and long-term data and information to better understand wetlands and their physical, biological and chemical components, such as soil, water, nutrients, plants and animals and the interactions between them, the status and trends in the health of wetlands, and the influence of wetlands in the global environment. Earth Observation technology may be of particular importance for the acquisition of information on wetlands in remote and inaccessible regions.

   ii) **Supporting the efficient management of wetland areas.** The collection of short-term and long-term data and information to allow the efficient inventory, assessment and monitoring of wetland sites, in the context of their catchments and basins, as well as to provide support to the development and implementation of restoration or rehabilitation plans.

   iii) **Contributing to improve the performance of the Convention.** EO technology may be used to contribute to and enhance reporting mechanisms under the Convention and, through assessment of overall status and trends in the health of wetlands, to better assess the success of the Convention as a tool for sustainable development. It may also contribute to the creation of common data sets and information systems and may help in harmonizing methodologies, procedures and formats for the gathering and analysis of information required for better decision-making, including harmonised information gathering and reporting between different multilateral environmental agreements.

The information needs of the Ramsar user community

9. Actors involved in the implementation of the Ramsar Convention, those who may be able to take advantage of EO technology to meet their needs, range from the Convention's bodies such as the Bureau and the Scientific and Technical Review Panel, international agencies, National Convention Focal Points and scientists to non-governmental organizations, wetland managers and local communities. However, the type of information required by these different categories of users may vary significantly depending upon their role within the implementation of the Convention.

10. Table 1 gives an overview of the requirements and needs, in terms of information products and services, of the user community (i.e., national and international bodies involved in the implementation of the Ramsar Convention and other related organizations). In this table, users have been categorised in terms of the spatial scale of their role: global, regional, national or local. Moreover, user requirements have been split into two main groups: global and local. This responds to the logic that regional and national organizations usually meet their information needs by aggregating local information, whereas, on the contrary, some requirements of "global" organizations cannot be easily fulfilled by a simple collection and aggregation of local data.

11. EO technology can provide significant support to user organizations in fulfilling some of the information requirements shown in Table 1:

    i) For global information needs, the global nature of EO data renders EO technology a unique tool to provide global information to users on a regular basis.

    ii) Concerning the information needs at local scale, EO technology represents an efficient source of continuous and synoptic information not only for the wetland sites themselves but also at the scale of the entire basins that supply water to the wetlands. This provides novel capabilities to users, who may take advantage of EO technology, for instance, to extend inventory information and monitoring activities throughout the catchments of wetlands (as a tool to identify and monitor threats upstream in the catchments that could potentially damage the wetland site).

12. It is worth noting that in some cases, managing large wetland sites and the corresponding catchment area needs inventory, assessment and monitoring of a huge geographic area (for example, the over 6 million hectares of the Okavango Delta Ramsar site, Botswana). Even though Table 1 treats all 'sites' in the local information category, in these cases of very large 'sites' this requires collecting and analysing information at national and even regional scale which, in many cases, can only be done effectively by using EO technology.

How can Earth Observation support end-users through providing their information needs?

13. An overview of the capabilities of existing EO technology to fulfil user requirements, drawn from the analyses made by the TESEO wetlands project, can be outlined as follows:

14. So far, EO data has been used cautiously as a source of information for conservation activities in wetland areas. Most applications to date concern wetland research activities rather than operational applications. This limited use of Earth Observation for wetland conservation and wise use purposes appears to be a consequence of a combination of several factors, including:

    i) the cost of the technology;
    ii) lack of capacity in the necessary technical capabilities;
    iii) the unsuitability of currently available EO data for some basic applications (e.g. insufficient spatial resolution);
    iv) the lack of clear, robust and efficient user-oriented methodologies and guidelines for using this technology; and
    v) the lack of a solid track record of successful case studies that can form a basis for operational activities.

15. Despite these drawbacks, existing EO technology does have several advantages over other methods of data acquisition, which makes EO a powerful complement to the more traditional conservation activities and methods such as field collection of data. Advantages of EO include: large area coverage, frequent visiting times, continuous and synoptic information, and reduced cost compared with airborne imagery (e.g., aerial photography).

