WETLANDS INTERNATIONAL

A Manual for an Inventory of Greater Himalayan Wetlands

ICIMOD

FOR MOUNTAINS AND PEOPLE

About the Organisations

International Centre for Integrated Mountain Development

The International Centre for Integrated Mountain Development, ICIMOD, is a regional knowledge development and learning centre serving the eight regional member countries of the Hindu Kush-Himalayas – Afghanistan  , Bangladesh  , Bhutan  , China  , India  , Myanmar  , Nepal  , and Pakistan  – and based in Kathmandu, Nepal. Globalisation and climate change have an increasing influence on the stability of fragile mountain ecosystems and the livelihoods of mountain people. ICIMOD aims to assist mountain people to understand these changes, adapt to them, and make the most of new opportunities, while addressing upstream-downstream issues. We support regional transboundary programmes through partnership with regional partner institutions, facilitate the exchange of experience, and serve as a regional knowledge hub. We strengthen networking among regional and global centres of excellence. Overall, we are working to develop an economically and environmentally sound mountain ecosystem to improve the living standards of mountain populations and to sustain vital ecosystem services for the billions of people living downstream – now, and for the future.

Wetlands International

Wetlands International works to sustain and restore wetlands and their resources for people and biodiversity. We are an independent, not-for-profit, global organisation. Based mostly in the developing world, we have 20 regional, national or project offices with a presence in all continents and a headquarters in Ede, the Netherlands.

We work in over 100 countries to tackle the most pressing problems affecting wetlands. With the support of governmental and NGO members and donors, we promote and demonstrate the positive role that wetlands can play in addressing biodiversity loss, poverty and climate change. Our work ranges from research and community-based field projects to advocacy with governments, corporates and international policy fora and conventions. Wetlands International works through partnerships and is supported by contributions from an extensive specialist expert network and tens of thousands of volunteers.

A Manual for an Inventory of Greater Himalayan Wetlands

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Foreword

There is a need in the Hindu Kush-Himalayan region for capacity building in integrated water resource management and for broadly applicable wetland inventory tools to support this. In response to these needs, Wetlands International and the International Centre for Integrated Mountain Development (ICIMOD) have coordinated and implemented the project 'Support for the conservation of high altitude wetlands through application of the Asian wetland inventory approach and stakeholder-led catchment management in Bhutan, China, India and Nepal' supported by the Asia Pro Eco programme of the European Commission. We gratefully acknowledge the important assistance from the EC.

The project focus on wetlands is in line with ICIMOD's emphasis on promotion of sustainable management of natural resources and ecosystem services as a basis for improving peoples' livelihoods and maintaining biodiversity integrity in the Hindu-Kush Himalayan region. Through this document and project output, 'A Manual for an Inventory of Himalayan Wetlands', the project contributes to the strengthening of regional member countries' knowledge-base on wetlands and thus their capacity to make informed decisions on wetland management. This is important not only for local communities and the wetland biodiversity they depend on for their livelihoods, but also for the many downstream stakeholders.

Wetlands International promotes wetland inventorisation as a key activity that should underpin the sustainable use of wetlands and their resources and biodiversity for people around the world. In 2002, Wetlands International pioneered a new approach to assessing wetlands that provided the potential to link inventory information to planning and practice in sectors engaged in water management across Asia – "A Manual for an Inventory of Asian Wetlands". This project has adapted and tested the Manual in the Hindu-Kush Himalayan Region taking into account the unique and challenging conditions found there.

Challenges for wetland inventory regarding classification and delineation are present in all Asian regions; in the greater Himalayan region the specific issues of remoteness and large altitude variations present additional practical challenges to both field and remote sensing methods. We hope that the availability of this Manual will stimulate greater Himalayan countries to undertake inventories to establish the status of their wetlands – so that further habitat loss and degradation do not occur and the greater Himalayan region benefits from wetlands' goods and services. The Manual should also be seen as a means to easily share wetlands inventory experiences within the greater Himalayan region. It is urgent to share lessons-learned, because the time available to people in the region to reach a sustainable level of natural resource use while achieving the development of society they want, is running short.

On behalf of ICIMOD and Wetlands International we would like to thank all teams and individuals involved in the Project and the development and production of this document and in particular our partners in this project: ARGEOPS in The Netherlands and the Centre for Ecology and Hydrology in Wallingford, UK. Furthermore we would like to thank the participants from government and civil society organisations who have contributed to the development of this approach through their encouragement and feedback, most especially from the project focal countries of Bhutan, China, India and Nepal and more widely from those that have contributed as part of the Himalayan Wetlands Initiative Forum,

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Preface

Mountain wetlands are globally recognised to be ecosystems under a broad range of pressures that threaten their integrity as significant resources of water and biodiversity, putting the services and products that millions of people depend on at risk. Adding to the problem-picture are issues concerning increasingly erratic precipitation in mountains and an increase in glacier-melt and associated lakes. Combined these are creating increasing risks of landslides and floods downstream which pose grave threats to people's lives and livelihoods, biodiversity and community economy.

The potential negative effects on Himalayan countries' ecology and economy through changes to the mountains' water resources are serious and should prompt governments to immediately initiate remedial action programmes, should these not already be underway. Many wetlands in the Himalayan region extend from one country to another, or, at least, share their catchments between two or more countries. Developing national capacity and action plans for wetland conservation and sharing information within a regional collaboration is urgently needed to minimize the impacts of threats (particularly from climate change).

In recognition of these needs, this manual on wetland inventory has been developed as an output from the project 'Support for the Conservation of High Altitude Wetlands through application of the Asian Wetlands Inventory approach and stakeholder-led catchment management in Bhutan, China, India and Nepal'. The project contributes to the conservation and wise use of high altitude wetlands by providing technical support to and assisting Ramsar Convention regional Contracting Parties. Strategic wetland inventory was identified as a priority activity by Hindu-Kush Himalayan countries participating in the Himalayan Initiative Forum, a regional group of government and civil society representatives working to promote regional cooperation in wetland conservation under this Convention.

The objective of the Greater Himalayan Wetlands Inventory Manual (GHWI Manual) is to contribute to the conservation and management of greater Himalayan wetlands by providing countries with an easily accessible tool for data-collection, on which informed management decisions can be made; for example, to ensure sustainable use of wetland services and to also take preventive action to avoid damage from glacial lake outburst floods. It structures wetland inventory information into a river basin related landscape hierarchy thus enabling wetland functioning and services to be more easily related to the basic units of river basin management – the basin, sub-basins and catchments. Furthermore it links collection and organisation of this information to innovative remote-sensing techniques enabling the delineation and description of wetlands that are otherwise too remote and time-consuming to physically visit.

The GHWI should not be seen as a static document. Updates and improvements on its content should be noted by users and discussed at regional meetings and agreed revisions should be incorporated in a later version. While the GHWI Manual is self-explanatory on the methodology it presents, it is acknowledged that there could be a need in the greater Himalayan member countries for training in wetland inventory techniques and/or a need for lessons-learned exchange opportunities. The availability and use of the GHWI Manual will hopefully boost exchange between countries at all levels towards the development of sustainable wetlands management policy and supporting technical activities.

ICIMOD and Wetlands International

Acknowledgements

The GHWI Manual is the result of a partnership between Wetlands International, ICIMOD, ARGEOPS and the Centre for Ecology and Hydrology (CEH) on the project 'Support for the conservation of high altitude wetlands through application of the Asian wetland inventory approach and stakeholder-led catchment management in Bhutan, China, India and Nepal'. Wetlands International has provided overall coordination and technical guidance to the project. ICIMOD has lead and managed technical coordination and implementation in the Hindu-Kush Himalayan region. ARGEOPS in The Netherlands provided technical guidance in remote-sensing techniques. CEH in Wallingford, UK, provided input on risk assessment and integrated water resources management.

Within ICIMOD the Manual is a component of its Integrated Water and Hazards Management (IWHM) and Integrated Knowledge Management (IKM) Programmes. In this respect, many thanks are due to the following ICIMOD staff members: Prof Hua Ouyang, Programme Manager IWHM; Dr Mats Eriksson, Senior Water Specialist; Mr Rajendra Shilpakar, Water Resources Analyst; Mr Pradeep Mool, Remote Sensing Specialist; Mr Sushil Pandey, ICT Specialist; Mr Kabir Uddin, GIS Analyst; Mr Valdemar Holmgren, Wetlands Specialist (Consultant), Mr Santosh Nepal (Research Assistant); Mr Subodh Dhakal, Intern; and Ms Celeste Harris, Researcher. Thanks also to the former ICIMOD staff members Dr Xu Jianchu (Programme Manager, IWHM) and Mr Sushil Pradhan (GIS Specialist).

Within Wetlands International, the Manual's development has been supported through its headquarters office in Ede (HQ), The Netherlands and its South Asia Office New Delhi, India (WISA), Our thanks go in particular to Dr Chris Baker, Head of Programme and Strategy (HQ), Wetlands and Water Resource Management, Ms Ellen Diémé, Technical Officer, (HQ); Dr Chaman Trisal, Director (WISA) and Mr Ritesh Kumar, Sr Technical Officer (WISA).

Within ARGEOPS in The Netherlands thanks in particular go to Mr Leon Schouten and Mr Eric Van Valkengoed for supporting the application of suitable remote-sensing techniques to complement the Asian Wetland Inventory approach and the needs in the region.

Within CEH thanks in particular go to Prof Mike Acreman, Dr Gwyn Rees, and Dr Charlie Stratford.

ICIMOD is particularly pleased that the project has enabled a strengthening of collaboration with the Government of Nepal's Department of National Parks and Wildlife Conservation (DNPWC). Thereby, our thanks go to Mr Jhamak B Karki, Under Secretary, DNPWC, Government of Nepal, for facilitating national support to the project. Many thanks go also to our regional colleagues Mr Bao Daming and Mr Yan Chenggao, The Convention on Wetlands Management Office, State Forestry Administration, PR China; Dr Siddharth Kaul, Ministry of Environment and Forest, Government of India, and Mr Raling Nawang Drukdra, Department of Forests, Ministry of Agriculture, Bhutan for continuous support and constructive contributions to the project.

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The project is grateful to all Wetlands International and ICIMOD colleagues who have assisted in various ways with the finalisation of this manual in particular the former ICIMOD Director General, Dr J Gabriel Campbell and Wetlands International Head of Programme Dr Doug Taylor for supporting the beginning of this project and Dr Andreas Schild, present Director General of ICIMOD, for his continued encouragement, and the staff of the Publications Unit who brought the project to its conclusion. Should someone have been overlooked in being mentioned here, please know that your contribution was really appreciated!

Executive Summary

This document, the Manual for Inventory of Greater Himalayan Wetlands or GHWI Manual, has been developed to assist governments, professionals, and the public to identify wetlands of national and international importance, and to serve as a basis for prioritising their conservation in conjunction with sustainable management of natural resources, in particular, water, fisheries and forestry, and national development initiatives. There is a broad and growing consensus that wetlands are critically important ecosystems that provide locally and globally significant social, economic, and environmental benefits. Wetland inventory implementation is promoted by the Ramsar Convention (RCS 2006) as a means to

- identify the function and values of wetlands, including ecological, social and cultural values;
- establish a baseline for measuring future change in wetlands' functions and values;
- identify where wetlands are and which the priority sites for conservation are;
- provide a tool for planning and management at both practical and/or political levels; and
- allow comparisons between wetlands and management procedures at different levels of management (local, national, and international).

Furthermore, a wetland inventory can provide information to support national programmes and reporting requirements for other international treaties, such as the conventions on biological diversity, migratory species, desertification, world heritage, and climate change. Thus, a wetland inventory can supply information for many purposes and involve many different stakeholders. It is essential that any inventory provides information in a format readily usable by key stakeholders, and thus important that users of the information are consulted before any inventory is developed and implemented. The purpose of a wetland inventory and the manner in which the information will be used should be agreed between stakeholders before data collection commences.

The methodology for wetland inventory outlined in this manual uses a strategic and hierarchical approach of four levels to collect information. It is based on the Asian Wetland Inventory (AWI) developed by Wetlands International. The methodology also takes advantage of new technologies of data acquisition (e.g., remote sensing), storage, and dissemination. These provide an effective tool for collecting information for the management of natural resources derived from, or dependent on, wetlands and for meeting national obligations under international agreements.

Entry and management of inventory data at Levels 1 (river basin) and 2 (sub-basin) can be done by a regional or national organisation, whereas Level 3 (wetland complex) and Level 4 (wetland habitats) should be the responsibility of individual national agencies and organisations, see Chapter 3. The system is developed in such a way that Level 3 and Level 4 data can be hosted by the country itself according to capacity. On-site field data collection at Levels 3 and 4 can be achieved with the simple means of a pen and the data sheets provided in Annex 2.

The four-tiered data-collation and mapping levels for wetland inventory presented in this Manual are suggested to lie within the following map scales:

1 1: 500,000 to 1:1,000,000 scale maps for major river basins

2 1:250,000 to 1:500,000 scale maps for sub-basins

3 1:25,000 to 1:250,000 scale maps for wetlands complexes

4 1:5,000 to 1:25,000 scale maps for wetland habitats

With regard to computer-based data management, an interactive GIS-based dynamic web-system (the Greater Himalayan Wetlands Information System, GHWIS) has been developed by ICIMOD to visualise the complete wetland database. The system contains common GIS functionalities such as query, pan, zoom, and export, and has been developed using the open source internet mapping software MapServer. The database is linked to the metadatabase and both are integrated with the web mapping tool to serve derived map products. As of 2008, the GHWIS is under development (beta version) and hosted by ICIMOD, see Chapter 4.

The key features of the GHWI methodology are to apply a hierarchical and scalar framework to standardised categories of data including bio-geographical, socioeconomic, and cultural values of the wetland ecosystems. The framework links the mapping scales and the possible level of detail of data, while, where necessary, map production is made using secondary sources and remotely-sensed satellite data. A summary is provided of potential satellite data types applicable for wetlands resources mapping.

Although the Ramsar wetland classification is useful to provide a broad framework for rapid identification of the main wetland habitat types, it is recommended to use standard hierarchical national/regional land use and land cover classification schemes to complement the Ramsar typology. An international standard hierarchical classification system such as the FAO Land Cover Classification can also be used for wetland classification.

The Manual is prepared as follows. The main text is preceded by an Introduction (Chapter 1) and a description of the Aims (Chapter 2), the Methods (Chapter 3), and the Information Management System developed for the Inventory (Chapter 4). The largest part of the Manual is dedicated to Chapter 5 which provides step-by-step guidelines, with examples, for data collation at each hierarchical level. The associated data collection sheets for each level are presented in Annex 2.

Acronyms and Abbreviations

AWI	-	Asian Wetland Inventory
DEM	-	digital elevation model
FAO	-	Food and Agriculture Organization
GHWI	-	Greater Himalayan Wetlands Inventory
GHWIS	-	Greater Himalayan Wetlands Information System
GIS	-	geographic information system
ICIMOD	-	International Centre for Integrated Mountain Development
IUCN	-	International Union for the Conservation of Nature
IWMI	-	International Water Management Institute
MA	-	Millennium Ecosystem Assessment
MODIS	-	Moderate Resolution Imaging Spectro-radiometer
NOAA	-	National Oceanic and Atmospheric Administration
Ramsar	-	The Ramsar Convention on Wetlands (Ramsar, Iran, 1971)
SRTM	-	Shuttle Data Topographic Mission
UNEP	-	United Nations Environment Programme
UTM	-	Universal Transverse Mercator
WCMC	-	World Conservation Monitoring Centre
WRI	-	World Resources Institute

1 Introduction

The water resources of the greater Himalayan region are under mounting pressure from the demands of growing populations and economies, and also from the ever-more evident impact of climate change. Wetlands are ecologically critical water resources found in a broad range of categories within various landforms throughout the greater Himalayan region. Himalayan wetlands[1] such as lakes, marshes, peatlands, wet grasslands, streams, glacial lakes, and rivers provide many important ecological functions and services to sustain livelihoods in the mountains as well as in the populous and economically and agriculturally valuable areas downstream.

Wetlands, including high altitude wetlands (HAWs), contribute to flow-regulation in major river systems like the Amu Darya, Brahmaputra, Ganges, Indus, Irrawaddy, Mekong, Salween, Tarim, Yangtze, and Yellow. Wetlands support high biological and cultural diversity: they are important staging points for migratory birds and many are breeding and nursery places for birds, fish, and amphibians. Wetlands store water, feed groundwater aquifers, trap sediments, and recycle nutrients, thereby enhancing both the quantity and quality of water in the water cycle. Wetlands also foster vegetation growth, which lessens soil erosion, and thus contribute to reduction of risk of disasters by landslides and floods. The land and water stabilising qualities of wetlands are often overlooked.

Sustainable development practice in general should include sound wetland management in order to maximise water-resource integrity, and this is particularly important in mountain areas where water loss is a constant challenge. The wetlands in the Himalayan region often do not receive appropriate recognition and hence are poorly documented. Figure 1 indicates the influence of Himalayan river water on the vast land areas where millions of people make their livelihoods.

Himalayan wetlands are extremely vulnerable to a wide range of human and environmentally-driven threats, including overgrazing by livestock, water diversion for agriculture and human use, increasing pollution due to change in lifestyle of the local inhabitants, and increased tourism. Climate change and variability will dramatically affect wetlands and the provision of their services, as the water cycle on which these wetlands depend will change.

