Pakistan Wetlands Programme

Pakistan Wetlands GIS, Integrated Database Design

The Ministry of Environment's Pakistan Wetlands Programme

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List of Acronyms

AWI	Asian Wetlands Inventory
CSDGM	Content Standard for Digital Geospatial Metadata
DBMS	Database Management System
ERD	Entity Relationship Diagram
FGDC	US Federal Geographic Data Committee
GBIF	Global Biodiversity Information Facility
GIS	Geographic Information System
GPS	Global Positioning System
GUI	Graphic User Interface
ICT	Information & Communication Technology
IUBS	Internation Union of Biological Sciences
NCCW	National Council for Conservation of Wildlife
NGO	Non Governmental Organisation
RFP	Request for Proposal
RIS	Ramsar Information Sheet
SDBMS	Spatial Database Management System
SDE	Spatial Database Engine
SQL	Structures Query Language
TDWG	International Working Group on Taxonomic Databases
PWGIS	Pakistan Wetlands Geographic Information System
PWP	Pakistan Wetlands Programme
WSPS	Wetlands Survey Programme Section
WWF	World Wide Fund for Nature (a.k.a. World Wildlife Fund)

Executive Summary

National wetlands inventories are developed to map the extent and characteristics of wetlands as country level database. GIS-based Pakistan Wetlands Inventory (PWI) being developed under the Pakistan Wetlands Programme, aims to promote the sustainable conservation of freshwater and marine wetlands and associated important biodiversity.

All of the Pakistan Wetlands Programme activities are covered in its 10 Outputs. Output 2 is composed of long-term wetlands survey programme and wetlands GIS. The overall goal of PWGIS Integrated Database Design is to provide a mechanism to assimilate information being produced through wetlands surveys and wetlands GIS development process.

Taking into account the programme structure and inventory needs three main components, environmental characteristics, time-series biological survey observations and spatial datasets related to wetlands were identified. Standardised international data models for these three components, were studied respectively: *A Manual for Asian Wetlands Inventory*, *Observational Data Standards of Taxonomic Database Working Group* and *Geograpic Information – Metadata ISO 19115.* In addition, Ramsar Information Sheet (RIS) was thoroughly studied to accommodate all socio-ecological parameters necessary for wetlands evaluation. A comprehensive database, PWI data model, was designed by modifying and integrating them together to serve the specific needs of the inventory. Standard data encoding forms were also designed for eight thematic areas of survey programme which include Birds, Mammals, Fish, Reptiles/ Amphibians, Planktons, Vegetation and Water Quality.

PWI data model is implemented in OGC compliant open source software framework. Database Postgres with spatial extension PostGIS is used to tightly couple the spatial and non spatial entities of the inventory. This is similar to the infrastructure being used by GBIF for its global biodiversity portal.

A web-based application will be built on the top of the currently designed PWI data model. The envisaged application will be compatible to connect with global biodiversity portals like GBIF and visualization of PWI data records over the Google Earth.

1 Background

1.1 Pakistan Wetlands Programme

In Pakistan, wetlands cover approximately 10% of its total area including both natural and manmade. Pakistan is a signatory to the international Ramsar Wetlands Convention and has adopted the comprehensive wetlands definition used by the parties to this Agreement: “Areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static, flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six metres.” Presently 19 wetlands of Pakistan have been designated as Ramsar Sites, with a total surface area of 1,343,627 hectares.

Pakistan’s wetlands and their rich biological resources are threatened by over-exploitation, habitat destruction and polluted environments. The main causes for wetland degradation are ineffective management, poor stakeholder participation and lack of coordination for management strategies (Kashif and Naseem 2006).

Pakistan Wetlands Programme is being specifically implemented under the umbrella of the long-standing Ramsar Convention. The Programme aims to promote the conservation of the country’s freshwater and coastal wetlands and their associated biodiversity.

Creation of an enabling environment for the conservation of these pristine wetlands is one of the primary outcomes of the project. Project activities are being carried out in the areas given below.

- Strengthening of appropriate institutions for the sustainable management and conservation of wetlands;
- Development and implementation of a comprehensive National Wetlands Conservation Strategy;
- Enhancement of planning and management capacity for wetlands conservation by the introduction of decision-making tools such as Geographic Information Systems;
- Enhancement of technical capacity within key government agencies and communities to conserve wetlands;
- Improvement of public awareness and support for wetlands
- conservation; and
- Development of effective financial sustainability mechanisms

All of the project activities are covered in its 10 Outputs, Output 2 specifically emphasizes on the use of information and communication technologies (ICT) for the conservation and management of wetlands.

Output 2: Planning and land-use decision-making of wetlands conservation agencies at all levels is enhanced through the provision of comprehensive, current wetlands information, decision support systems and tools utilising spatial and other data from the Wetlands GIS Database.

Output 2.1: A Wetlands Survey Programme Section (WSPS) is set up within the PMU under the overall direction of the NCCW.