16. The next generation of EO satellites will have improved technical capabilities, including higher spatial resolutions, more frequent visiting times, and improved spectral features, which will provide the user community with enhanced information quality with which to pursue the objectives of the Ramsar Convention.

17. The TESEO wetlands project has made an analysis of the main capabilities of EO technology to fulfil user requirements, summarised below.

18. The analysis has addressed two main issues:

    i) the degree of maturity of different EO applications in the context of wetlands; and
    ii) the advantages/drawbacks of different EO sensors to fulfil user information needs.

19. Table 2 provides an overview of the degree of maturity of existing EO technology to provide users with the required information. The table also includes some information about the most suitable sensors amongst those currently available for use for different purposes of wetland inventory, assessment and monitoring. A more detailed description of the technical characteristics of each of the sensors mentioned in Table 2 is provided in Table 3.

20. Table 4 provides an analysis of the main advantages and disadvantages of the most suitable sensors for use in the context of wetlands. The table also identifies the applications for which these sensor are particularly well suited. As well as data collected by satellite-based sensors, airborne sensors are also included, since these are currently one of the most widely use sources of information for wetlands management in many parts of the world.

21. The analysis demonstrates the considerable potential of EO technology to support the user community in pursuing the objectives of the Ramsar Convention. However, to turn this potential capability into operational applications, it is still necessary to bring together more closely the Ramsar and EO communities in order to increase mutual understanding and knowledge. To carry out this task, a number of issues should be urgently addressed:

    i) Strengthening the communication between the Ramsar Convention and the EO community[2];
    ii) Reviewing the data cost policy, specially in developing countries;
    iii) Fostering capacity building and training activities among the user community, especially in developing countries;
    iv) Fostering the integration of EO-derived products and services within the user internal working procedures (e.g., the use of EO data in combination with traditional approaches);
    v) Creating a solid track record of successful case studies;
    vi) Developing clear user-oriented guidelines for the use of EO data within the Ramsar Convention;
    vii) Developing advanced sensors with improved capabilities (specially, spectral and spatial resolutions);
    ix) Developing novel user-tailored EO applications;
    x) Developing robust automatic or semi-automatic data processing methodologies, which minimise the need for intervention by an human operator; and
    xi) Improving the promotion of the capabilities of EO technology within the Ramsar user community;

Conclusions and future developments

22. The past few decades have seen a great development of the EO technology, not only of sensor capabilities but also in data processing techniques and user-driven applications. However, despite these significant developments, EO is still an experimental rather than an operational tool. In this context, ESA is carrying out different programmatic activities aimed at supporting the user community in the transition from an experimental use of EO to the fully operational integration of EO technology within the user daily working procedures. The TESEO initiative is part of these activities.

23. The final results of the TESEO wetlands project, along with the other TESEO projects concerning desertification, forestry and the Kyoto Protocol and marine pollution, will contribute to better defining novel user-oriented applications to be developed within ESA application programmes (e.g., Data User Programme). They will, if appropriate, contribute to further consolidation in the ESA's GMES Service Element, which is the ESA contribution to the joint European Union/ESA GMES (Global Monitoring for Environment and Security) initiative.

24. With further refinement of the user requirements and under the leadership of the Ramsar Convention, ESA may consider the financing of the development of a dedicated service aimed at matching the information needs of the Ramsar Community. These activities

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2 In the context of the TESEO initiative, a User Forum has been included in the ESA's TESEO portal (http://earth.esa.int/TESEO). In this web-based Forum, users will find the main results of the TESEO project, surveys aimed at getting a better understanding of user information needs, and a direct way to communicate and collaborate with the ESA's TESEO team.

represent an important component of the ESA technical, financial and human effort intended to better bridge the gap between the user and EO communities.

25. The next generation of EO satellites will provide novel and advanced capabilities to monitor wetlands worldwide on a regular basis. The success of such new technology will depend on the capability of the different actors involved in the space sector (i.e., space agencies, value-added companies, research institutions) to develop user-driven cost-effective operational applications. This should form the basis of achieving the necessary transition from a financing scheme based on research and development programmes (e.g., ESA's Data User Programme, and the European Union's 5th Framework Programme) to a user-based financing scheme, where users (e.g., national environmental ministries, local administrations) support the full cost of the operational use of EO.