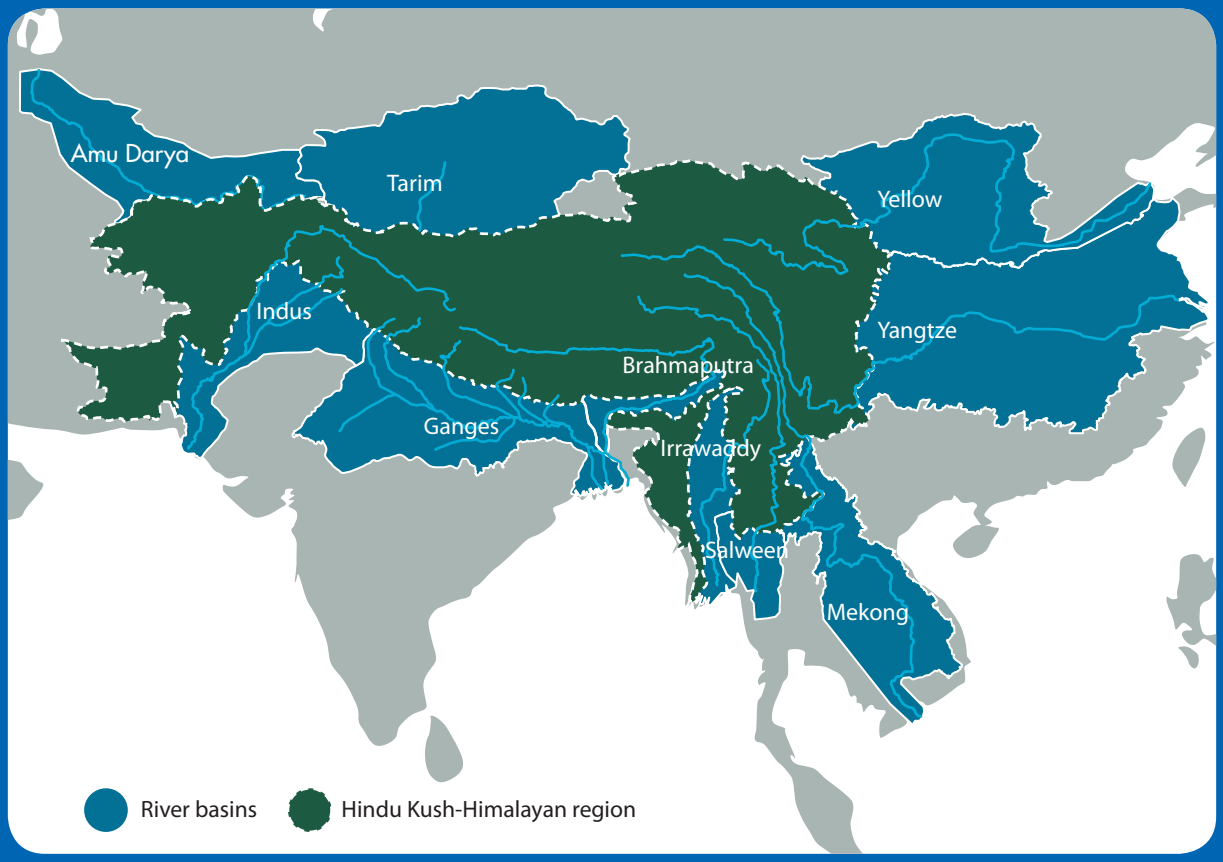
A significant aspect of Himalayan water resources, including for wetlands, is the great variation in altitude, terrain, and water location throughout the mountains, and the occurrence of high altitude wetlands. Ongoing climate change effects with melting of the ice of Himalayan glaciers are documented and show an alarming trend in glacier retreat and formation/expansion of glacial lakes (Bajracharya et al. 2007). A baseline study conducted between 1999 and 2003 reported about 15,000 glaciers and 9,000 glacial lakes in Bhutan, Nepal, Pakistan, and selected basins of China and India (Mool et al. 2005). Increased volumes of meltwater constitute threats to people's lives and livelihoods through flooding and landslides. Increased air and water temperatures also bring risks of changes in the quality of standing water, with lower salinity and increased photosynthesis and a change in biota (WWF 2006).

These factors constitute a special situation for the Himalayan wetlands, and specifically for HAWs. While wetlands in general have productive and protective functions and services, some HAWs have the potential to cause catastrophic damage to people and the landscapes they live in. These are the glacial lakes formed from melting glacier ice. The rising temperatures from global warming have now been melting mountain glaciers for some 40-50 years – a 'recent' phenomenon in our modern history. This is happening in mountains all over the globe and the resulting increase of glacier meltwater equates to an increase in the threat of glacial lake outburst floods (GLOFs). These can occur when the build up of meltwater breaks through the lake edge, resulting in destructive torrents and floods in downstream areas.

The potential negative effects on the ecology and economy of the Himalayan countries through changes to the mountains' water resources are serious and should prompt governments to immediately initiate remedial action programmes, should these not already be underway. This should be done at both national and regional levels. The transboundary nature of Himalayan rivers and some high altitude wetlands will require collaborative efforts between countries in the region, to achieve sustainable and effective management of wetlands and water ecosystems.

[1] *For the purpose of this document, 'Himalayan wetlands' indicates wetlands located within the greater Himalayan region (the Himalayan - Hindu Kush - Pamir-Alay region).*

Figure 1: **Overview of the major river basins of the greater Himalayan region**



There is an urgent need for management action that supports both conservation and wise use of the wetlands important for landscape productivity, and that supports risk reduction from potential GLOFs and other natural disasters. The first step towards achieving this is to establish wetland location, type, and character through an inventory system, and to build baseline information on their physical status and their ecological functions and services. Without baseline information, it is not possible to develop strategies to counter threats to Himalayan water resources and biodiversity. Neither can targeted actions be implemented in a systematic and prioritised way in the field.

The recognition of the ecological significance of wetlands led to the establishment in 1971 of the Ramsar Convention (The Ramsar Convention on Wetlands, Ramsar, Iran, 1971) as a leading framework for their conservation and sustainable use. Among the ICIMOD member countries in the greater Himalayan region, all except Afghanistan and Bhutan are currently (July 2008) Contracting Parties to the Convention. Afghanistan is already in the process for accession to become a contracting party and Bhutan has initiated dialogue for the same. As the leading framework for global technical knowledge transfer and national institutional strengthening concerning conservation and the sustainable use of wetlands, the Ramsar Convention provides overall support to the concept of the Greater Himalayan Wetlands Inventory (GHWI) and this Manual. Ramsar also provides substantial support to wetland inventory methodology through Convention Resolutions (see Annex 1). Decisions concerning the conservation, management, and wise use of wetlands should be made on the basis of reliable knowledge on wetland ecosystems, and wetland inventories can provide the crucial initial information (Dugan 1990, Finlayson 1996). The Ramsar Convention encourages its contracting parties to undertake efficient wetland inventories, particularly to identify all sites that meet the criteria for selecting wetlands of international importance.

In order to distinguish wetland inventory activities in the Himalayan region from other places, the term Greater Himalayan Wetlands Inventory (GHWI) will be used from now on in this Manual. The implementation partnership of ICIMOD and Wetlands International in the 'Support for the conservation of high altitude wetlands through application of the Asian Wetlands Inventory approach and stakeholder-led catchment management in Bhutan, China, India and Nepal' project enabled a seamless basis for the GHWI to adopt the Asian Wetland Inventory (AWI) developed by Wetlands International.

The key feature of the AWI approach is the use of a hierarchical, map-based approach to define the most appropriate land and resource management units at four levels of detail, from river basin to wetland habitat, that are related to the scale of the maps and contained within a standardised GIS (geographic information system) format. River basins or river catchments are important geographical units for wetland management. Wetlands are distributed from the top of the catchment to the deltas at the catchment-bottom, indicating clearly the network and interdependence of water resources. The interconnected nature of river systems highlights the fact that successful water management requires the adoption of an approach which helps to avoid the problems associated with isolated and often short-sighted use of water and land resources in one area, which often have adverse impacts elsewhere within the river basin. The hierarchical wetland inventory approach allows for strategic collection of information at these different geographical scales (see Chapter 3) within a river basin and, furthermore, provides a framework for considering individual habitats and sites within and outside of established jurisdictional boundaries. This promotes better planning for development and conservation of wetlands at national and sub-regional (transboundary) levels throughout the region.

It is in the context of the scenario described above that this GHWI Manual has been developed. The objective is to contribute to the conservation and management of greater Himalayan wetlands by providing countries with an easily accessible tool for collecting data which can be used as a base for informed management decisions, for example decisions on ensuring sustainable use of wetland benefits and on taking preventive action to avoid damage from GLOFs.

The GHWI Manual covers a broad range of inventory techniques and includes high-level technical aspects of remote sensing analysis. However, it is emphasised that the Manual should be used at the level that is appropriate for the users' capacity. It is important to collect as much wetland information as possible. Therefore, all categories of field officers and remote sensing analysts are encouraged to use the GHWI Manual to their ability, and to share their experiences with each other and other colleagues in the region.

The main users of the GHWI Manual are presumed to be line agency department heads and technical officers from land-use planning, agriculture, forestry, fishery, wildlife, and protected areas and water resources management, and their project partner organisations (bilateral, international, and non-government organisations, and others). Although one line agency would usually have the formal mandate for wetland management and be considered a 'lead agency', global wetland management experience has shown that a multi-disciplinary approach has many technical, field, and data management benefits. In this, the Ramsar authorities in each member country have important roles to play in coordination and support.

It is hoped that professionals such as lecturers, teachers, and technical advisers, working in such fields as biodiversity research and conservation, environmental sciences, geography, geology, and development assistance environment-oriented projects, will also contribute to achieving the aims of fulfilling their countries' wetland inventory needs. Moreover, there are many people in the ranks of civil society who can contribute to achieving a national wetland inventory. Keen amateur birdwatchers, entomologists, herpetologists, botanists, geologists, and so on can play a significant role in wetland inventory and wetland management and contribute to full wetland inventory coverage in the member states of the greater Himalayan region.

Global experience has shown the importance of including local knowledge in wetland inventories and it is strongly emphasised that local community members should be involved from the beginning as team members of wetland inventory in the greater Himalayan region. The methods described in the GHWI Manual provide guidelines for a full inventory at a high technical level. However, important information on the status of wetlands can be collected with simple means through field observations and local people's knowledge, should the capacity of the user not fully meet the relatively high technical requirements presented in this manual.

The structure of the Manual is as follows. The main text is preceded by this Introduction (Chapter 1) and a description of the Aims (Chapter 2), the Methods (Chapter 3), and the Information Management System developed for the Inventory (Chapter 4). The chief body of text is comprised of the step-by-step guidelines for data collection at each level of the wetland inventory hierarchy, Level 1 (river basin) to Level 4 (wetland habitats), which is presented in four sections in Chapter 5. Data-collection sheets for each level are presented in Annex 2. Reading the sections in Chapter 5 with the corresponding data sheet example at hand should enable a good understanding of the various data collections proposed in this Manual for each level.

2 Aims

The GHWI approach aims to develop a standardised and compatible method that can be applied nationally and regionally in the greater Himalayan region[2]. It aims to support initiatives for the conservation of wetlands, including high altitude wetlands, to do the following:

- Develop standardised field data collection sheets
- Provide core data and information on high altitude wetlands to Ramsar site and water resource managers, to research institutions in the region, and to international conventions and treaties on wetlands, climate change, biodiversity, migratory species and desertification as support for their implementation
- Analyse long-term trends in Himalayan wetlands and their natural resources
- Disseminate these analyses for wider consideration and application in the conservation and wise use of wetland resources
- Enable regular revisions and updates of information on wetlands of national and international importance in the Himalayan region
- Establish a regional web-based platform to share wetlands and water information as a tool for regional cooperation

The concept of this manual is to provide a step-by-step guide for compiling wetland inventory data that achieves the GHWI aims. The other distinguishing feature of the GHWI is its compatibility with an integrated river basin approach, which has been identified as the way forward for achieving conservation and wise use of Himalayan wetlands and biodiversity.

[2] The geographic qualifier 'greater Himalayan' is not very precise. ICIMOD's target area includes the Hindu-Kush, Karakorum, Pamir-Alay, and other neighbouring ranges along an arc extending some 3,500 km over all or part of eight countries from Afghanistan in the west to Myanmar in the east.

3 Methods

One of the key features of the GHWI approach is the use of remotely sensed satellite data for classification of land use and land cover in order to describe wetland types and area in different detail at each hierarchical level of data collection. Other features of the GHWI approach are

- the production of maps using secondary sources and remotely-sensed data (satellite data);
- the collection and analysis of standardised categories of data including bio-geographical, socioeconomic, and cultural values of the wetland ecosystems;
- the above-stated done within a hierarchical and scalar framework which links the mapping scales and the level of data-detail that it is possible to achieve;
- the use of remotely sensed satellite data for classification of wetlands resources.

3.1 Definition of Wetlands

Wetlands are areas where water is the primary factor controlling the environment and the associated plant and animal life. They occur where the water table is at or near the surface of land or where the land is covered by shallow water. It is not easy to define wetlands, and many definitions exist throughout the world. The definition of wetlands used by the Ramsar Convention (RCS 2006) has gained worldwide recognition and acceptance and is adopted as the basis for this inventory:

> "Wetlands are areas of marsh, fen, peatland, or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres."

Article 2.1 of the Ramsar Convention provides that areas defined as wetlands 'may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands'. In this respect the definition adopted provides support for formal national and international purposes associated with the Ramsar Convention, but is sufficiently broad to support other wetland analyses that may use a narrower definition.

The Ramsar typology of wetland habitats and ecosystems (see Box 1) is useful and has been widely used to provide a broad framework for rapid identification of the main wetland habitat types, based on a mixture of vegetation, soil, inundation, and landform features. However, this system is not easily applied in the context of multi-scale classification using Earth observation technology (Jones et al. 2008).

Therefore, it is recommended to use standard hierarchical national/regional land use and land cover classification schemes (whichever exists), which internally can be translated to the Ramsar typology. If these land-use /land-cover schemes are not available, it is suggested to refer to an international standard hierarchical classification system such as the FAO Land Cover Classification (www.fao.org; for example (http://www.fao.org/sd/Eidirect/Eire0019.htm).

3.2 Wetland Delineation

The principal purpose of the GHWI is to delineate and map the region's wetland resources, reaching to the level of specific wetland habitats, and to display this information on base maps (e.g., topographic, thematic) or GIS-based maps, as available. It is intended that this would occur at different scales with the amount of detail being dependent on the explicit purpose of the inventory and the size and importance of the wetland. Thus a hierarchy of four mapping scales, as prescribed in the AWI, is applied, none of which are fixed and any of which can be used, see the example illustrated in Figure 2. Typical mapping scales, for example, could be:

1 1:500,000 to 1:1,000,000 scale maps for major river basins
2 1:250,000 to 1:500,000 scale maps for sub-basins

Box 1: **Ramsar Classification System for Inland and Human-made Wetland Types**

(Source: Ramsar Convention Secretariat 2008)

Inland Wetlands

L	Permanent inland deltas
M	Permanent rivers/streams/creeks; includes waterfalls
N	Seasonal/intermittent/irregular rivers/streams/creeks
O	Permanent freshwater lakes (over 8 ha); includes large oxbow lakes
P	Seasonal/intermittent freshwater lakes (over 8 ha); includes floodplain lakes
Q	Permanent saline/brackish/alkaline lakes
R	Seasonal/intermittent saline/brackish/alkaline lakes and flats
Sp	Permanent saline/brackish/alkaline marshes/pools
Ss	Seasonal/intermittent saline/brackish/alkaline marshes/pools
Tp	Permanent freshwater marshes/pools; ponds (below 8 ha), marshes and swamps on inorganic soils; with emergent vegetation water-logged for at least most of the growing season
Ts	Seasonal/intermittent freshwater marshes/pools on inorganic soils; includes sloughs, potholes, seasonally flooded meadows, sedge marshes
U	Non-forested peatlands; includes shrub or open bogs, swamps, fens
Va	Alpine wetlands; includes alpine meadows, temporary waters from snowmelt
Vt	Tundra wetlands; includes tundra pools, temporary waters from snowmelt
W	Shrub-dominated wetlands; shrub swamps, shrub-dominated freshwater marshes, shrub carr, alder thicket on inorganic soils
Xf	Freshwater, tree-dominated wetlands; includes freshwater swamp forests, seasonally flooded forests, wooded swamps on inorganic soils
Xp	Forested peatlands; peatswamp forests
Y	Freshwater springs; oases
Zg	Geothermal wetlands
Zk(b)	Karst and other subterranean hydrological systems; inland

Note: **'floodplain'** is a broad term used to refer to one or more wetland types, which may include examples from the R, Ss, Ts, W, Xf, Xp, or other wetland types. Some examples of floodplain wetlands are seasonally inundated grassland (including natural wet meadows), shrublands, woodland, and forests. Floodplain wetlands are not listed as a specific wetland type herein.

Human-made wetlands

1	Aquaculture (e.g., fish/shrimp) ponds
2	Ponds; includes farm ponds, stock ponds, small tanks; (generally below 8 ha)
3	Irrigated land; includes irrigation channels and rice fields
4	Seasonally flooded agricultural land (including intensively managed or grazed wet meadow or pasture)
5	Salt exploitation sites; salt pans, salines, etc
6	Water storage areas; reservoirs/barrages/dams/impoundments (generally over 8 ha)
7	Excavations; gravel/brick/clay pits; borrow pits, mining pools
8	Wastewater treatment areas; sewage farms, settling ponds, oxidation basins, etc
9	Canals and drainage channels, ditches
Zk(c)	Karst and other subterranean hydrological systems; human-made

3 1:25,000 to 1:250,000 scale maps for wetlands complexes
4 1:50,00 to 1:25,000 scale maps for wetland habitats

The four hierarchy scales will provide different information for wetland management. As the data fields for each scale are interlinked, it will be possible to compile the inventory in either a top-down or bottom-up approach, depending on the purpose. The information at each scale can also serve different reporting purposes.