Output 2.2: A national wetlands survey programme is designed and implemented. Activities will include but not limited to the following:

Output 2.3: The Pakistan Wetlands Geographic Information System (W-GIS) Database

is enhanced and deployed to conservation agencies.

1.2 Pakistan Wetlands GIS

Over the past few years GIS and Remote Sensing are playing vital roles in providing data and information that have proved useful for a wide range of applications in these areas, such as water and forest resources assessment and mapping, land use change detection, urban and rural development, species distribution, habitat mapping and biological data collection. Realizing this fact, the Programme has incorporated extensive GIS based studies under the title of "Development of Pakistan Wetlands GIS" in its output 2.3. This comprehensive study include delineation of wetlands in the country, building relevant GIS layers for the delineated wetlands, development of PWGIS integrated database, establishment of Mechanisms for data gathering and sharing, and capacity building of stakeholders in use of GIS and Remote Sensing tools and technologies.

Pakistan Wetlands GIS-based Wetlands Inventory (PWGIS) is being developed to map the extent and characteristics of the wetlands in the country. The inventory will serve multiple scientific, academic and awareness purposes. Hierarchal approach explained in "A Manual for Asian Wetlands Inventory" will be adopted. The spatial data developed during the project, will be maintained in a map series similar to SoP standardised map catalogue of scale 1:1 000 000, 1:250 000, 1:50 000 and 1:10 000. This will help in highlighting wetlands characteristics at various levels; from habitat to basin.

A master GIS Laboratory will be setup at NCCW, Ministry of Environment, Islamabad and small GIS set ups in the partner organisations. GIS and Remote Sensing trainings will be imparted to the staff of conservation agencies throughout the country.

1.3 Pakistan Wetlands Survey Programme

An effective monitoring and survey programme is a prerequisite for the assessment of ecological changes of the wetlands over the time. Such a programme is an integral component of wetland management plan and should enable full consideration of the values and benefits of the wetland when the extent and significance of the change is being assessed (RAMSAR, 1996).

Project document of Pakistan Wetlands Programme states that: as a consequence of technical and financial constraints, wetlands survey by government and private conservation agencies in Pakistan are, at best, sporadic. They consist of irregular counts and estimates of the more significant species in selected and easily accessible wetlands. Little effort is made to co-ordinate survey work between various agencies and provinces even in the case of endangered species. As the consequences of these realities there is limited ability to detect and respond with any level of sophistication to positive or negative small or large-scale trends in wetland environments (PWP, 2004).

To fill in the gaps in the knowledge of the geographic locations and health conditions of wetlands, the Wetlands Survey programme Section (WSPS) is setup at Programme's headquarter. The Co-coordinator Survey Programme is responsible for the recruitment of a broad range of specialists to carry out an integrated series of nation-wide wetlands' surveys. Using specialised services and equipment, survey teams will consist of staff from participating government agencies, NGOs, local communities and the private sector.

Detailed biological and socio-economic surveys will be undertaken at the beginning of the project to establish a baseline against which future progress may be measured. These surveys will be repeated at the mid-term stage, immediately prior to the midterm review, to provide a before and after assessment of the project activities and to adapt and even replace specific project intervention for increased effectiveness. Biological surveys will assess the change in species richness and density, improvements in range, habitats and overall health of the system. Socio-economic surveys will focus on the success of awareness-raising activities, change in income and livelihood stability for wetlands dependent communities.

The surveys will be conducted on diverse disciplines (e.g., limnology, ornithology and socio-economic). Integration of data from a variety of sources and disciplines is required to understand the ecological patterns. Technological development in information science has made it possible to integrate information belonging to a range of disciplines gathered from diverse sources. The integrated information collected during the survey will be stored into GIS-Based Wetlands Inventory and will be utilised in different components of the Programme as mentioned below in Figure 1.