Relevant Web sites

26. The following Web sites provide further information about the European Space Agency and its work, the ESA TESEO projects including its User Forum, and ESA's Data Users Programme:

ESA web site:	http://www.esa.int
TESEO project:	http://earth.esa.int/teseo
ESA's Data User Programme:	http://earth.esa.int/DUP
ESA's GMES Service Element:	http://earth.esa.int/gmes

Table 1. Overview of Ramsar Convention and wetland user information needs and requirements[3]

<table>
<tr><th>Scope</th><th>End-user</th><th>Requirements[4]</th></tr>
<tr><td>Global</td><td>Ramsar Bureau;
UN agencies (e.g., UNEP);
International NGOs (e.g., WWF);
International Research Org. (e.g., IGBP);
International Developing Agencies (e.g., WRI);
Scientific community;</td><td>Global extent of wetlands ant their temporal variations (seasonal, multi-year) as an input for global environmental models (carbon, methane production, etc.);
Global monitoring of wetlands with respect to global environmental changes;
Global inventory of wetlands[5];</td></tr>
<tr><td>Regional</td><td>Regional policy makers (e.g., EC);
Regional Developing Agencies (e.g., the African Development Bank);
Regional Environmental Agencies (e.g., EEA);</td><td rowspan="2">Inventorying and base mapping[6]:
• Wetland boundaries (e.g., size and variation);
• Land cover/use of the wetland site and the corresponding catchment area;
• Digital Elevation Model of the wetland site and the corresponding catchment area;
• Water regime, (e.g., periodicity, extent of flooding);
• Water chemistry (e.g., salinity, colour, transparency);
• Soil features (soil type, depth, etc.);
• Biota (vegetation zones and structure, wildlife);
• Location of potential threats to the wetland (in the wetland site and the corresponding catchment area);
• Additional information: e.g., infrastructures, land ownership, administrative boundaries);
Assessment activities:</td></tr>
<tr><td>National</td><td>National Focal Points;
Related National Ministries;
National Implementing Agencies;
National NGOs;</td></tr>
</table>

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[3] Adapted from (Ryerson et al., 2002)

[4] Requirements have been split into two main groups: Global and Local. This responds to the fact that regional and national organizations generally meet their information needs by aggregating local information. In contrast, some information requirements of "global" organizations cannot be derived by using only local information.

[5] By aggregating local information (see "inventorying and base mapping" below).

[6] Regional and national inventories are based on the aggregation of local information. Therefore, in the table we report the information needs at local level.

Local	Scientific community[7]; Local administrative authorities; Local wetland managers; Local basin authorities; Local NGOs; Land owners; Local communities; Farmers associations[8]; Fishing associations;	• Estimation of biological (e.g., vegetation condition), physical (e.g., water table), and chemical parameters (e.g., salinity), which characterise the ecological condition of a wetland; Monitoring activities: • Identification and monitoring of changes in the biological, physical, and chemical condition of the wetland site (e.g., changes in vegetation extend and/or condition, water table, water turbidity, etc.); • Identification and monitoring of threats in the wetland site and the corresponding catchment area, which may affect the wetland condition (e.g., alien species, overgrazing, urban expansion, agricultural activities, industrial pollutants, etc.). • Rapid reaction to catastrophic events (e.g., floods, pollution emergencies); Implementation of management (e.g., rehabilitation) plans: • Base information for planning and decision making (e.g., base maps); • Information to monitor the efficiency of the undertaken actions (on a case by case basis); • Environmental Impact Assessment (on a case by case basis);

Table 2. Degree of maturity of EO to match wetland user requirements

Information products[9]	**Maturity**	**Suitable sensors[10]**
	Global Information	
Global extend of wetlands as an input for global environmental models (carbon, methane production, etc.);	*Experimental*	*Medium resolution optical and SAR (e.g., ATSR, MERIS, ASAR-wide swath mode)*
Global monitoring of wetlands with respect to global environmental changes;	*Experimental*	*Medium resolution optical and SAR (e.g., ATSR, MERIS, ASAR-wide swath mode)*
Global inventory of wetlands[11];	*Semi operational*	*Very high and high resolution optical and SAR sensors (e.g., Landsat-7, SPOT-4, ASAR)*

[7] The scientific community has been included under both global and local subdivisions, to distinguish between the research activity focusing on understanding global issues (e.g., influence of wetlands in the global environment) and the research work aimed at better understanding wetlands and their processes.