The GHWI is built on the use of river basins as the basis for a geographical framework for Himalayan wetlands because they are topographically and hydrologically distinct. The GHWI also aims to promote the use of remotely sensed data for delineating wetland resources. Various satellite data can be used depending upon the size of the mapping unit and desired level of detail of the land-cover class. Table 1 provides a summary of satellite data that can be useful at different mapping scales as suggested above.

Table 1: **Summary of potential satellite data types applicable for wetlands resources mapping** (based on van Valkengoed 2007)

Area of site (km^2)	Preferred (minimum scale of map)	Minimum mapping unit	Satellite data type		Spatial resolution	Tentative cost (in US$)
10,000	1:1,000,000	–	Low resolution	SPOT-vegetation NOA	1 km	Available for free down-loading
1,000 to 10,000	1:500,000	–		MERIS	250-500m	
500 to 1000	1:250,000	20 ha (450 x 450m)			250-500m	
250 to 500	1:100,000	–	MODIS		30m	0.01¢ to $3.50 per km^2
100 to 250	1:50,000	5 ha (225 x 225m)	Low resolution	MERIS	30m	
10 to 100	1:25,000	3 ha (170 x 170m)	MODIS		15-30m	$3.50 to $80.00 per km^2
<10	1:5,000		Medium resolution	Landsat TM/ ETM+	5-10m	
				Landsat 7 (ETM+)	0.6-4m	
			ASTER			

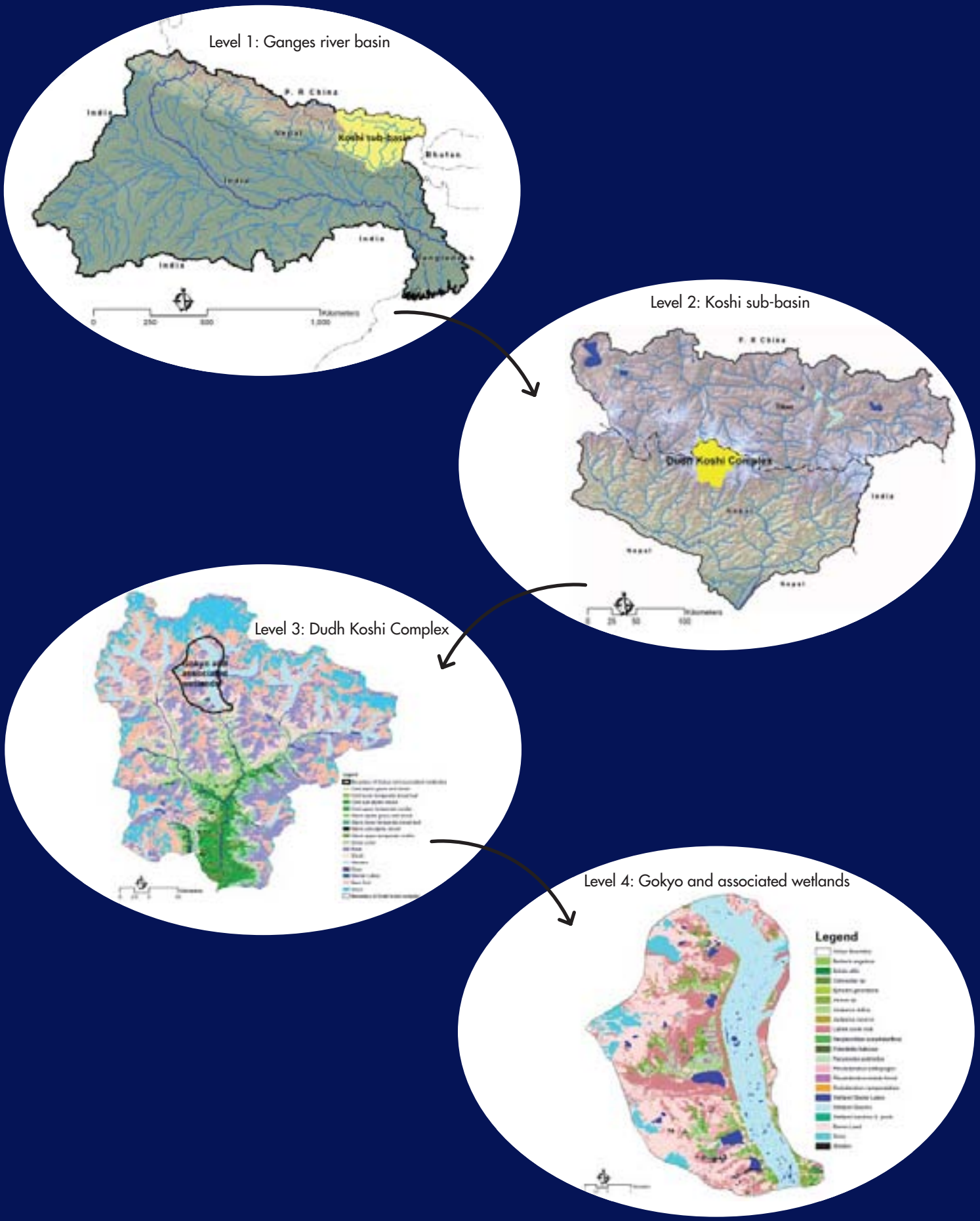
The geographical extent (basin boundary) of major river basins of the Himalayan region (see Figure 1) would be indicated on the basis of existing map-based products in ICIMOD. A text description and maps of the major geological, climatic, and vegetation features will accompany each river basin. An area within each river basin that shares common landforms and water regimes as determined by topographic and hydrologic features will be further delineated and presented on maps (i.e., sub-basin). These maps will provide the basis for delineating and mapping the complexes (or aggregations) of wetlands within the same sub-catchment, which can be further distinguished by topographical features into individual habitats or a wetland site for specific management purposes (e.g., Ramsar site).

3.3 Wetland Description

Another purpose of the GHWI is to describe the wetland resources of the greater Himalayan region using core data sets. For example, the initial analyses at Level 1 (river basins), comprise a broad-based description of river basins' wetlands from existing global and Asia regional maps. It further encompasses a description of geological, climatic, and ecological features based on existing information and presented in a geographic information system (GIS), making it possible to overlay layers with national borders, and geographic and demographic information as required.

The distribution and occurrence of sub-basins within each river basin is then described on the basis of similar characteristics for Level 2 (sub-basins), such as climatic, geological, hydrological and vegetation features. Each of the sub-basins can be further sub-divided for Level 3 (wetland complex/es) that comprise wetlands with broadly similar ecological characteristics and values. The most detailed data collection then focuses on Level 4 (wetland habitat or site) and describes the ecological character of the habitats of a wetland defined at Level 3.

Figure 2: **The four-tiered landscape (multi-scale) approach for wetland inventory. The level of detail varies with spatial scale in the four-level hierarchy from river basin to wetland habitat**



The descriptions outlined above should be undertaken by people with appropriate skills and access to the required resources, and in conjunction with relevant institutes and agencies, for accurate identification of information sources. The usefulness of all information will need to be assessed and then used as a basis for determining the extent of further analysis and data collection, including fieldwork. The methodology used at each level is in general as follows:

- Level 1 – desk study using existing information to describe each major river basin;
- Level 2 – desk study using available information to identify and describe the sub-basins;
- Level 3 – fieldwork and analysis to identify and describe wetland complexes within each sub basin; and
- Level 4 – detailed field work and analysis to delineate and describe habitats within each wetland complex.

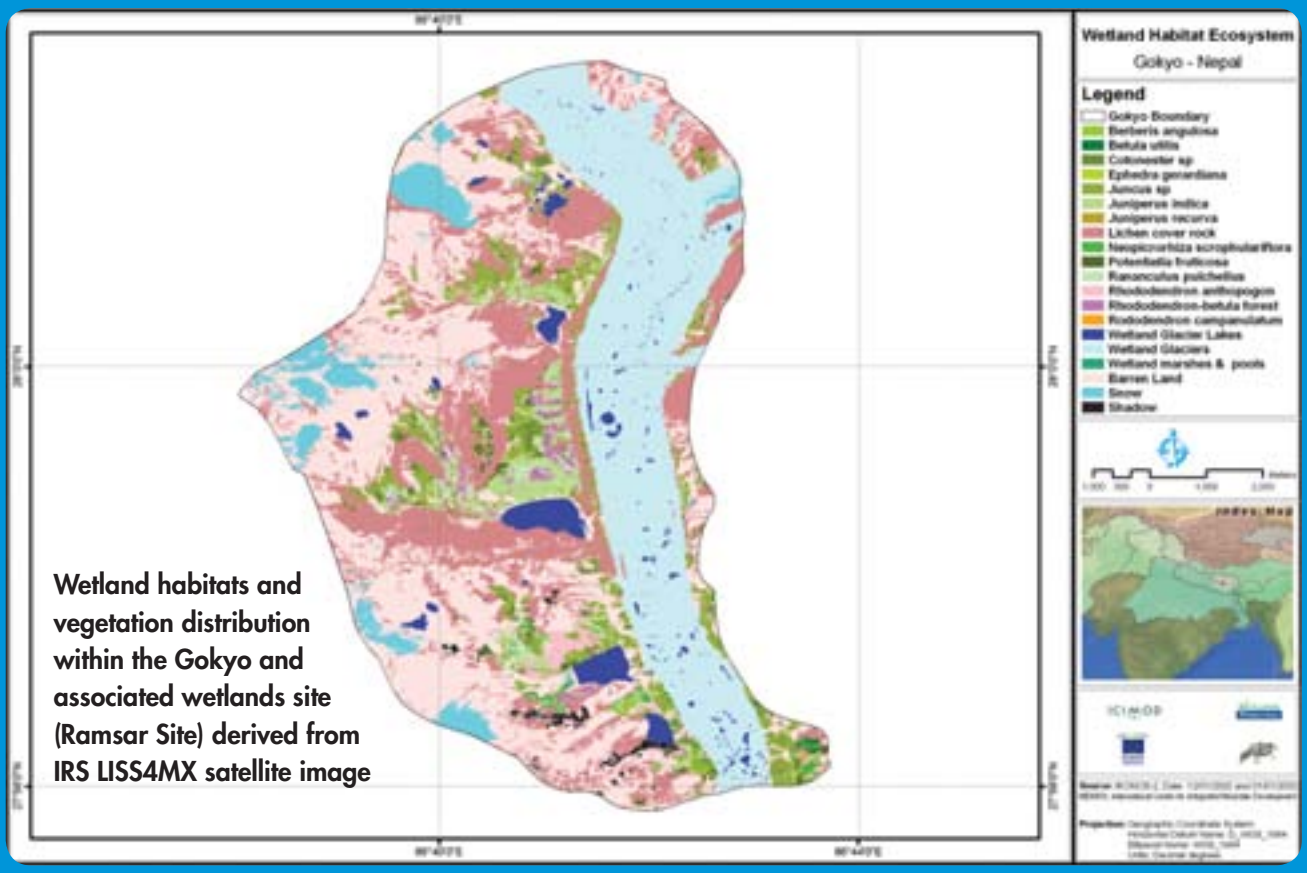
Data collection sheets have been developed together with a GIS-integrated database system for each level of the hierarchy (see Section 4 below). The data sheets indicate the core data that is considered necessary for each level of delineation and description of wetlands and provide a standardised format for recording and presenting this information.

A site-specific wetland description can be developed in consultation with local experts. An example of this is provided in Table 2. This shows the site-specific characteristics of a high altitude wetland in Nepal, where information was collected using local expert knowledge and developed with ICIMOD expertise.

Level 3 and Level 4 datasheets should be accompanied by a GIS-based vegetation map and detailed wetland habitats map (Figure 3). Other maps which could complement the data collection sheets and that are relevant for wetland monitoring and management purposes are change detection (land use land cover) and water cycle regime maps

Figure 3: **Example of the production of a wetland habitat map at Level 3/4**

High resolution satellite images (IRS LISS4MX, IKONOS) were used for detailed classification of the wetland habitats and associated dominant vegetation at Level 4. A field survey was conducted in the Koshi Tappu area to gather training samples for image classification. Training samples were generated based on local experts' knowledge and secondary information for Gongga township and Gokyo and associated wetlands. Using digital image processing techniques, the satellite data were classified to describe wetland habitats within the wetland sites.



Wetland habitats and vegetation distribution within the Gokyo and associated wetlands site (Ramsar Site) derived from IRS LISS4MX satellite image

(Jones et al. 2008). A change detection map will provide an overview of the main permanent changes in the wetland and its surroundings over a selected time period due to natural and anthropogenic factors, which allows the identification of (potential) threats affecting the area.

The water cycle regime (or hydroperiod) map provides information on the dynamics of the surface water of the wetland (Figure 4). When generated over several years, the production of such maps could serve as an important monitoring tool for the area's water cycle and help identify water regime variations that may affect the wetland system and its surroundings.

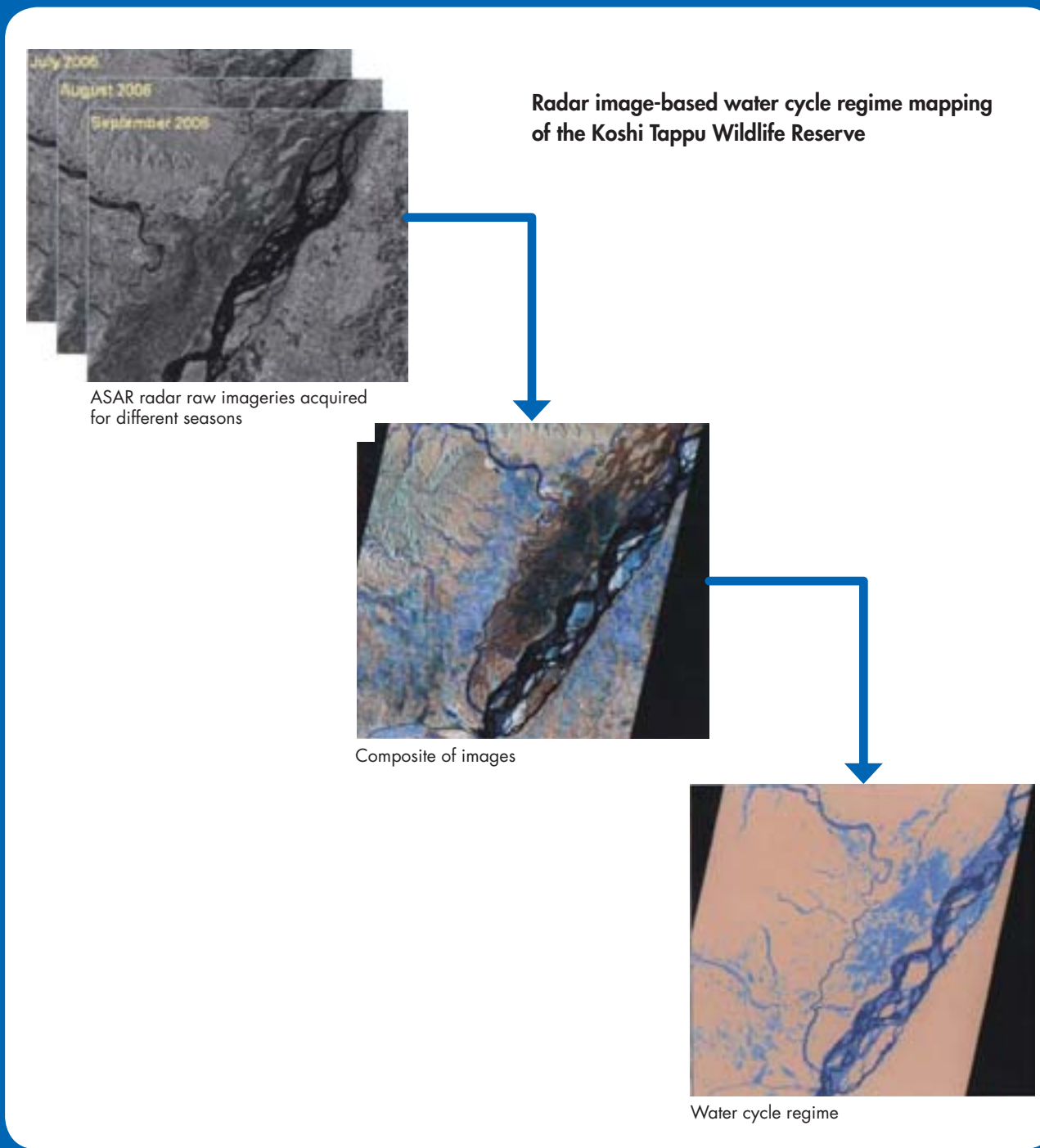
Table 2: **Land use and land cover classification scheme developed for the Gokyo and associated wetlands site (Ramsar site), Nepal**

Major land use		Level 3 – Wetland complex	Level 4 – Wetland habitat
1	Forest	a. Warm sub-alpine mixed	*Juniperus indica* (f)
		b. Cold upper temperate coniferous	*Betula utilis* (a)
		c. Warm upper temperate coniferous	*Abies spectabilis* (c)
		d. Cold lower temperate broad-leaf	*Prunus sp* (d)
		e. Warm lower temperate broad-leaf	*Rhododendron arboreum* (e)
		f. Cold sub-alpine mixed	*Rhododendron-Betula* forest (e)
2	Shrubland	a. Warm (moist) alpine grass and shrub	*Rhododendron anthopogon* (b)
		b. Cold (dry) alpine grass and shrub	*Rhododendron lepidotum* (a)
		c. Shrub mixed	*Bistortia milletii* (a)
			Ephedra gerardiana (b)
			Berberis angulosa (a)
			Cotoneaster sp (b)
			Salix sikkmensis (a)
			Rhododendron campanulatum sp (a)
3	Grassland	Grassland *Imperata* type	Grassland *Imperata* type
4	Herbs	Herbs	*Juncus sp*
			Neopicrorhiza scrophulariflora
			Meconopsis horridula
			Parnesia nubiculla
			Aster himalayca
			Rananculus pulchellus
			Potentiella fruticosa
			Juniperus recurva
			Primula sp
			Senecio sp
5	Agricultural land	Agriculture	
6	Urban / built up	Settlement	
7	Wetland	a. Permanent river	a. Permanent river
		b. Seasonal river	b. Seasonal river
		c. Glacial lakes	c. Glacial lakes
		d. Permanent freshwater marshes and pools	d. Permanent freshwater marshes and pools
		e. Snow and glaciers	
8	Barren land	Bare soil	Bare soil
9	Rock	Rock	Lichen covered rock of the forest belt
10	Other	Shadow	Shadow

Figure 4: **Example of the production of a water cycle regime map (Level 3/4)**

The distribution and extent of wetland habitats is dependent on the seasonal dynamics of the water cycle. The water cycle regime provides information on the annual variations of the surface water over the wetland area. Temporal, time-series satellite images can be used in deriving and mapping a water cycle regime. However, in practice it can be basically only be done with radar images, as optical images often fail in the wet season due to cloud cover.

It is important to acquire information on the extent of open water during very specific times of the season. These would normally include the high water and low water cycles. In the case of the Koshi Tappu Wildlife Reserve, three radar images – pre-monsoon, monsoon, and post-monsoon (2006) were acquired. A 'synthetic' image was produced by combining these three multi-dated radar images, and this was further classified into three general classes to depict permanent land, permanent water body, and seasonally inundated lands. Figure 1 represents the water cycle regime in the Koshi Tappu Wildlife Reserve area derived from ASAR data.



4 Greater Himalayan Wetlands Inventory Information Management

Effective information management is a critical component of the GHWI process and emphasis is placed on the use of up-to-date spatial datasets, databases, and GIS technologies. An information management system, the 'Greater Himalayan Wetlands Information System' (GHWIS), has been developed by ICIMOD in collaboration with Wetlands International to enable the extraction, analysis, and management of information that has been collated or created for each level of inventory. ICIMOD is currently hosting a beta version of the system which can be installed on any computer and operated offline. In the following, we provide an outline of the user guidance describing the navigation and data uploading functions and services available in the system.

The system consists of three inter-related but distinct elements as follows:

1. The GHWI database – an interactive, user-friendly, relational database, which stores the actual inventory information for each of the levels proposed in the GHWI methodology (see also the data collection sheets in Annex 2)
2. Metadata entry and querying interfaces – these comprise records describing individual inventory datasets
3. Web mapping tool – an interactive map display and querying capability to access a pre-processed spatial database including maps and satellite imagery

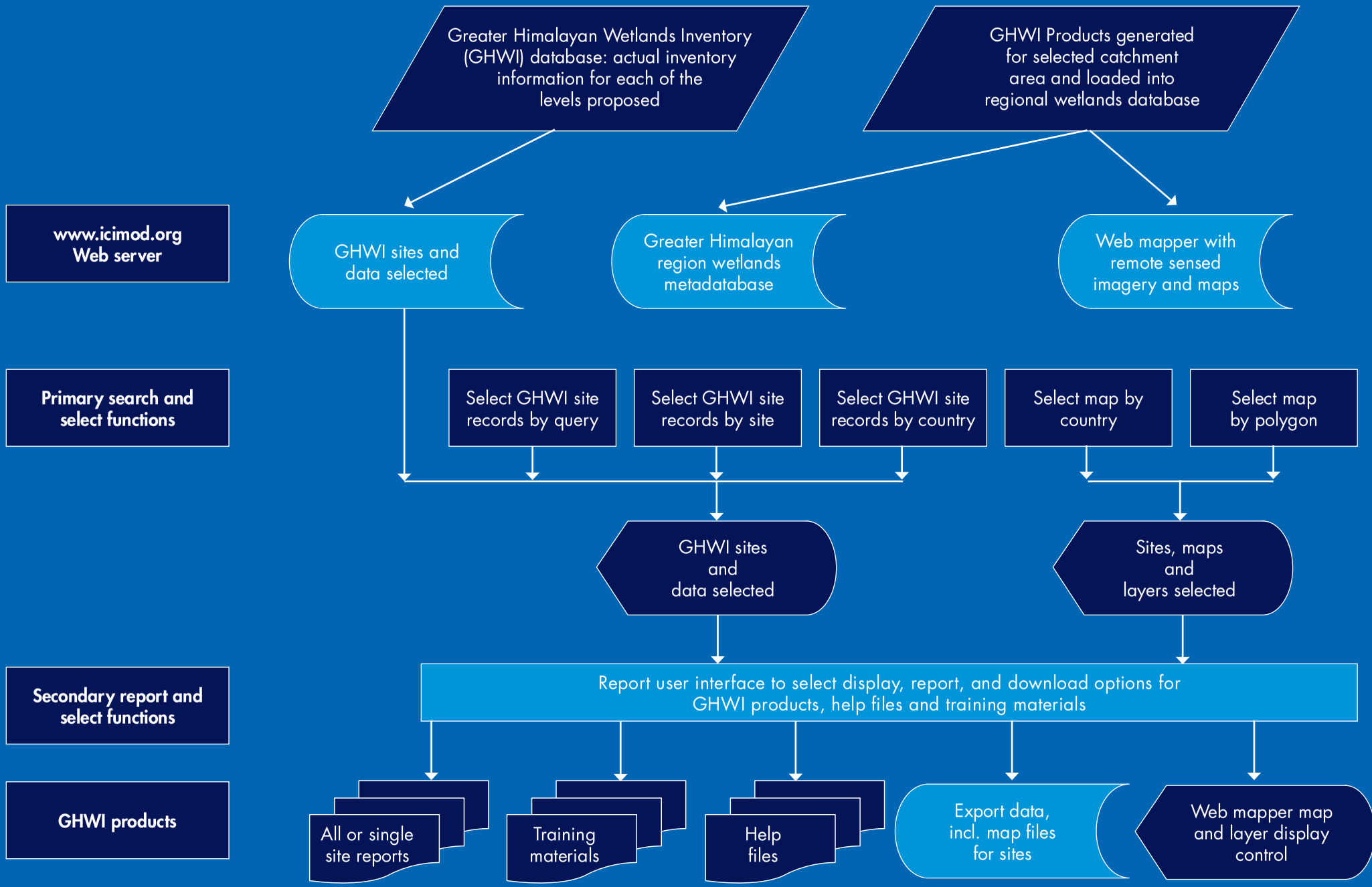
At its core, the information system is a computerised database engine with metadata entry and querying interfaces and GIS display and information retrieval capabilities. The wetlands inventory database is linked to the metadata database, and both databases are integrated with the web-mapping tool to serve derived map products. Figure 5 represents the data model showing the relationships between the inventory database, metadata, and web mapping subsystems. The main features of the GHWIS are as follows:

- GHWIS offers a tool to gather, extract, and manage information that provides information on wetlands in a systematic and scientific way.
- GHWIS follows the accepted approach of the Asian Wetland Inventory and Ramsar recommended metadatabase format modelled into FAO Geo-Network, an open source online spatial metadata management system.
- GHWIS emphasises the use of spatial datasets, satellite imagery, databases, and web mapping.
- GHWIS uses data prepared from earth observation, maps, and field observations for various levels of wetlands

The GHWIS will serve as the primary data management/storage/retrieval component of the GHWI and includes the following functionalities:

- A powerful querying capacity to allow customised query
- The ability to upload data from other formats and sources by regional partner agencies and organisations
- The ability to export/download data to other formats for further analysis
- Incorporation of a metadata component for each inventory and/or spatial dataset
- Structuring and storage of data in a hierarchical manner, defined by spatial scale and extent in line with GHWI methodology

Figure 5: **Data model for the relationship between the GHWI database, metadatabase and web mapper tool**



4.1 The Inventory Database

An extensive mySQL-based database has been designed to store the actual inventory information for each of the proposed levels. The GHWI data sheets described in Annex 2 identify the type and format of information that should be obtained and recorded for each level of the GHWI. A user-friendly password-protected interface has been developed for data access. Entry and management of inventory data at Level 1 (river basin) and 2 (sub-basin) can be done by a regional organisation such as ICIMOD, whereas Level 3 (wetland complex) and Level 4 (wetland habitats) can be the responsibility of the individual national agencies and organisations. The system is developed in such a way that Level 3 and Level 4 data can be hosted by individual countries and appropriate links can be provided from the regional database.

4.2 The Metadatabase

In order to ensure long-term management and efficient sharing of information and data, an interoperable metadata management system has been developed to store metadata on the GHWI datasets based on the metadatabase structure adopted by the Ramsar Convention. The metadata documented in the Ramsar format have been modelled into an FAO GeoNetwork platform that will be the foundation for data exchange and sharing in future. Metadata entry is password-protected. However, the user can access and/or download metadata through several options.

4.3 Interactive Web-mapping Tool

An interactive, GIS-based, dynamic web-system has been developed to visualise the complete wetland database. The system contains common GIS functions such as query, pan, zoom, and export. The system has been developed using the open source internet mapping software MapServer. The GHWI database is linked to the metadatabase, and both databases are integrated with the web mapping tool to serve derived map products. The interactive maps and available products are dynamic with respect to the level of options selected.

At present, the GHWIS (beta version) is hosted by ICIMOD and is accessible at (http://www.ghwis.icimod.org:8081/wetlandsnew2/index.php). A user's guide for the system is available under the help section. The system requires administrative authorisation for data management and data uploading in all three components. However, a general user can gain general information through the following procedures.

A river basin (Level 1) drop down list is available at all times. When a river basin is selected, the system zooms to fit the river basin in the mapper window and a list appears with available products for the selected river basin. Clicking on one of the products will show the specific map and, at the same time, a drop down list with Level 2 (sub-basin) information will appear. A link to the actual wetland inventory dataset (GHWI database) for that level will be provided.

When a sub-basin is selected (Level 2), a list with available products for that level will appear, as well as a drop down list with Level 3 information (wetland complexes) and a link to the Level 2 wetland inventory dataset (GHWI database). The same procedure is followed down to Level 4 (wetland habitat/site level). At Level 4, if the selected wetland habitat is a designated 'wetland of international importance' (Ramsar site), a link is provided to the data records of that site in the Ramsar sites database. While the entry and management of inventory and metadata will be the responsibility of the individual national agencies and organisations, maintenance and support will be provided by ICIMOD. Future development of the GHWIS will be managed by ICIMOD in consultation with partner agencies and organisations.

5 Inventory Data Collation

5.1 Level 1 Data – Major River Basins

The data fields recommended for an inventory at Level 1 are described below; a datasheet format is given in Annex 2. The datasheet should be accompanied by base maps available from existing secondary sources, for example topographic or thematic maps (scale approx. 1:500,000 to 1:1,000,000), or GIS-based maps, or maps derived from satellite data (e.g., MODIS, NOAA) for each basin in which the wetland inventory is to be compiled.

5.1.1 River basin code system

The GHWI uses the logical code system for river basins developed by Finlayson et al. (2002) in which the first two letters of the river basin name is the code for the main basin. For sub-basins within this basin, the first two letters of the sub-basin's name is added to the first two letters of the main basin, making a four-letter code ID. Similarly, at Level 3 (wetlands complex) the first two letters of the name are added to the four letters of main basin + sub-basin, describing the wetland complex with a six-letter code. The same approach is followed for the Level 4 wetland habitat/site. This coding system is illustrated in Figure 6. The proposed codes for selected rivers draining the Himalayas are presented in Table 3.

Figure 6: **Code system adopted by the GHWI from Level 1 (river basin) to Level 4 (wetland habitat)**

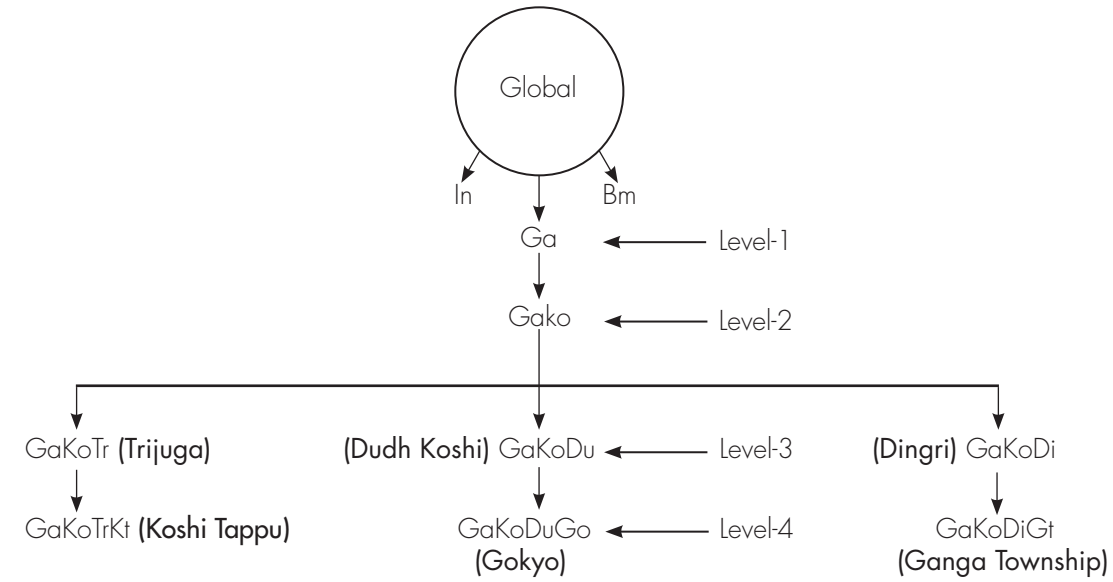


Table 3: **Names, proposed codes, and some basic statistics of the major river basins of the Himalayan region**

Name	Code[a]	Area (km²)[b]	Mean discharge[b] (m³/s)	Population density[b] (No./km²)
Amu Darya	Am	534,739	1,376[c]	39
Brahmaputra	Bm	651,335	21,261[c]	182
Ganges	Ga	1,016,124	12,037[c]	401
Indus	In	1,081,718	5,533	165
Irrawaddy	Ir	413,710	8,024	79
Mekong	Me	805,604	9,001[c]	71
Salween	Sw	271,914	1,494	22
Tarim	Ta	1,152,448	1,262	7
Yangtze (Chiang Jiang)	CJ	1,722,193	28,811[c]	214
Yellow (Huang He)	Hh	944,970	1,438[c]	156

Sources : [a] adapted from Finlayson et al. 2002; [b] Xu, Jianchu et al., 2008; [c] Data were obtained from the Global Runoff Data Centre (GRDC) for the following lowest downstream stations of the river basin: Chatly (Amu Darya), Bahadurabad (Brahmaputra), Farakka (Ganges), Parse (Mekong), Datong (Yangtze), Huayuankou (Yellow)

5.1.2 Geographic extent

Define the geographic extent of the river basin by using standard geographical coordinates from an appropriate map or geo-corrected image. The coordinates are determined by taking the latitude of the most northern and southern extremes and the longitude of the most eastern and western extremes of the area.

The geographic extent recorded in this section will be used as a base reference for the spatial data query and display facility in the information system. Hence it is recommended to record a slightly greater extent of the basin than the exact limits to enable proper display of the spatial data in the system. This is applicable for all levels from 1 to 4. The geographic extent of the ten major river basins as listed in Table 5 is being uploaded in the GHWIS. The basin boundary is updated using HYDRO1k data and SRTM DEM. Other thematic maps for the Ganges basin have been uploaded in the system as an example product.

5.1.3 Geology

General descriptions of the main geological provinces of the river basins are available from datasets which can be downloaded from the website of the U.S. Geological Survey (http://certmapper.cr.usgs.gov/rooms/we/index.jsp). They can also be provided on a CD ROM upon request.

5.1.4 Climate

The major river basins of the region can be divided into one or more climate classes using the Koeppen climate classification (http://koeppen-geiger.vu-wien.ac.at/). A description of each climate zone (based on monthly rainfall and temperature data) is available from datasets on the United Nations Food and Agricultural Organization (FAO) web site (http://www.fao.org/sd/EIdirect/climate/EIsp0002.htm).

5.1.5 Ecoregions

Recently (May 2008), the system of 'Freshwater Ecoregions of the World' (FEOW) has been introduced, which provides a new global biogeographical regionalisation of the Earth's freshwater biodiversity. Covering virtually all 426 freshwater ecoregions on Earth, this first-ever ecoregion map, together with associated species data, is a useful tool for underpinning global and regional conservation planning efforts, particularly for identifying outstanding and imperilled freshwater systems; for serving as a logical framework for large-scale conservation strategies; and for providing a global-scale knowledge base for increasing freshwater biogeographical literacy. The freshwater ecoregion maps can be downloaded from the FEOW web site (http://www.feow.org/). Reports for each ecoregion synthesising biodiversity and threat data are also available online.

The freshwater ecoregion map serves as a complement to the global terrestrial (http://www.worldwildlife.org/science/ecoregions/item1267.html) and marine ecoregion maps (http://www.worldwildlife.org/science/ecoregions/marine/item1266.html) and differs from them in that freshwater species (primarily fish) and freshwater processes drove the map delineation. More information on ecoregions can be downloaded from the WWF web site (http://worldwildlife.org/science/index.html).