[8] Note that some of the requirements mentioned in Table 1 under a certain category (e.g., Local) may not fulfil the information needs of some of the corresponding users: (e.g., farming organizations may not require a wetland inventory, but rather only information about potential threats that may affect their activity).

[9] The generation of many information products (e.g., land-cover mapping, water quality parameters, etc.) requires the combined use of both EO data and ground measurements.

[10] See Table 3 for a detailed description of the sensors;

Local Information

Inventorying and base mapping:

• Wetland boundaries (e.g., size and variation);	*Operational*	*Very high and high resolution optical and SAR sensors (e.g., Landsat-7, SPOT-4, ASAR)*
• Land cover/user of the wetland site, and the corresponding catchment area;	*Operational*	*Very high and high resolution optical and SAR sensors (e.g., Landsat-7, SPOT-4, ASAR)*
• Digital Elevation Model of the wetland site and the corresponding catchment area;	*Operational*	*SAR sensors (e.g., ERS-1, ERS-2)*
• Water regime, (e.g., periodicity, extend of flooding);	*Operational*	*Very high and high resolution optical and SAR sensors (e.g., Landsat-7, SPOT-4, ASAR)*
• Water chemistry (e.g., salinity, colour, transparency);	*Experimental*	*Hyper-spectral and superspectral optical sensors (e.g., Hyperion, ASTER, MERIS)*
• Soil features (depending on vegetation cover);	*Experimental*	*Very high and high resolution optical and SAR sensors (e.g., Landsat-7, SPOT-4, ASAR)*
• Biota (only vegetation zones and structure);	*Operational*	*Very high and high resolution optical and SAR sensors (e.g., Landsat-7, SPOT-4, ASAR)*
• Location of potential threats in the wetland site and the corresponding catchment area;		
○ Mapping alien species ○ Mapping urban areas ○ Mapping agricultural areas	*Operational*	*Very high and high resolution optical and SAR sensors (e.g., Landsat-7, SPOT-4, ASAR)*
○ Mapping areas affected by overgrazing	*Experimental*	*Very high and high resolution optical and SAR sensors (e.g., Landsat-7, SPOT-4, ASAR)*
○ Mapping industrial pollution sources and damaged areas	*Experimental*	*Hyper-spectral and superspectral optical sensors (e.g., Hyperion, ASTER , MERIS)*
• Additional information:		
○ Infrastructures (e.g., roads)	*Semi operational*	*Very high and high resolution optical and SAR sensors (e.g., Landsat-7, SPOT-4, ASAR)*

[11] By aggregating local information (see "inventorying and base mapping" below).

Information products	Maturity	Suitable sensors
Assessment activities:		
• Estimation of biological, physical, and chemical parameters, which characterise the ecological condition of a wetland;		
○ Vegetation condition;	*Same as above*	*Same as above*
○ Water chemistry;	*Same as above*	*Same as above*
○ Water regime;	*Same as above*	*Same as above*
Monitoring activities:		
• Identification and monitoring of changes in the biological, physical, and chemical condition of the wetland site:		
○ Changes in vegetation condition;	*Same as above*	*Same as above*
○ Changes in water chemistry;	*Same as above*	*Same as above*
○ Changes in water regime;	*Same as above*	*Same as above*
• Identification and monitoring of threats in the wetland site and the corresponding catchment area, which may affect the wetland condition:		
○ Changes caused by alien species;	*Same as above*	*Same as above*
○ Expansion of urban areas;	*Same as above*	*Same as above*
○ Expansion of agricultural areas and shifting cultivation;	*Same as above*	*Same as above*
○ Expansion of the area damaged by overgrazing;		
○ Variations in the extend of industrial pollution and damaged area;	*Same as above*	*Same as above*
	Same as above	*Same as above*

• Rapid reaction to catastrophic events (e.g., floods, pollution emergencies);	*On a case by case basis*	*On a case by case basis*
Implementation of restoration or rehabilitation plans:		
• Base information for planning and decision making;	*On a case by case basis*	*On a case by case basis*
• Information to monitor the impacts of the undertaken actions;	*On a case by case basis*	*On a case by case basis*
• Environmental Impact Assessment	*On a case by case basis*	*On a case by case basis*

Table 3. Overview of available relevant EO sensors and technical characteristics[12].