5.1.6 Vegetation

Datasets suitable for describing the vegetation of the geographical regions can be obtained from the Global Land Cover 2000 database, European Commission Joint Research Centre, 2003 (http://www-tem.jrc.it/glc2000). The database provides two types of products, the global land cover dataset, which is a harmonisation of all the regional products into a global product with a generalised legend, and regional land cover datasets with a regionally specific legend, to provide as much detail as possible. The regional land cover datasets can be used for describing the vegetation within the basin.

5.1.7 Hydrological regime

Describe the hydrological regimes of the basin, including overall water availability, lean and peak season flows, and degree of basin fragmentation, with reference to published data or sources such as the Watersheds of the World, published by World Resources Institute (WRI), International Union for the Conservation of Nature (IUCN), Ramsar Convention on Wetlands, and International Water Management Institute (IWMI) (IUCN 2003, no date) which provides data on water availability and extent of fragmentation.

5.1.8 Wetland area and type

Record the approximate amount of wetland for each major river basin in the region (in sq.km) and the proportion of the river basin that is known to be occupied by wetlands. The Global Lakes and Wetland Database created by using all published sources (Lehner and Doll 2004) is available for free download at (http://www.worldwildlife.org/science/data/item1877.html). The lakes, reservoirs, rivers, and different wetland types are provided in the form of a raster map at 30-second resolution and can be used to describe wetland types and area for major river basins.

5.1.9 Wetland ecosystem services

Describe the goods and services that are provided by wetlands in the region using the information developed by the Millennium Ecosystem Assessment (MA 2005) (www.millenniumassessment.org) as a guide (Table 4). As per the MA framework, ecosystem services are defined as the range of benefits people derive from the ecosystems, and have been broadly classified into provisioning, regulating, cultural, and supporting.

Provisioning services are products obtained from wetlands, including food and fibre, fuel, genetic resources, biochemicals, natural medicines, pharmaceuticals, ornamental resources, and freshwater (see Table 4).

Regulating services are benefits obtained from the regulation of wetland processes, including air quality maintenance, climate regulation, water regulation, erosion control, water purification and waste treatment, regulation of human diseases, biological control, pollination and storm protection.

Cultural services are non material benefits people obtain from wetland ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences, including cultural diversity, spiritual and religious values, knowledge systems, educational values, inspiration, aesthetic values, social relations, sense of place, cultural heritage values, recreation, and eco-tourism.

Table 4: **Categorisation of region-wide goods and services provided by wetlands** (MA, 2005)

Ecosystem services	Examples
Provisioning	Food, freshwater*, fibre fuel
Regulating	Climate regulation, water, erosion, disease
Cultural	Spiritual, recreational, aesthetic, educational
Supporting	Primary production, soil formation, nutrient cycling

Supporting services are services necessary for the production of all other ecosystem services and include soil formation, nutrient cycling, and primary production.

The wetland ecosystem services within an inventory context have to be interpreted hierarchically. For example, the regulating services are more explicit at the basin and sub basin level, the cultural and provisioning services are more obvious at lower hierarchies, i.e.,wetland complex and wetland site scale. Document the ecosystem services that are dominant at basin scale. Watersheds of the World, published by WRI, IUCN, Ramsar convention on wetlands and IWMI can provide additional inputs for such information (http://www.iucn.org/about/work/programmes/water/wp_resources/wp_resources_eatlas).

5.1.10 Development activities

Describe the most important development activities within the basin. Conservation and management of wetlands has to be placed in the context of development activities which take place at various scales and thereby influence, or have a potential to influence, the values and functions of the wetlands. These include urbanisation, agricultural development, industrial development, and others which have the potential to affect wetlands through influencing water use, resource use patterns, or even the functional role of wetlands.

5.1.11 Management issues and threats

Identify the primary reasons for the loss and degradation of wetlands in the region by using information drawn from the WWF Ecoregion Maps for Asia (www.wwfus.org/ecoregions/index.htm) and the MA Framework for Assessment (MA 2003). The threats or pressures concerned (Table 5) are referred to as 'indirect drivers' in the MA framework and are regarded as the major forces which influence one or more of the 'direct drivers' that are described in Level 2.

Note that the difference between issues and threats has been defined by Ntiamo-Baidu (2001):

- A wetland issue is an underlying socioeconomic and/or political factor (e.g., urbanisation, population pressure, sectoral structures) that could lead to adverse change in the ecological character of a wetland.
- A threat to a wetland is a specific natural or human-induced factor (e.g., landslides, volcanic eruptions, water pollution, siltation, agricultural expansion, over-exploitation) that could have a detrimental effect on the ecological character of the wetland or even cause its disappearance.

Table 5: **Indirect drivers of major management issues and threats** (source MA 2003)

Indirect driver	Examples
Demographic	Population growth and demographic structure; spatial distribution of population
Economic	Globalisation and trade policy; economic growth and structures; consumption patterns; income and wealth distribution; agriculture, forestry and fishery policies
Socio-political	Governance/collective action; democracy; institutional settings; attitude towards gender; involvement in conflict/war
Science and technology	Agricultural innovation; information technology; rate of technical change; access to information/intellectual property rights
Cultural and religious	Beliefs, consumption choices

5.1.12 Data sheet completion

- Name and address of compiler: the name and address of the compiler should be stated as shown in the datasheet.
- Date sheet completed/updated: state the date of data sheet completion or update.

5.2 Level 2 Data — Sub-basins

Data collection at Level 2 focuses on sub-basins within each of the major river basins determined earlier at Level 1. Depending on the size of the areas concerned, one or more sub-basins of a major river basin can be regarded as a single unit.

The Level 2 data sheet should be accompanied by base maps available from existing secondary sources, for example topographic or thematic (scale approx. 1:250,000 to 1:500,000), or GIS-based maps, or maps derived from medium to low resolution satellite data (e.g., MODIS, NOAA) for the sub-basin for which the inventory is being compiled.

Data on some wetland regions can be derived from the International Union for the Conservation of Nature (IUCN) web site (IUCN 2003, no date). This provides information about large sub-basins within a river basin. In most cases the watersheds of each sub-basin will need to be defined manually and a decision made about whether or not the area shown comprises a distinct wetland region as it is, whether it needs further subdivision, or whether it warrants being grouped with adjoining sub-basins. In making the decisions required, access to a topographic map or a digital elevation model (DEM) of the primary river basin is of considerable assistance. The SRTM DEM (http://srtm.csi.cgiar.org/) can serve as a good source for such purposes. If a reasonably good DEM is available, the sub-basin boundary can be delineated using a hydro-processing tool in GIS software like ArcGIS or ILWIS.

5.2.1 Name and code of sub-basin

Identify each sub-basin by a discrete name (using the name of the largest river draining the area) and a code (e.g., numeric or text). Note that the unique code initially used for the major river basin (Level 1, see Section 5.1.1) in which the sub-basin is located, always remains the same. A coding system is adopted for this inventory as illustrated in Figure 4, in which the first two characters of the code describe the main basin in which the sub-basin is located and next two characters define the name of the sub-basin. A similar approach is adopted for coding Levels 3 and 4.

5.2.2 Geographic location

Define the location of a sub-basin using standard geographical coordinates. Determine the coordinates by using an appropriate map or geo-corrected image and taking the latitude of the most northern and southern extremes and the longitude of the most eastern and western extremes of the area.

It is recommended to include a centroid to identify the geometric centre of the sub-basin. The centroid can be obtained from GIS-based maps and it can be useful for quickly identifying the location of the area and possible sources of information from maps and remotely sensed imagery.

5.2.3 Climatic characteristics

The resolution of the global climatic classification map (http://www.fao.org/waicent/faoinfo/sustdev/Eldirect/climate/Elsp0002.htm) appears to be too coarse for the sub-basin level due to the high variation in climate within short spatial distances in the Himalayan region. The Koeppen classification description can be used to describe climatic characteristics based on the observed precipitation and temperature within and around the sub-basin. If climatic characteristics are described based on published stations' information, it is recommended to record the name, code, and geographic location of the station (latitude and longitude), which will enable spatial visualisation of the climatic data in the GHWIS.

The World Water and Climate Atlas published by the International Water Management Institute (http://www.iwmi.cgiar.org/WAtlas/Default.aspx) provides eleven agro-climatic parameters including mean monthly air temperatures and precipitation. This can be an alternative source for climatic characteristics.

5.2.4 Physical features

Altitude range

Define the altitude range of the area by providing the minimum and maximum elevation. The SRTM, which can be downloaded from the CGIAR consortium for spatial information (http://srtm.csi.cgiar.org/Index.asp) can be used to compile altitude information.

Wetland area and type

Record the spatial extent of wetland (in km^2) using Table 6 as a guide. Many attempts have been made to map wetland extent in the region using remotely sensed data (see Garg et al. 1998, Vijayan et al. 2004, ICIMOD 2007). If such data exists and covers the entire sub-basin, it can supplement the Global Lakes and Wetlands Database (Lehner and Doll 2004) for recording wetland types and area in the sub-basin.

Table 6: **Surface area of wetland in the sub-basin**

Category	Extent (%)
Very large	>75
Large	50 - 75
Medium	25 -50
Small	<25

In the case of wetlands that have a linear form (i.e., channel features such as rivers and streams), record the cumulative length of the channel (in km) and, if possible, differentiate between the extent of the stream orders concerned (i.e., compare the sizes of the different rivers in the region). The smallest streams, which have no tributaries, are called first order streams; when two of these coalesce they form second order streams; and when two second order streams join they form third order streams; and so on).

Geological characteristics

Describe the specific geological features of the area, noting that these should be a more detailed sub-set of the information presented in the Level 1 data sheet. The major geological classes published by Wandrey and Law (1999) for South Asia and Steinshouer et al. (1999) for Asia Pacific including China can be used for describing geological characteristics at sub-basin level.

Water regime

Provide data on mean annual runoff (MAR) and seasonality of flows in the river system of the sub-basin, with reference to published data on river discharge. It is suggested to record basic station information and geographical location for such published river discharge data. Long-term mean monthly discharges provided by the Global Runoff Data Centre (GRDC) (http://www.bafg.de/GRDC) operated by the World Meteorological Organization (WMO) can serve as an additional source of data to describe the water regime.

5.2.5 Ecoregion

Describe the bio-geographical unit or ecoregion within the sub-basin from the same ecoregion map used in Level 1 (see 5.1.5). The freshwater ecoregion maps can be downloaded from the FEOW web site (http://www.feow.org/). Reports for each ecoregion synthesising biodiversity and threat data are also available online and can be helpful for describing the ecoregion.

5.2.6 Vegetation

Describe the major vegetation features of the area, noting that at the very least this should be more detailed than the information presented at Level 1. Sources of such data can be sought in country/region vegetation maps and descriptions from well-established organisations such as the Space Application Centre in India. If this type of data is not available for the entire sub-basin (or difficult to assess), use the same major vegetation features used in Level 1.

5.2.7 Wetland ecosystem services

Describe the wetland ecosystem services which manifest themselves at the sub-basin level using the same classification scheme as in Section 5.1.9. At sub-basin level, some of the cultural functions will become more prominent in addition to the regulatory services.

5.2.8 Development activities

Describe the developmental activities at the sub-basin level which have the potential to influence wetland values and functions. These may include such things as channelisation schemes, floodplain conversion schemes, and settlement expansion.

5.2.9 Management issues and threats

Identify the specific reasons for the loss and degradation of wetlands in the region and expand on the management issues and threats identified at Level 1. The threats concerned are referred to as 'direct drivers' in the MA framework (Table 7) and are regarded as the forces that have direct influence on the ecosystem services described earlier.

Table 7: **Direct drivers of management issues and threats** (adapted from MA 2003)

Direct driver	Examples
Changes in local land use and cover	Landscape fragmentation, cover change, dewatering
Species introduction or removal	Invasive plants and animals that subsequently become declared weeds, pests, or vermin
Technology adaptation and use	Advanced fishing technologies leading to depletion of fish stocks, pesticide usage, irrigation
External inputs	Fertiliser use, pest control
Harvest and resource consumption	Fishing, logging, sand and gravel extraction
Climate change	Glacier retreat, glacial lake outburst flood (GLOF)
Natural, physical, and biological drivers	Desertification, volcanoes

5.2.10 Jurisdiction

Describe each sub-basin in terms of its national and local jurisdiction. The International Organisation of Standardisation (ISO) codes should be used to show national jurisdiction and the names of provinces, counties and city administration units stated under each relevant ISO country code (if available).

5.2.11 Data sheet completion

- Name and address of compiler: state the name and address of the compiler as shown in the datasheet.
- Date sheet completed/updated: state the date of data sheet completion or update.

5.3 Level 3 Data — Wetland Complexes

Level 3 data collection focuses on defining and describing 'wetland complexes' (the maximum inundated area of the wetlands) within the sub-basin identified at Level 2.

The Level 3 data sheet should be accompanied by base maps available from existing secondary sources, for example topographic or thematic maps (scale approx. 1:25,000 to 1:250,000), or GIS-based maps at a suitable scale, depending on the extent of the wetland complex concerned.

The larger the river basin, the larger is the number of sub-basins (or sub-catchments) within it. Wetland complexes are hydrologically linked because they lie within the same sub-catchment and can either be entire sub-catchments, a group of individual wetlands (also of various types), or a number of smaller discrete wetlands (sometimes only a few hectares in size). The watersheds between wetland complexes serve to distinguish the sub-catchments involved.

In addition to the hydrological boundary, it is recommended to considered the ecological region, or existing conservation units where applicable (e.g., national parks), or administrative units (e.g., county) while delineating a wetlands complex. This will facilitate collation of the non-spatial information required at Level 3, such as demographic data.

As considerably more data are required at this level, it is recommended that data collection is conducted on a priority basis and in conjunction with other parties and wetland programmes. As a wetland region (sub-basin) can contain a number of wetland complexes, it is also noted that data collection should be done efficiently as similar data is required for all wetlands within each complex.

5.3.1 Name and code of wetland complex

State the name and code to identity each wetland complex by using the procedure followed for Levels 1 and 2. A subsidiary code (using decimals) can be used to further define the primary code at Level 3. Alternately, the name and code can be derived from local maps by adopting the name of the largest river draining the complex. Where no river name exists for the wetland complex, the name of the province, county or other administrative unit in which the complex is located should be used.

5.3.2 Geographic location

State the geographic extent of the wetlands complex, recording latitude and longitude from its delineated boundary within the sub-basin in the same manner as in Levels 1 and 2 (at a minimum, the upper left and lower right extremities of the complex must be recorded).

In most cases, like topographic maps, a projected coordinate system such as the Universal Transverse Mercator (UTM) system is used. In such a system, the coordinates would be expressed as metres of Eastings and Northings (e.g: 211396E 8489624N). Recording the coordinates as metres increases the relative accuracy with which the boundary of the wetland complex is defined. It also assists with area and distance calculations. In this case, translate the projected coordinate system to a geographic coordinate system using the detailed projection parameter normally provided in maps.

The current version of the GHWIS database management system does not have a facility to provide geographic extent in metric coordinates. In addition, it is important to recognise that projected coordinate systems may not be suitable for recording the geographic locations of all wetland complexes. In some situations, for example when the boundary of two projected system zones run through the complex, it is recommended that a geographic coordinate system be used. In such a situation, the coordinates should be recorded as decimal degrees of latitude and longitude.

Those responsible for entering data must therefore specify whether they are using a geographic or projected coordinate system, and if the latter, the type of projection that is applied (for example, the WGS 1984 UTM projection) and, where appropriate, the map grid zone in which the complex occurs.

5.3.3 Climatic characteristics

Record general information on average rainfall, temperature range (including average temperatures), relative humidity (9 am and 3 pm), prevailing winds, and evaporation (Class A pan) and note the location of the weather station (name, latitude and longitude, altitude).

5.3.4 Ecological character

The 7th Ramsar Conference in San Jóse, Costa Rica, in 1999 revised and adopted the definition of 'ecological character' based on expert advice from the Convention's Scientific and Technical Review Panel (STRP). This definition, as adopted by Resolution VII.10, is as follows:

> "Ecological character is the sum of the biological, physical, and chemical components of the wetland ecosystem, and their interactions, which maintain the wetland and its products, functions, and attributes."

On this basis, the core data required to describe the 'ecological character' of a wetland complex should be grouped under three headings describing the physical, physico-chemical, and biological features of the complex.

Physical features

Altitude range

Record the altitudinal range of the wetland complex by defining its minimum and maximum elevation in metres above n sea level (m amsl). This information is normally available from topographical maps, orthophotographs, and/or national and regional land survey or mapping services.

Spatial extent

Establish/describe the spatial extent of the wetland complex (in km^2).

Soil types

Describe the dominant soil type(s) within the area of the wetland complex using standardised soil classifications taken from national soil maps. Depending on the size of the wetland complex, the FAO digital soil map of the world (http://www.fao.org/geonetwork/srv/en/metadata.show?id=14116&currTab=distribution) can serve as an additional source of such information.

Water regime

Describe the mean monthly and annual inflow and run-off generated by the catchment, based on availability of measuring-station data. If such data is unavailable, predictive models can be used for runoff estimation, but such techniques will obviously involve considerably more time and expertise. Record the cumulative length of the main rivers and streams draining the complex (in km) and, as done at Level 2 (section 5.2.4), differentiate between the extent of the stream orders concerned.

The distribution and extent of wetlands habitat classes is dependent on the seasonal dynamics of the water cycle. The water cycle regime provides information on the dynamics of wetlands with respect to the high and low water level situations. This can be described by a hydroperiod (inundation pattern) map using temporal time-series satellite images (particularly radar data, as optical images often fail in the wet season due to cloud cover). For this purpose, at least two radar images of two major extreme hydroperiods (peak flow season and low flow season) are required to enable classification of the water cycle regime into three basic classes: i) permanent water body, ii) seasonally inundated area, and iii) permanent land (Figure 4).