Sensor	Spatial Resolution	Swath Width	Spectral features	Visiting time & Archive
		Very High Resolution Optical Multispectral Satellites:		
IKONOS (Space Imaging, Commercial)	1m panchromatic 4m multispectral	60km	*4 spectral bands;* *Range 0.45 - 0.88μm;*	1-3 days Data not routinely collected
		High Resolution Optical Satellites (multispectral, superspectral and hyperspectral):		
EO-1 ALI (NASA)	10m, panchromatic 30m, multispectral	37km	10 spectral bands; Range 0.48 - 2.35μm;	Experimental Data not routinely collected
TERRA ASTER (NASA)	15m - 90m	60km	14 spectral bands; Range 0.52 -11.65μm;	Experimental Data not routinely collected
EO-1 HYPERION (NASA)	30m	7.5km×100km	220 spectral bands; Range 0.4 - 2.5μm	Experimental Data not routinely collected
Landsat 5TM & 7ETM (NASA)	30m (126m Thermal IR)	185km	*7 spectral bands;* *Range 0.45 - 2.35μm;*	16 days Archive available since 1984
SPOT series (SPOT Image, Commercial)	10m, panchromatic 20m, multispectral	60km	4 spectral bands; Range 0.50 - 1.75μm;	26 days Archive available since1990
SPOT-5 (SPOT Image, Commercial)	HRG 20m, SWIR 10m, multispectral 5m, panchromatic 2.5m, supermode pan HRS – for stereo acquisitions 10m, panchromatic	60km 120km	4 spectral bands; Range 0.50 - 1.75μm;	26 days Operational since 2002 Archive no yet available
		High Resolution Synthetic Aperture Radar (SAR) sensors:		
ENVISAT ASAR (ESA)	6m - 100m	50km - 500km	C Band Multi-polarisations	3 days; (35 days with the same geometry) Not yet operational

[12] Only the most relevant EO sensors are included.

ERS-1 & 2 (ESA)	24m	100km	C Band VV polarisation	3 days; (35 days with the same geometry) Archive available since 1991
RADARSAT-1 (CCRS)	10m - 100m	50km – 500km	C Band HH polarisation	3 days; (34 days with the same geometry) Archive available since 1995
RADARSAT-2 (CCRS)	6m – 100m	50km – 500km	C Band Multi-polarisations	3 days; (24 days with the same geometry) Not yet operational

Sensor	Spatial Resolution	Width swath	Spectral features	Visiting time period
		Medium Resolution Optical Super-spectral Sensors:		
ENVISAT MERIS (ESA)	300m	1150km	15 spectral bands; Range 390nm - 1040nm;	3 days; (35 days with the same geometry) Not yet operational
TERRA MODIS (NASA)	250m	2330km	36 spectral bands Range 0.62 – 16.385µm;	2 days Archive available since 2000
		Coarse Resolution Optical Multispectral Sensors:		
NOAA AVHRR (NASA)	1.1km	2399Km	5/6 spectral bands Range 0.58 – 12.50 µm	1 day Archive available since 1979
ERS-1 & 2 ATSR (ESA)	1km	512km	7 spectral bands; Range 0.55µm - 12µm;	3 days; (35 days with the same geometry) Archive available since 1991
ENVISAT AATSR (ESA)	1km	512km	7 spectral bands; Range 0.55µm - 12µm;	3 days; (35 days with the same geometry) Not yet operational
OrbView-2 SeaWiFS (NASA)	1.1km	2800km	8 spectral bands; Range 0.402 – 0.885 µm	1 day; (16 days with the same geometry)

Table 4. Advantages and drawbacks of EO sensors[13]