Groundwater

Record water table average and range if ground water monitoring stations are available within the wetland complex. Provide basic information on monitoring wells, such as their location (latitude, longitude) and unique ID.

As groundwater has a very important role in wetland hydrology and many wetland complexes are located in groundwater discharge areas, it is advisable to search for information about the hydrogeology of the area in which the wetland complex is situated. These data are generally found in reports on the underlying geology (lithology and stratigraphy) of the area and include information on the aquifer systems that may be present in these subterranean flow paths, the base-flows of rivers that drain the region, springs, and seepage zones. Provide a brief summary of this kind of information as a free text description.

Physico-chemical features

Water quality

Provide an overview of river health with specific reference to stressors such as the level of nutrients/toxicants (during low flow periods), sediment inputs (during high flow periods), acidification, and salinisation, where water quality data are available. These data can be drawn from existing reports in liaison with the local water authority or ministries (e.g., hydro-meteorology, water resources, irrigation, industry, agriculture, mining). Wherever possible, indicate the sources of contributing nutrients (e.g., fertilised crop or pasture land, sewage outfalls), toxicants (e.g., mining, industrial effluents) and sediments (e.g., cropland, irrigation return waters). Additional information on wastewater discharges and point or non-point source of polluters, indicating specific type of pollutants, can be comprehensive information for assessment of water quality.

Categorise the sediment input as negligible, intermediate, or high, and, where wastewater discharges are known to contaminate streamflows, try to estimate the proportion of wastewater to streamflow using the guidelines provided in Table 8. However, it is acknowledged that as compliance to discharge standards is rarely met in developing countries, the relevance may well be questionable. If insufficient data are available, this should be stated.

Table 8: **Likely level of impact of wastewater discharges on water quality** (after Kotze et al. 1994)

Wastewater input (%)	Probable impact assuming compliance with discharge standards
<5	Low
5 - 20	Intermediate
>20	High

Biological features

The biological features of the wetland complex should be described using general indices that give an overview of the importance of the region for biodiversity. The indices include vegetation cover, dominant vegetation types, the biological importance of the wetland, and noteworthy species (endemic or threatened species of flora and fauna).

Biological condition of the complex

Describe the vegetation cover in the wetland complex by estimating the relative proportions of the dominant vegetation types in the landscape using existing reports or maps. Describe known trends in the status and condition of vegetation (with specific reference to the occurrence of introduced and natural weeds – beneficial and noxious) and similar trends (if any) in fauna populations. If insufficient data are available this should be stated.

Species and associations of biological significance

List all the wetland-dependent threatened plant and animal species in the complex, indicate their status and the habitats in which they occur. Additionally, if the wetland complex regularly supports 1% of the individuals in a population of a threatened species, this should be stated.

Use information on the WWF (http://www.worldwildlife.org/science/index.html) and IUCN (www.iucnredlist.org) web sites for assessing the species of biological importance in the complex.

Other biodiversity databases containing information on the status of species poorly represented in the 2008 IUCN Red List of Threatened Species include those for fish (http://www.fishbase.org) and plants (UNEP-WCMC Threatened Plant Database – www.unep-wcmc.org/species/plants/overview.htm). For the purpose of determining species of national significance supported by the area, use other local data sources include National Red Data Books (if available) and local experts.

Habitat(s)

Name or list the habitats and sites which are found in the complex using the Ramsar classification for guidance and provide the area of each habitat in hectares (ha) or square kilometres (km^2), in preparation for, or in anticipation of, launching Level 4 of the inventory procedure (section 5.4). It is important to note the unit clearly.

In the event of a habitat classification system other than the Ramsar classification being used, provide the bibliographic details and date of the classification adopted.

5.3.5 Population demographics

Describe the characteristics of the human population in the wetland complex with the aid of government statistics (census data), Note, that as official population and demography data are generally related to administrative regions, population density data can be recorded either as the number of villages/towns/cities in the area with populations greater than a certain number, or as the number of inhabitants per km^2 (Table 9). Where possible, describe demographic characteristics in the complex (like population, age structure, seasonal variation in numbers, long-term trends) and the principle activities of people living in the complex (like agriculture, grazing, aquaculture, forestry).

Table 9: **Population density categories** (using inhabitants per km^2)

Population density	Inhabitants per km^2
Very dense	>500
Dense	200-500
Moderate	100-200
Low	20-100
Sparse	1-20
Uninhabited	<1

5.3.6 Wetland ecosystem services

Describe the major goods and services of the wetland habitat using the information presented in Table 4 as a guide, but adding site-specific details that may not have been apparent at previous levels. The services derived from the habitat include products that are obtained directly from the wetland as well as some less tangible services based on social or cultural values. At wetland complex level, provisioning services will become more prominent in addition to the cultural functions.

5.3.7 Land and water use

Describe and, where possible, map the manner in which the complex is used by local people. The categories presented in Table 10 can be used as a guide noting, where appropriate, whether or not these are undertaken for subsistence or for commercial purposes and using mainly traditional or modern techniques.

Table 10: **Classification of major land and water uses of wetland complexes** (example from Trijuga complex, Nepal)

Land/water use	Example of use by people
Cropland	Rice, other cereals
Grazing	Pasture for cattle, buffalo
Horticulture	Mango orchards, bananas
Urban	Rural roads
Fishing	Ponds for fisheries, traditional fishing in rivers and wetlands
Forestry	Timber, fuelwood
Water supply	Surface water for irrigation and domestic use
Transport	Ferry, houseboat, canoe for crossing river
Extractive industry	Sand/gravel extraction from river
Conservation	Wildlife reserve, Ramsar site (Koshi Tappu Wild Life Reserve)
Recreation	Bird watching, rafting, picnics

5.3.8 Institutional arrangements

Describe the management jurisdiction over the wetland complex and, where necessary, the proportion of the area managed by one or other jurisdiction. This includes the following categories: national, provincial, and local authorities; private ownership; and any legal instruments that may be in force (e.g., legislation and/or policies).

5.3.9 Management issues and threats

Describe the management issues that specifically confront local communities as users of the system (e.g., overfishing, illegal hunting, decline in agricultural or fisheries production) and human threats to sustainable use of the area that may well be beyond their control (e.g., herbicide/pesticide use in the surrounding croplands, eutrophication, upstream use of the river system that supplies water to the complex). Describe the impacts of the development activities mentioned in Levels 1 and 2. Use Table 11 as a guide for each wetland complex. Describe also the management practices and plans (if any) being

Table 11: **Management issues and threats to wetland complexes**

Direct driver	Examples of management issues and threats
Climate change	Flooding of residential areas, roads and infrastructure, bank erosion, siltation
Desertification	Irrigation, water diversion and wetland drainage
Species introduction and biotic invasion	Alien invasive species and environmental weeds, vermin and pest animals
Natural resource extraction	Agriculture, grazing, fishing, fuel, forage, thatch, hunting, aquaculture, forestry, mining
Industrialisation and urbanisation	Flooding/flood control, vegetation clearance and fire, sedimentation, infrastructure/housing, quarrying/sand mining, recreational activities, agricultural expansion
Pollution	Expansion of existing and development of new industries without adequate regulation and planning controls
Waste disposal systems	Solid waste, faecal contamination, pesticides, fertilisers
Land and water use	Lack of awareness on wetland values, environmental flows for wetlands ecosystem
Agricultural production systems	Ownership and access to land and resources
Disease emergence and drug resistance	Increasing population and pressure due to poverty; urban or rural expansion; poorly resourced government agencies, shortage of trained personnel; weak implementation of legislation

employed or developed by agencies working in the area. Record the number of people interviewed, and the names and status of the informants. Describe the incidence of disease within the human population (in %), where the utilisation of a wetland complex presents risks to human health, and the type of disease carrying organisms living in the wetland (e.g., mosquitoes, liver flukes, snails). Describe the underlying reasons for, and extent of, any habitat loss or degradation that is evident, and where wetland complexes are subject to natural threats (e.g., from climate change, floods, erosion, sediments).

5.3.10 Data sheet completion

- Name and address of compiler: state the name and address of the compiler, as shown in the datasheet
- Date sheet completed/updated: state the date of data sheet completion or update.

5.4 Level 4 Data — Wetland Habitat/s or Wetland Site

Level 4 data collection focuses on defining and describing the 'wetland habitats' that occur within the wetland complexes identified at Level 3. Even if they lie within the same complex, wetland habitats do not necessarily have the same characteristics. For example, they would not necessarily experience the same water regime or have the same ecological characteristics. Nor would they provide the same goods and services or require the same form of management.

The AWI approach aims to record a core data set at Level 4 for each individual habitat identified within the complex. For the purpose of the GHWI, a wetland site identified for some specific management purpose is considered as Level 4 (e.g., Gokyo and associated wetlands – a Ramsar site in Nepal). This does not mean that all Ramsar sites should be considered as Level 4. The decision can be made based on the area of the site and diversity of the habitats.

The Level 4 data sheet should be accompanied by base maps available from existing secondary sources, for example topographic or thematic maps (scale approx. 1:5,000 to 1:50,000), or GIS-based maps at a suitable scale, depending on the extent of the wetland habitat/s or site concerned.

The data collection for wetland habitats must be done efficiently because similar information is needed for all habitats within a given wetland complex or region. Therefore, it is inevitable that substantially more groundtruthing, analysis of existing maps, and use of existing references is required. As such, Level 4 data becomes the core data set relevant to the primary interests of the managers of a particular wetland habitat or individual site. Wherever possible, it is recommended to use high-resolution optical data for classifying wetland habitats. However, extensive field survey is required to conduct groundtruthing for classification and clarification of the satellite data.

5.4.1 Name and code of the wetland habitat

State a name and a code for each habitat. This must be done. The name can be derived from local communities or existing references. Where multiple names exist (e.g., in the case of transboundary wetlands where names in different languages or dialects are used for the same site), use them all. And where no name exists, a descriptive qualifier or typology used by the Ramsar or any other classification can be used. Use the code as described in Figure 4.

5.4.2 Geographic location

Define the extent of the wetland habitat or wetlands site as accurately as possible. This is important. At a minimum, the coordinates representing the upper-left and lower-right extremities must be recorded. Record coordinates in latitude and longitude for the purpose of uploading information in the database system (GHWIS) in the same way as for Level 3.

For spatial analysis purposes, it is recommended to use a projected coordinate system the same as the reference map for the site (e.g., topographic map). The use of this system enhances the ability to extract additional information, particularly those items relating to area calculations. It is necessary to record complete information about the type of projection system used, which is normally provided in the reference map (topographic map).

5.4.3 Climatic characteristics

Describe the average and the range of precipitation, noting the wettest and driest months; monthly temperature, noting the hottest and coolest months; the range of relative humidity (9 am and 3 pm) and the most and least humid months; the range of annual evaporation (Class A pan); and the prevailing winds and time of year when the wind regime changes. In each case, provide the source and date of the information used. Note the location of the nearest meteorological recording station (name, latitude and longitude, altitude, period of records).

5.4.4 Ecological character

Physical features

Geomorphic setting

Describe the landform (or cross-sectional geometry) of the habitat/site using the terms supplied in Table 12. In general, there are at least six basic landform types that determine the occurrence of wetlands, and whilst they are intergradational, it is important to describe the entire landform in which the habitat/site is situated and not just parts of it (adapted from Semeniuk and Semeniuk 1995).

Table 12: **Categories of landforms that are host to wetlands**
(adapted from Semeniuk and Semeniuk 1995 and Kotze et al 1994)

Landform	Definition	
Basins	Basins are depressed basin shaped areas in the landscape with no external drainage. They may be shallow or deep and may have flat or concave bottoms. They usually have clearly defined margins.	
Channels	Channels refer to any incised water course. They may be shallow or deep but always have clearly defined margins.	
Flats	Flats have a slope of less than 1%, little or no relief, and diffuse margins. Flats can be incised by a channel thereby giving rise to the term 'channelled flats'.	
Slopes	Slopes are areas with a gradient of greater than 1%, which may be concave or convex.	
Crest of hills or highlands	Crests of hills or highlands are generally convex areas on the top of mountains, hills, or similarly raised areas.	

Altitude range

Record the altitude range of the habitat in metres above mean sea level (m amsl). This information is normally available from topographical maps, orthophotographs, and/or national and regional land survey or mapping services.

Note: Wetlands located at 3,000 m amsl and above should be considered as high altitude wetlands (HAWs). This name should be stated after the category they belong to (as stated in Table 13), e.g.: 'slope/high altitude wetland', or 'crest/high altitude wetland'.

Spatial

Define the areal extent of the habitat/site using the scale shown in Table 13.

Table 13: **Terms for defining the areal extent of a wetland complex** (adapted from Semeniuk and Semeniuk 1995)

Classification	Frame of reference for all categories except channels	Frame of reference for channels (width to length relationship)
Very large	>10 x 10 km	> Several km wide; hundreds of km long
Large	1000 x 1000 m to 10 x 10 km	Several hundred m wide; several to tens of km long
Medium	500 x 500 m to 1000 x 1000 m	Hundreds of m wide; thousands of m long
Small	100 x 100 m to 500 x 500 m	Tens of m wide; hundreds of m long
Very small	<100 x 100 m	Several m wide; tens of m long

In addition, obtain the following spatial data

Surface area – Measure the surface area using GIS applications and record the area in hectares. Provide an indication of the extent to which a wetland may vary in size from one season to another. After flood events, inundation maps can be a source of information about the variation in wetland extent (drawn from remotely sensed data as described above); aerial photographs (where available) can be another useful source of reference.

Length – measure the maximum length of the wetland habitat in kilometres.

Width – measure the maximum and average width of the wetland habitat, in metres or kilometres. The average width can be recorded as the average of five equal segments drawn perpendicular to the flow.

Basin morphology

Bathymetry – Record any existing information about the depth of the basin (i.e., maximum depth and, where known, average depth). If these data are not available, they should be obtained by taking the measurements needed using either a depth sounder or a hand held plumb line graduated in metres (at 10 cm intervals).

Erosional status

Describe the susceptibility of the habitat/site to erosion (wind, storm, or current-induced, e.g., flash flood).

Soil types

Describe the dominant soil type(s) within the habitat of interest, using existing soil maps and/or reports. State what soil classification system is used and the date of data collection (if known). The FAO soil classification scheme (Purnell et al. 1994) is one of the most commonly used systems for naming soils in a consistent way and is recommended on the grounds that it provides an adequate description of the general nature of the soil mantle and has been well tested in the field. Where remotely sensed data are available, these can also serve as a useful source of information about soil saturation within the habitat.

Bottom sediments/substrata

Search for and document any information about the nature of the sediments and/or substrata on the floor of the wetland. Sediments include organic and mineral particles of all sizes and composition. However, in the event of such data not being available, a simple visual or textural method of classifying the substrata in situ may need to be used, noting that core samples may be necessary where the water depth is in excess of approx. 1.5m (Table 14).

Water regime

Describe the water regime (or hydroperiod) using one or more of the four terms shown in Table 15. The water regime can be further described by supplying information on the seasonal and inter-annual depth (maximum, minimum and average), the pattern of flows into and out of the wetland and the period(s) of inundation and the area flooded. The source of inflow should be recorded (e.g., river, groundwater, spring, rainfall only, artificial) and, if possible, both the inflow and outflow recorded as permanent, seasonal, intermittent, episodic, or none, on hydrographs.

Supplement the water regime information with a water cycle regime map that can be derived from radar data as described in Figure 4.

Table 14: **Texture based substrate classification** (adapted from Begg 1984)

Textural class	Texture /general appearance	Percentage composition[a]	
		% clay	% sand
Stoney	Rough or gritty texture, evidence of small stones and pebbles	n/a	n/a
Coarse sand	Disintegrates readily, individual sand grains can be readily seen and felt, shell fragments are common	n/a	80
Fine sand	Well packed, clean, disintegrates readily and individual sand grains hard to distinguish	10	90
Muddy sand	Sandy material noticeably discoloured by mud	20	80
Sandy mud	Muddy material with equal quantities of sand and mud	50	50
Silt or mud	Silty or muddy material, loose when moist, with traces of sand	70	30
Silty clay	Sand barely evident; usually grey, sometimes containing iron concretions	90	10
Clay	Sand not evident; stiff and tenacious material, greasy when moist; solid grey to blue grey in colour	100	n/a
Peat	Organically laden substrata containing partly decomposed plant remains; spongy when wet	n/a	n/a
Ooze	Fine black, organically laden sludge, generally smelling of hydrogen sulphide	n/a	n/a

an/a = not applicable

Table 15: **Categories of non-tidal water regimes for wetland habitats** (adapted from Semeniuk and Semeniuk 1995)[a]

Water regime	Definition
Permanently inundated	Areas where land surface is permanently covered with free-standing water (except in years of extreme drought)
Seasonally inundated	Areas where land surface is semi-permanently flooded; when surface water is absent, water table is at or near surface
Intermittently inundated	Areas where the land surface is temporarily flooded; surface water is present for a brief period during the year but water table is otherwise well below the soil surface
Seasonally waterlogged	Areas where land surface is saturated for extended periods but surface water is seldom present

[a]Note: Inundated means soils that are covered with free-standing water; the soil below the surface in these situations is also saturated (waterlogged)
Waterlogged means soils that are saturated with water, but where the water does not inundate the soil surface

Groundwater

Record information on the depth of the water table and the seasonal variation in depth in the near vicinity of the wetland habitat, as data availability and/or local knowledge allows.

Physio-chemical features

The following features describe the water quality of the wetland habitat and, unless known, are measured using standard techniques as given in 'Standard methods for the examination of water and wastewater' (Clesceri et al. 1998) and general limnological texts such as those of Moss (1980), Wetzel and Likens (1991), and Wetzel (2001).