Advantages	Drawbacks	Main applications
	Airborne Sensors (aerial photography, hyperspectral):	
• High spatial resolution • Widespread use, widely understood; • Many supply companies available; • Technology for base mapping is widely	• High cost; • Small width of coverage; • Logistical and political impediments in many parts of the world;	• Creation of high resolution base maps; • High resolution Land cover/use and change; • Vegetation condition and type (especially

[13] Adapted from (Ryerson et al., 2002)

available;	• Acquired by order (no frequent or periodic acquisition); • Lack of solid automatic techniques for data analysis (in many cases, photo-interpretation is required); • No systematic archive data available; • Not suitable for large or remote geographic areas; • Acquisition depends on weather conditions; • Complex data analysis techniques for hyperspectral imagery (experimental);	with hyperspectral sensors: e.g., AVIRIS); • Water chemistry (only with hyperspectra sensors: e.g., AVIRIS); • Water regime;
Very High Resolution Optical Multispectral Sensors:		
• High spatial resolution • Can be acquired without special permission; • Images are digital; • Stereo imagery available; • Technology for base mapping is similar tc the one used with Aerial photography; • Allows frequent or periodic acquisitions; • Archive data will be available;	• High cost; • Relative small width of coverage; • Lack of solid automatic techniques for data analysis (photo-interpretation is required); • Not suitable for large geographic areas; • Depends on cloud cover; • Archive data is not yet available (very recent technology)	• Creation of high-resolution base maps; • High resolution Land cover/use and change; • Water regime; • Vegetation condition and type;
High Resolution Optical Sensors (multispectral, superspectral and hyperspectral):		
• Frequent global coverage; • Global archive available; • Good discrimination of many surface features; • Solid methodologies for automatic data analysis available; • Low cost; • Suitable for large geographic areas (e.g., wetland site and catchment area); • Existing and widely known archive data for multispectral sensors;	• Spatial and spectral resolution prevents very accurate mapping and fine discrimination of vegetation and water quality indices; • Depends on cloud cover; • Complex data analysis techniques for hyperspectral imagery (experimental); • Archive data is not yet available for superspectral and hyperspectral sensors (very recent technology);	• Creation of base maps; • Land cover/use and change; • Vegetation condition and type; • Water chemistry (only very few parameters); • Water regime; • Potential threats (not suitable for some industrial pollution) • Soil features (depending of vegetation cover); • Mapping infrastructure (e.g., roads);

Advantages	**Drawbacks**	**Main applications**
Medium Resolution Superspectral Sensors:		
• Frequent global coverage; • Spectral resolution allows water quality and accurate vegetation condition applications; • Solid methodologies for automatic data analysis available;	• Small spatial resolution prevents local scale mapping; • Depending on could cover; • Archive data is not yet available (very recent technology)	• Land cover/use and change at national, regional and global scales; • Vegetation condition and type at national, regional and global scales; • Water chemistry at large scale (e.g., coastal areas, large water bodies);

• Low cost; • Suitable for large scale mapping (e.g., national, regional and global scales); • Archive data will be available;		
Coarse Resolution Optical Multispectral Sensors:		
• Frequent global coverage; • Solid methodologies for automatic data analysis available; • Low cost; • Suitable for large scale mapping (e.g., national, regional and global scales);	• Small spatial resolution prevents local scale mapping; • Spectral resolution prevent the identification of several features; • Depends on cloud cover;	• Vegetation condition and type at national, regional and global scales;
High Resolution SAR Sensors:		
• Not depends on cloud cover; • Frequent global coverage; • Global archive available; • Good discrimination of many surface features (also emergent vegetation in wetlands); • Solid methodologies for automatic data analysis available; • Low cost; • Suitable for large geographic areas (e.g., wetland site and catchment area); • Archive data available and well known; • Allow accurate DEM and subsidence monitoring;	• Poor discrimination of vegetation type; • Geometric distortion of topography; • Information in image may be affected by meteorological conditions (e.g., wind over wetlands may hinder the accurate mapping of the water table);	• Creation of base maps; • Land cover/use and change (especially in combination with optical data); • Water regime; • Potential threats (not suitable for industrial pollution) • Soil features (depending of vegetation cover); • Mapping infrastructure (e.g., roads); • DEM; • Subsidence;