Surface water

Temperature – Describe the annual range of water temperature of the major part of the flooded area and the annual average temperature. Note details of the recording station(s) and depth and time of measurements. If data are available, this can be recorded for each season or each month of the year and a mean annual value given. If insufficient data are available, this should be stated. Where possible, classify the water body according to the thermal characteristics shown in Table 16.

Table 16: **Categories of thermal characteristics based on different types of mixing** (adapted from Bayly and Williams 1981)

Category	Definitions
Amictic	Never mixes (remains permanently ice-covered)
Oligomictic	Rarely mixes (remains warm at all depths)
Monomictic	Mixes once a year
Dimictic	Mixes twice a year
Polymictic	Mixes many times in a year

Salinity – Provide the annual range of the salinity of the major part of the flooded area, noting details of the recording station(s) and depth and time of measurements, where known. If data are available, these can be recorded for each season or each month of the year and a mean annual value given. If insufficient data are available this should be stated. Where possible classify the water body according to the salinity characteristics shown in Table 17.

Wetland habitats with seasonal variability in salinity are categorised by the salinity status which exists for most of the year. For example, a wetland that ranges from freshwater for most of the year, to brackish during the short dry season, would be classified as 'freshwater'. The salinity can further be described as 'constant' (salinity remains within a single salinity range) or 'fluctuating' (salinity that markedly fluctuates throughout the year).

In the event of salinity data being unavailable, conductivity measurements can be used to calculate the salinity using a conversion factor.

pH (hydrogen ion concentration) – Provide the annual range of the pH of the major part of the flooded area, noting details of the recording station(s) and depth and time of measurements. If data are available, these can be recorded for each season or each month of the year and a mean annual value given. If insufficient data are available this should be stated.

Where possible classify the water body using the scale shown in Table 18, with pH 6.6-7.5 being 'neutral', lower numbers being more acidic and higher numbers alkaline.

Transparency – Provide the annual range of water transparency of the major part of the flooded area as recorded with a 20-30 cm diameter Secchi disc and note details of the recording station(s) and depth and time of measurements. If data are available these can be recorded for each season or each month of the year and a mean annual value given. If sufficient data are not available this should be stated. Where possible, classify the water body according to the transparency categories shown in Table 19.

Whilst the term 'colour' should not be confused with 'transparency', it should be noted that the 'opaque' category can be subdivided into the following:

- 'Black'/tea-coloured water – indicates staining by peat in the catchment
- Greenish water – indicates relatively high productivity
- Brown/cloudy water – indicates high concentrations of suspended solids

Nutrients – Provide the known annual range of nitrogen (nitrate and total nitrogen) and phosphorous (ortho-phosphate and total phosphorous) concentrations in the major part of the flooded area, noting details of the recording station(s) and depth and time of measurements. If data are available these can be recorded for each season or each month of the year according to the categories shown in Table 20. If insufficient data are available this should be stated.

Table 17: **Salinity classification**

Classification	Salinity (gL^{-1})
Fresh	<0.5
Brackish	0.5-18.0
Semi-saline	18.0-30.0
Saline	30.0-40.0
Hypersaline	40-100
Ultrasaline	>100

Table 18: **Acidity/alkalinity classification based on pH units**

Classification	Range (pH)
Very strongly acidic	1.0-2.9
Strongly acidic	3.0-3.9
Acidic	4.0-4.9
Weakly acidic	5.0-6.5
Neutral	6.6-7.5
Weakly alkaline	7.6-8.5
Alkaline	8.6-9.9
Strongly alkaline	10.0-11.5
Very strongly alkaline	11.5 +

Table 19: **Classification of transparency as measured with a Secchi disc** (adapted from information provided in Moss 1980)

Category	Secchi disc depth (m)
Opaque	<0.05
Very turbid	0.05-0.25
Turbid	0.25-2.50
Clear	2.5-25.0
Very clear	>25

Table 20: **General relationship of wetland productivity to average concentrations of total phosphorous** (from Wetzel 2001)

Category	Total P (µgm/l)
Ultra-oligotrophic	<5
Oligo-trophic	5-10
Meso-eutrophic	10-30
Eutrophic	30-100
Hyper-eutrophic	>100

A test kit can also be used for rapid determination of the trophic status of a wetland. In the case of phosphorous, the test is based on the classic molybdenum blue colorimetric test for 'weakly coordinated' phosphate, otherwise known as orthophosphate, or filterable reactive phosphorous (FRP). Instead of using a spectrophotometer, a simple colour comparison is made using a disc.

Groundwater – if available, provide information on the chemical composition of groundwater in unconfined shallow aquifers in the general area.

Biological features

Vegetation

Dominant assemblages – List all the vegetation assemblages present, using the classifications used during the vegetation studies of the site and, if available, the most widely accepted vegetation classifications at regional and state levels. For open water areas, indicate the stable state, i.e., whether the water body is macrophyte or phytoplankton dominated. Use Table 21 as a guide.

Table 21: **Example format for categorisation of vegetation assemblages** (example from Tasek Bera, Malaysia)

Vegetation assemblage	Total area in wetland (km^2)	% of total area covered	Physical/hydrographic setting
Freshwater swamp forest	4100	67	seasonally inundated mineral soils with some peat areas
Pandanus/Lepironia marsh	2050	32	fringing open water areas, rarely drying out
Open water	100	1	
Total	**6250**		

Dominant species – Provide a list of species (as shown in Table 22) indicating growth strategy (annual, perennial, geophytic, perennial), growth form (terrestrial or aquatic species), and the structural type (grasses, herbs, sedges, shrubs, ferns, palms, trees). For aquatic species (i.e., plants that have vegetative parts that are permanently or seasonally inundated) indicate if they are emergent, floating-leaved, free-floating, submerged rooted, or free floating submerged. It should be noted that Specht (1981) and Walker and Hopkins (1984) define a tree as a 'woody plant with a single stem within 2m of the ground'; a shrub as a 'woody perennial plant with multiple stems arising within 2m of the base'; grass as 'herbaceous plants in the family Poaceae'; sedges as 'herbaceous plants, normally with tufted growth habit and from the family Cyperaceae or Restionaceae'; forbs as 'herbaceous plants that are not grasses or sedges'; and the term aquatic to mean 'herbaceous plants that live only in water'.

Table 22: **Example format for categorisation of plant species** (current application of AWI in Koshi Tappu, Nepal)

Species	Common/local name	Growth strategy	Growth form
Dalbergia sissoo	Sissoo	Perennial	Riverine successional tree
Acacia catechu	Khair	Perennial	Riverine successional tree
Saccharum spontaneum	Kans	Perennial	Terrestrial grass
Phragmites karka	Narkat	Perennial	Wetland dependent grass
Typha angustifolia	Pater	Perennial	Wetland dependent grass
Cymbopogon pendulus		Perennial	Terrestrial grass
Tamarix dioica	Jhauwa	Perennial	Riverine shrub (salt tolerant)
Digitaria adscendens		Annual	Terrestrial grass
Fimbristylis squomosa	Motha	Annual	Sedge
Persicaria lapathifolia		Annual	Wetland dependent herb
Echinochloa crusgalli	Sama	Annual	Wetland dependent grass
Echinochloa colona	Sama	Annual	Wetland dependent grass
Eicchornia crassipes	Jal Kumbhi	Perennial	Floating aquatic weed
Paspalum disticnum		Annual	Wetland dependent grass
Cyperus compressus		Annual	Wetland dependent sedge
Alternanthera sessilis		Annual	Wetland dependent grass

Alien invasive species and environmental weeds – List alien invasive species and natural weed species, beneficial and noxious, indicating which species are introduced and providing estimates of cover for each as area (ha) or percentage cover (%) of the site.

Species and assemblages of conservation significance – List the plant species and/or assemblages present by status (endangered, vulnerable, rare, threatened), level (global, national, state, regional), and, where appropriate, indicate the legislation applicable to each level of significance. For plant assemblages it is advisable to record the source of the information used as the same assemblage may be recorded differently in subsequent surveys. Use Table 23 as a guide. Use the UNEP-WCMC Threatened Plants Database as a reference (http://www.unep-wcmc.org/species/plants/overview.htm). This contains information on the status of plant species of conservation significance throughout the world.

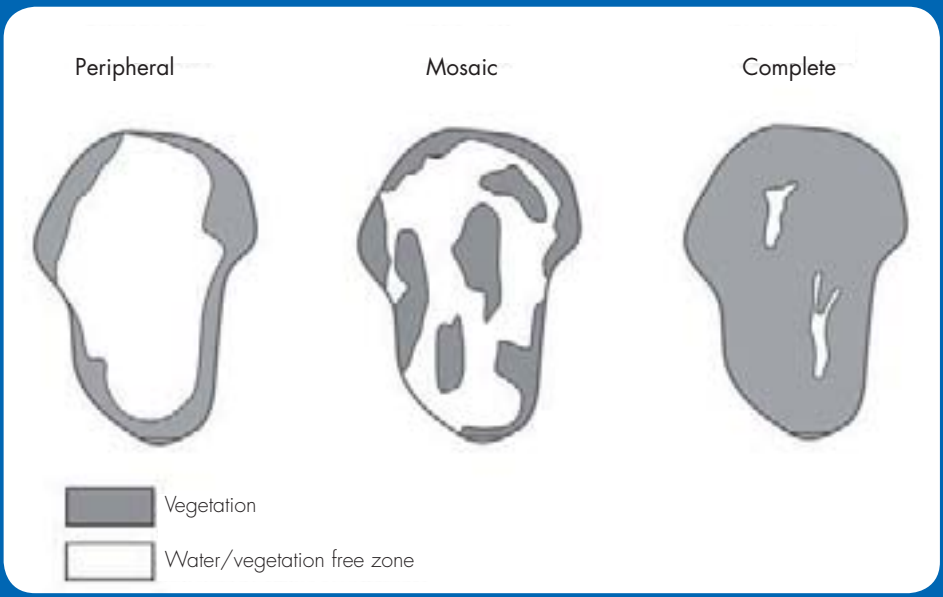
Table 23: **Example format for recording plant species and assemblages of conservation significance** (example from Koshi Tappu, Nepal)

Taxon	Taxonomic group	Distribution	Status	Level
Begonia tribenensis	Begoniaceae	Endemic to central and Eastern Nepal	Very rare	National
Oroxylum indicum	Bignoniaceae	East to West region of Nepal between 200-1400m	Vulnerable	National (IUCN)
Rauwolfia serpentine	Apocynaceae	East to West region of Nepal between 100-1000m	[a]Protected Endangered CITES-II	National (IUCN)
Acacia catechu	Leguminosae	Lowland riverbed, East to West region	[b]Protected	National, GoN
Bombax malabaricum	Bombacaceae	Lowland Terai to midland	[b]Protected	National, GoN

[a] Banned for export except processed with permission of Dept. of Forest Description
[b] Banned for transportation, export and felling for commercial purposes

Vegetation cover – Describe the 'vegetation cover' by estimating the relative proportions of vegetation cover and open water using the categories proposed by Semeniuk and Semeniuk (1995). Make use of aerial photographs or cover maps of the habitat, normally obtainable from the offices of local planning authorities and/or government agricultural or forestry services. High resolution satellite data (e.g., IKONOS, Quickbird, IRS LISS4) are also highly useful in categorisation of vegetation cover. These are illustrated in Figure 6 below. Note that due to the gradational nature of vegetation cover, the temptation to attribute more precise categories of 'percentage cover' should be avoided. However, where the areal extent of the vegetation cover is greater than 90%, the cover can be considered as 'complete'.

Figure 6: **Categories of vegetation cover (after Semeniuk et al 1990)**



Fauna

Dominant assemblages and species – Provide a list of animal species associated with the site (vermin and pest species included), with the view of providing a record of species richness and diversity for each of the main taxonomic groups present (i.e., invertebrates, vertebrates – mammals, birds, fish, and so on). Make specific reference to any species that may have declined or increased over time.

Species of conservation significance – List species of conservation significance (endangered species first, followed by vulnerable and rare species), including those listed in national, or state legislation as threatened or as listed migratory species, and so on. Use Table 24 as a guide. Use the '2008 IUCN Red List of Threatened Species' (http://www.iucnredlist.org) to determine internationally important and endangered species supported by the habitat (similar to the case for species of conservation significance at Level 3). For fish species the following can also be used (http://www.fishbase.org). For the purpose of determining species of national significance supported by the habitats of interest, use other local data sources include National Red Data Books (if available) and local experts.

Table 24: **Example format for recording animal species of conservation significance** (example from Koshi Tappu, Nepal)

Taxon	Taxonomic group	Distribution	Status	Level
Bubalus arnee	Bovidae	S & SE Asia	Endangered	(P), III
Bos gaurus	Bovidae	S & SE Asia	Endangered	(P), I
Platanista gangetica	Platanistidae	S Asia	Endangered	(P), I
Elephus maximus	Elephantidae	Asia	Endangered	(P), I
Gavialis gangeticus	Gavialidae	S & SE Asia	Endangered	(P),I
Crocodylus palustris	Crocodylidae	S Asia	Vulnerable	IUCN
Varanus flavescens	Varanidae	S Asia	Endangered	P
Python molurus bivittatus	Boidae	SE Asia		2
Francolinus gularis	Phasianidae	Nepal, India, Bangladesh	Globally threatened–Vu National threatened–EN	BI 2001
Anas formosa	Anatidae	S Asia (N): winter vagrant	Globally threatened	Unknown

Note: Rare = <5% chance to be seen at the site Very Rare = <5 records at the site

Populations – in situations where abundance data are available, tabulate the average and maximum estimated population numbers present as shown in Table 25a. Describe the abundance of the fauna (e.g., key species, largest concentrations) paying particular attention to breeding populations (where data available tabulate as in Table 25b), migratory populations (e.g., birds, fish) and key migration periods in wetland. Where known, draw attention to populations of wetland species that may have declined or increased over time.

In the event of abundance data being unavailable, provide an indication of the abundance of the species concerned (e.g., A = abundant ; C = common ; U = uncommon; R = rare) and status (e.g., B = breeding; W = wintering; R = resident; V = vagrant).

Table 25: **Example format for the tabulation of population abundance data (a) and information on breeding populations (b)**

(a) Population abundance

Species	Status	Average number	Maximum number	Date of census (month / year)

(b) Breeding populations

Species	Number of breeding records

Alien invasive and vermin/pest species – list and describe the alien invasive and vermin/pest species present in each habitat, indicating which species are introduced.

Habitats

Tabulate the wetland habitats using the most widely accepted existing habitat classification scheme (Box 2). As shown in Table 26, list the key taxa of the fauna that occur in each habitat. Where known, draw attention to what are considered to be key habitats for breeding fauna or for species of conservation significance and indicate whether any such habitats may have declined or increased in area and/or quality over time. Where possible, describe the faunal characteristics of each habitat using species richness data to give an indication of the importance of the habitat for the maintenance of biodiversity.

Table 26: **Example format for listing of key faunal taxa associated with each major habitat together with an indication of the available information for each**

Habitat type	Key fauna taxa	Available information
Open water	Invertebrates, amphibia, waterbirds	September 1992; December 1996, very limited, numerous surveys (50+) have been conducted over the period 1965 – present
Fringing bushes and reeds	Waterbirds	Numerous surveys (50+) have been conducted over the period 1965 – present
River channel	Fish	August 1994

Biological significance of the habitat

Describe the biological importance of the habitat by using the criteria defined by the Ramsar Convention for identifying wetlands of international importance (http://www.ramsar.org/key_criteria.htm). The Ramsar Convention presents nine criteria to assess the importance of a wetland habitat with a specific emphasis on birds and fish, see Table 27. Determine population estimates of water birds that meet the criteria of internationally important sites by using the 'Waterbird Populations Estimates' from Wetlands International (Delany and Scott 2006).

Table 27: **Summary of the criteria for listing a wetland as internationally important under the Ramsar Convention**

Criterion	Description
1	A representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region
2	Supports vulnerable, endangered, or critically endangered species or threatened ecological communities
3	Supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.
4	Supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions
5	Regularly supports 20,000 or more waterbirds
6	Regularly supports 1% of the individuals in a population of one species or subspecies of waterbird
7	Supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity
8	Important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend
9	Regularly supports 1% of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species

Socioeconomic features

Provide information on communities living in and around the wetland. Classify these into the following:

1 Demographic features: population, growth rates

2 Social profile: access to social amenities, viz safe drinking water and sanitation, education, medical facilities, and others

3 Economic profile: income, access to banking and credit facilities, resource linkages, contribution of wetlands to incomes and livelihoods, seasonality of resource use

4 Institutional arrangements: community institutions, governance structure, belief systems (include taboos) in relation to the wetlands and other natural resources

5 Stakeholders and conflicting interests

6 List any particular spiritual or medicinal or sacrosanct significance, by any group or stakeholder

5.4.5 Habitat classification

The GHWI/AWI approach focuses on collecting the core data that may be required, amongst other things, to classify wetland habitats. Users of this manual are entitled to use whatever classification system they prefer. However, it is recommended to convert the classification into the Ramsar classification system (see Box 1).

5.4.6 Wetland ecosystem services

Describe the major goods and services of the wetland habitat using the information presented in Table 7 as a guide, but add site-specific details that may not have been apparent at previous levels. The goods and services derived from the habitat include products that are obtained directly from the wetland as well as some less tangible services based on social or cultural values.

5.4.7 Land and water use

Describe and, where possible, map the manner in which the habitat is used by local people: note matters such as the yield obtained from crops or fisheries; whether wetland use is seasonal or year-round; the extent of cultivated areas; the type of gear used for fishing; whether there are any social, economic, or political conflicts (e.g., conversion to farmland, dam construction).

Describe the land and/or water use made of the habitat by local communities by refining or expanding upon the data collated earlier at Level 3 (Table 11). Note, where appropriate, whether or not these are undertaken for subsistence or for commercial purposes and use mainly traditional or modern techniques.

5.4.8 Management issues and threats

For each habitat, describe the management issues that confront local communities as users of the habitat by refining/expanding upon the data collated earlier at Level 3 (Table 11). Deliberately highlight the management practices or plans (if any) being employed or developed by agencies working in the area and record the number of people interviewed, and the names and status of the informants. Similarly, where the utilisation of a wetland habitat presents risks to human health, the type of disease carrying organisms living in the wetland and the incidence of disease within the human population should also be described.

5.4.9 Monitoring and management programmes

Provide details of any existing or proposed monitoring programmes and management plans for the habitat. This includes the names of any government agencies, NGOs, or other interest groups working in the area and a brief indication of the programmes active (title of project, objectives, time frame, applicability to wetland management, and person(s) or organisation(s) responsible).

5.4.10 Data sheet completion

- Name and address of compiler: state the name and address of the compiler as shown in the datasheet.
- Date sheet completed/updated: state the date of data sheet completion or update.

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Annexes

Annex 1: Resolution VII.20 on Wetland Inventory

People and Wetlands: The Vital Link'7th Meeting of the Conference of the Contracting Parties to the Convention on Wetlands (Ramsar, Iran, 1971), San José, Costa Rica, 10-18 May 1999 Priorities for wetland inventory

1 RECALLING Recommendation 1.5 which called upon Contracting Parties to prepare inventories of their wetlands *'as an aid to the formulation and implementation of national wetland policies'* to assist in promoting the wise use of wetlands in their territory;

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

3 AWARE of Action 6.1.3 of the Strategic Plan 1997-2002 which calls upon the Ramsar Bureau and the International Organization Partners to *'utilize information from regional wetland directories, national scientific inventories of wetlands and other sources, to begin development of a quantification of global wetland resources, as baseline information for considering trends in wetland conservation or loss';*

4 NOTING the report entitled *Global review of wetland resources and priorities for wetland inventory* and its recommendations as prepared and presented by Wetlands International to Technical Session IV of this Conference, in response to Action 6.1.3 of the Strategic Plan 1997-2002;

5 APPRECIATIVE of the financial support provided for the preparation of the above report by the Governments of the Netherlands, Norway, and the United Kingdom;

6 NOTING WITH CONCERN the findings of the Wetlands International report that, based on the information gathered within the constraints of this project, few countries, if any, have comprehensive national inventories of their wetland resources, and that it is therefore not possible to provide a baseline of the world's wetland resources with any confidence;

7 RECOGNIZING the priorities for future wetland inventory, both in terms of types and regions, as identified in the report and endorsed by the Second International Conference on Wetlands and Development (Dakar, Senegal, November 1998);

8 CONSIDERING that this Conference has also adopted Guidelines for developing and implementing National Wetlands Policies (Resolution VII.6), the Wetland Risk Assessment Framework (Resolution VII.10), the Strategic Framework and guidelines for the future development of the List of Wetlands of International Importance (Resolution VII.11), and Resolution VII.17 on Restoration as an element of national planning for wetland conservation and wise use, all of which, as noted by the previous Resolutions and Recommendations referred to in paragraphs 1 and 2 above, would be greatly assisted by the availability of national scientific inventories;

9 TAKING ACCOUNT of the findings given in the report prepared by the World Conservation Monitoring Centre and presented to COP7 Technical Session IV entitled Shared wetlands and river basins of the world; and

10 NOTING the scope of the proposed Millenium Assessment of the World's Ecosystems, currently under development, to deliver valuable related information of relevance to the application of the Convention;

The Conference of the Contracting Parties

11 URGES all Contracting Parties yet to complete comprehensive national inventories of their wetland resources, including, where possible, wetland losses and wetlands with potential for restoration (Resolution VII.17), to give highest priority in the next triennium to the compilation of comprehensive national inventories, in order for related actions such as policy development and Ramsar site designations to be carried out with the best information possible;

12 FURTHER URGES that in undertaking inventory activities Contracting Parties give consideration to affording highest priority to those wetland types identified as at greatest risk or with poorest information in the Global review of wetland resources and priorities for wetland inventory report;

13 REQUESTS Contracting Parties to give consideration in their inventory activities to adopting a suitable standardised protocol for data gathering and handling, such as that provided by the Mediterranean Wetlands Initiative (MedWet), and the use of standardised low-cost and user-friendly geographic information system methods;

14 ENCOURAGES Contracting Parties with shared wetlands or river basins to work cooperatively in the gathering of inventory and related management information, as urged through the Guidelines for international cooperation under the Ramsar Convention (Resolution VII.19);

15 REQUESTS the Scientific and Technical Review Panel, in collaboration with Wetlands International, 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 Contracting Parties with a view to promoting international common standards;

16 CALLS UPON Contracting Parties to review the arrangements they have in place for housing and maintaining their wetland inventory data where it exists, and, as necessary, to seek to establish a central repository or to ensure that access to this information resource is possible for all decision-makers, stakeholders and other interested parties, where possible through the World Wide Web and CD-ROM formats;

17 ALSO ENCOURAGES Contracting Parties and other interested organizations and funding bodies to provide the resources to allow Wetlands International to complete and document suitable standardised protocols for data gathering and handling as well as a comprehensive assessment of wetland inventory information, and to develop procedures for regularly updating this information and making it readily available through the World Wide Web and CD-ROM formats;

18 FURTHER CALLS UPON the bilateral and multilateral donors to give priority to supporting the wetland inventory projects submitted by developing countries and those in economic transition, noting, as urged above, the desirability of such projects being undertaken; and

19 DIRECTS the Standing Committee to give special attention to appropriate wetland inventory projects in its consideration of projects submitted to the Ramsar Small Grants Fund.

Annex 2: Data Sheets – Level 1 River Basin to Level 4 Wetland Habitats

Some sections of the data sheets provided below have been elaborated further than the data entry sheet that will be appeared in the Information System to ensure that all necessary information to describe the corresponding sections is collected/collated systematically before data uploading starts.

Level 1 Data Sheet – Major River Basins

Note: the users are requested to expand number of rows in the tables below as per the number classes exist in the corresponding map. The area of total area for each class can be computed from attribute table of the map.

1. Name and code of major river basin

Name	
Code	

2. Geographic extent

	Minimum (dd-degree decimal)	Maximum (dd)	Central (dd)
Latitude (°N)			
Longitude (°E)			
Projection information used for			

3. Climate

Code	Name of climatic class	Area (km²)

Free text description of climate	
Source of information	

4. Geology

Code	Name of geological class	Area (km²)

Free text description of geology	
Source of information	

5. Ecoregions

Code	Name of ecoregions class	Area (km²)

Free text description of ecoregions	
Source of information	

6. Vegetation

Code	Name of vegetation class	Area (km²)

Free text description of vegetation	
Source of information	

7. Hydrological regime

Free text description of regime	
Source of information	

8. Wetland area and type

Code	Wetland type	Area (km²)

Free text description of wetland area and type	
Source of information	

9. Wetland ecosystem service

List of goods and services	Description of services

Source of information	

10. Development activities

List of activities	Description of activities

Source of information	

11. Management issues and threats

Indirect driver	Description of Issues and threats

Source of information	

12. Data sheet completion

Name and address of compiler	
Date sheet compiled/updated	

Level 2 Data Sheet – Sub-Basins

Note: the users are requested to expand the number of rows in the tables below as per the number of classes that exist in the corresponding map. The area or % of total area for each class can be computed from the attribute table of the map.

1. Name and code of sub-basin

Name	
Code	

2. Geographic location

	Minimum (dd)	Maximum (dd)	Central (dd)
Latitude (°N)			
Longitude (°E)			
Projection information used for area calculation			

3. Climatic characteristics

Code	Name of climatic class	Area (km²)

Free text description of climate	
Source of information	

4. Physical features

4.1 Type of region: sub-basin

4.2 Altitude range:

Minimum (m amsl)	
Maximum (m amsl)	
Free text description of altitudinal variation	
Source of information	

4.3 Wetland area and type

Code	Wetland type	Area (km²)

Free text description geology	
Source of information	

4.4 Geological characteristics

Code	Geological feature	Area (km²)

Free text description of wetland area and type	
Source of information	

4.5 Water regime

Station index	Station name	Lat	Long	Long term mean discharge (m^3/s)					
				Annual average	Minimum flow		Maximum		Period of record
					m^3/s	Month	m^3/s	Month	

Free text description of regime	
Source of information	

5. Ecoregions

Code	Name of ecoregion	Area (km^2)

Free text description of ecoregions	
Source of information	

6. Vegetation

Code	Vegetation type	Area (km^2)

Free text description of Vegetation	
Source of information	

7. Wetland ecosystem services

Categories of wetland ecosystem services	Description of relative importance of the services

Source of information	

8. Development activities

List of activities	Description of activities

Source of information	

9. Management issues and threats

Categories of direct drivers	Description of issues and threats associated with the direct driver

Source of information	

10. Jurisdiction

National or local	
Source of information	

11. Data sheet completion

Name and address of compiler	
Date sheet compiled/updated	

Level 3 Data Sheet – Wetland Complexes

[Note: expand the tables below as and when necessary]

1. Name and code of wetland complex

Name	
Code	

2. Geographic location

	Minimum (dd)	Maximum (dd)	Central (dd)
Latitude			
Longitude			
Projection information			

3. Climatic characteristics

Station information

Station index (ID)			
Official name			
Latitude (dd)			
Longitude (dd)			
Altitude (m amsl)			
Mean Annual precipitation (mm)			
Period of record			

Monthly climate characteristics	Unit	Average	Range				
			Min	Month	Max	Month	
Monthly precipitation	mm						
Monthly temperature	°C						
Monthly humidity (9 am)	%						
Monthly humidity (3 pm)	%						
Monthly evaporation (Class A pan)	mm						
Prevailing wind	m/s						
Free text description of climate							
Source of information							

4. Ecological Character

4.1 Physical features

a. Altitude range

Minimum (m amsl)	
Maximum (m amsl)	

Free text description of altitude variation	
Source of information	

b. Spatial

Area	Unit:

Free text description of spatial extent	
Source of information	

c. Erosional status

Free text description of erosional status	
Source of information	

d. Soil types

List of soil type categories	Area (or % of total area of the complex)

Note: if a GIS version of the soil type map is available, the above table can be filled out from the attribute table of the map, otherwise provide a list of dominant soil types.

Free text description of soil types	
Source of information	

e. Water regime

Station index	Station name	Lat	Long	Long term mean discharge (m^3/s)					
				Annual average	Minimum flow		Maximum		Period of record
					m^3/s	Month	m^3/s	Month	

Other water regime characteristics:

Length of main stream within complex (km^2)	To be derived from stream network map
Stream order differentiation	To be derived from stream network map
Free text description of water regime	
Source of information	

If a water cycle regime (hydroperiod) map is prepared, derive the following information from the map:

Water regime characteristics (hdroperiod)	Area

f. Groundwater

Well ID	Lat	Long	Depth of water table (m)				Source of inflow*
			Max	Month	Min	Month	

* Ar – artesian; SAf – shallow aquifer; DAf – deep aquifer

Free text description groundwater	
Source of information	

g. Physico-chemical features

Level of contamination and sedimentation

Stressor	Level of contamination	Source of stressor
Waste water discharge		
Nutrient		
Toxicant		
Salinity		
Sediment load		
Free text description of water quality		
Source of information		

4.3 Biological features

a. Biological condition of complex

Free text description (relative proportions of vegetation cover (%); trends in status / condition of vegetation; trends in fauna populations)	
Source of information	

b. Species and associations of biological significance

Free text description (Assessment of biological significance using WWF and IUCN data)	
Source of information	

c. Habitat(s)

List of habitat types	Area

Free text description	
Source of information	

5. Population demographics

No of people or population density	
Major activities	
Free text description of population features and activities in complex	
Source of information	

6. Wetland ecosystem services

Categories of wetland ecosystem services	Description of relative importance of the services

Source of information	

7. Land and water use

List of land and water uses in the complex	Free text description of the manner in which land/water is used by local people

Source of information	

8. Institutional arrangements

Free text description jurisdiction and ownership of complex	
Source of information	

9. Management issues and threats

List of management issues and threats	Free text description

Source of information	

10. Data sheet completion

Name and address of compiler	
Date sheet compiled/updated	

Level 4 Data Sheet – Wetland Habitat/Site

[Note: expand the tables below as and when necessary]

1. Name and code of wetland habitat/s

Name	
Code	

2. Geographic location

	Minimum (dd)	**Maximum (dd)**	**Central (dd)**
Latitude			
Longitude			
Projection information			
Source of information			

3. Climatic characteristics

Note: if climatic characteristics recorded for all the stations within and around the complex in Level 3, copy the characteristics of nearest station from the habitat/site.

Station information

Station index (ID)			
Official name			
Latitude (dd)			
Longitude (dd)			
Altitude (m amsl)			
Mean annual precipitation (mm)			
Period of record			

Parameter	**Unit**	**Average**	**Range**				
			Min	**Month**	**Max**	**Month**	
Monthly precipitation	mm						
Monthly temperature	°C						
Monthly humidity (9 am)	%						
Monthly humidity (3 pm)	%						
Monthly evaporation (Class A pan)	mm						
Prevailing wind	m/s						
Free text description of climate							
Source of information							

4. Ecological Character

4.1 Physical features

a. Geomorphic setting

Inland setting (basin; channel; flat; slope; or highland)	
Free text description	
Source of information	

b. Altitudinal range

Max	
Min	

c. Spatial extent

Area (in)	Size class	Length (m or km specify)	Width (m or km specify)

d. Basin morphology

Bathymetry: Water depth (m)

Max	
Min	
Average	
Free text description	
Source of information	

e. Erosional status

Erosional status	
Free text description	
Source of information	

f. Soil types

List of dominant soil types	
Free text description	
Source of information	

g. Bottom sediments substrata

Substrate class	
Free text description	
Source of information	

h. Water regime

Hydroperiod (water cycle regime)	Area

Inflow sources (Streamflow/overland/rainfall/groundwater)	
Outflow (Permanent/seasonal/intermittent/episodic or none)	

Free text description of water regime	
Source of information	

i. Groundwater

Well ID	Lat	Long	Depth of water tale (m)				Source of inflow*
			Max	Month	Min	Month	

* Ar – Artesian; SAf – Shallow Aquifer; DAf – deep aquifer

Free text description	
Source of information	

4.2 Physio-chemical features

a. Surface water quality

Monitoring station information (if available)

Station ID/name	
Latitude	
Longitude	

• Surface water quality

Parameter	Unit	Max	Time/date of measurement	Min	Time/date of measurement	Annual range	Classification
Temperature							
Salinity							
pH							
Transparency							
Nutrients							
Total N & Nitrate							
Total P & ortho-P							
Source of information							

Sediment load	Unit	Value	Source of information
Annual sediment input			
Rate of loss of site			

• Pesticides

Free text description of presence and concentration of pesticides	
Sources of information	

Free text description of overall surface water quality	
Sources of information	

b. Groundwater

Free text description of presence and concentration of pesticides	
Sources of information	

4.3 Biological features

a. Vegetation

• Dominant vegetation assemblages

List of Vegetation assemblage	Total area in wetland	% of total area covered	Physical/hydrographic setting

Free text description	
Sources of information	

• Dominant vegetation species

List of plant species	Common/local name	Growth strategy	Growth form

Free text description	
Sources of information	

• Alien invasive species and environmental weeds

List of invasive species and environmental weeds	
Free text description (with cover estimates)	
Sources of information	

• Species and assemblages of conservation significance

Taxon	Taxonomic group	Distribution	Status	Level

Free text description	
Sources of information	

• Vegetation cover

Relative Proportions of Vegetation cover %	
Free text description	
Sources of information	

b. Fauna

• Dominant assemblages and species

List of dominant assemblages and species	
Free text description of major features (using species composition and species richness data for major invertebrate and vertebrate assemblages	
Sources of information	

• List of animal species of conservation significance (with indication of whether endangered, vulnerable or rare):

Taxon	Taxonomic group	Distribution	Status	Level

Free text description	
Sources of information	

• List of populations abundance data

a. Population abundance

Species	Status	Average No.	Maximum No.	Census date (month / year)

b. Breeding populations

Species	Number of breeding records

Free text description (key species, largest concentrations, breeding populations, key migration periods)	
Sources of information	

• Alien invasive and vermin/pest species

List of invasive and/or vermin/pest species	
Free text description	
Sources of information	

c. Habitats

Habitat type*	Associated key faunal taxa	Available information

*from habitats map (if produced using high resolution satellite data or existing map)

Free text description	
Sources of information	

d. Biological significance of habitats/site

Assessment of biological significance of habitat(s) using Ramsar criteria	
Free text description	
Sources of information	

4.4 Socioeconomic features

Socioeconomic features	Description	Source of information
Demographic features		
Social profile		
Economic profile		
Institutional arrangements		
Stakeholders and conflicting interests		

5. Habitat classification

Based on the detail land use land cover map or wetlands habitats map (if produced using high resolution satellite data) classify the habitats using the Ramsar typology.

Wetland type/s	
Free text description	
Sources of information	

6. Wetland ecosystem services

List of wetlands services	Free text description of services

Source of information	

7. Land and water use

List of land water use associated with the habitat/site	Description manner in which land/water used by local people

Source of information	

8. Management issues and threats

List of management issues and threats	Description of management issues and threats

Source of information	

9. Monitoring and management programmes

List of monitoring and management programmes	Free text description organisation/persons and projects involved

Source of information	

10. Data sheet completion

Name and address of compiler	
Date sheet compiled/updated	

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