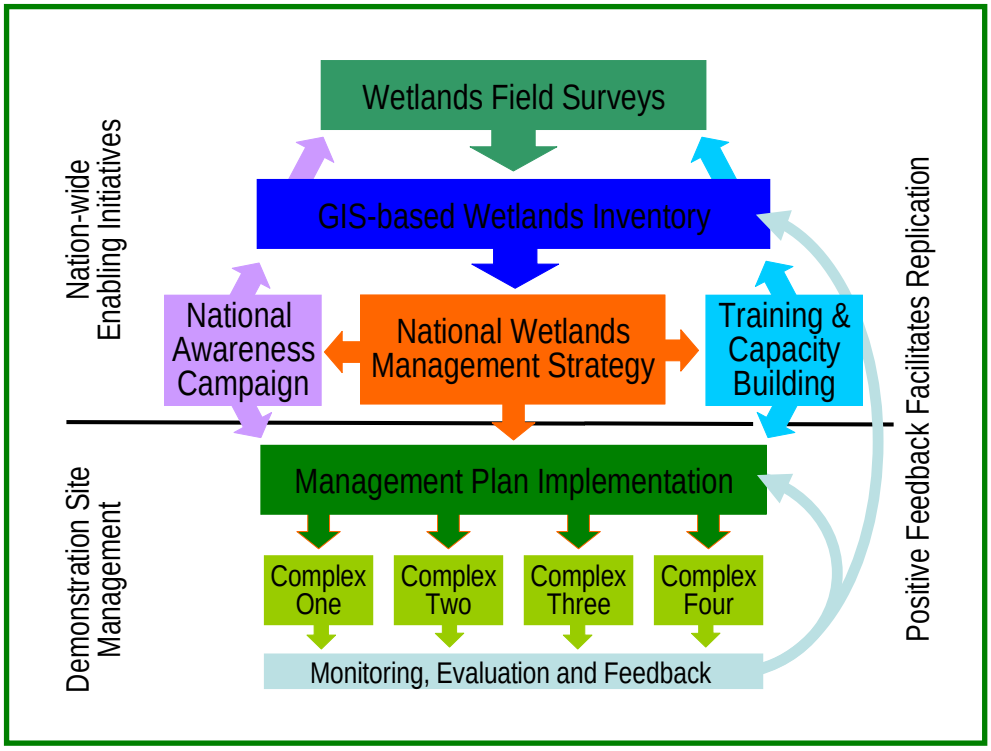

Figure 1: Inter-relationships of output 1-10 (PWP, 2004)

1.4 Goal and Objectives of PWGIS Integrated Database Design

The overall goal of the PWGIS Integrated Database Design is to provide a mechanism to assimilate information being produced in the various activities of Pakistan Wetlands GIS. Objectives of the development of integrated database design are to:

- Development of standardised survey technique (data encoding forms) for conducting biodiversity field surveys.

- Development of metadata database of spatial dataset (e.g., satellite images, topographic layers, digital elevation model) being produced in on-going Wetlands GIS.

- Development of Pakistan Wetlands Inventory Database through integration two above mentioned activities with other relevant inventory literature like Ramsar Information Sheet and Asian Wetlands Inventory data sheets.

2 Standardised Wetlands Survey Procedure

Pakistan Wetlands Survey Programme is conducting extensive filed surveys to determine health conditions of wetlands and to discover species diversity in their surroundings. Biodiversity surveys are conducted to find out which species exist in a particular area. Data gathered from these surveys will be used for numerous purposes like monitoring endangered populations and evaluating conservation priorities of the wetlands.

As field data has to be compared or analyzed, data collection of surveys must be kept consistent, not just between different surveyors but also from site to site and time to time. Standardization ensures that differences between two surveys are realistic and not the result of uneven collection method. Existing geographical data standards and standard data should be used whenever possible, and an overall consensus on authority files or systems is to be achieved within the biological discipline. Funding bodies should encourage researchers to document and reference the databases used to publish their research (Berendsohn, *et. al.,* 1999). The collection and management of information related to biodiversity and earth sciences is complex. At a time when it is increasingly expected that the majority of wildlife and earth science data should and will become widely available through electronic means, it is essential that there is a full understanding of the nature of the data and there are the standards to improve the degree of interoperability and improve the chances of reliable data retrieval (Copp, 2004).

The International Working Group on Taxonomic Databases (TDWG) is a non profit scientific and educational association, affiliated to the International Union of Biological Sciences (IUBS), formed to establish international collaboration on development, and promotion of guidelines for the recording and exchange of data about organisms. Observational Data Subgroup of TDWG is responsible to incorporate observation-based monitoring of biological organisms data into existing federation mechanisms of the bioinformatics community. A potential outcome of this subgroup is to develop a rich description standard for observational and monitoring data. Global Biodiversity Information Facility (GBIF) is the biggest existing network about biodiversity data, and therefore has great interest in having a single standard protocol to search and retrieve data from different data providers. Protocols that resulted in TDWG have been funded by GBIF.

During the biodiversity surveys observations take place through the data collection events. According to TDWG an Observation refers to the documentation or measurement of an occurrence (e.g. the occurrence of a particular taxon at a given location). They can be documented in many ways, but typically observational data refers to location and other information derived from sources other than museum voucher collections. Observational data often include attributes beyond location, such as relative or absolute abundance, extent of occurrence, demographic, ecological associates, and environmental conditions.

PWI data model incorporates core data elements, defined by Observational Data Subgroup, into its database. The core attributes include:

- What - identification of the observed entity / taxon identification attributes
- Who - observer / collector of the information
- When- observation / collection event date / time
- Where - location attributes
- How - survey methods / intensity / protocol
- Evidence– documentation attributes (specimens, references, images)
- Biology - associated biological attributes
- Environment - associated environmental attributes

The above core data elements will provide a framework for the diverse disciplines involved in biodiversity surveys to work under similar standards. All the primary components including Survey, Survey event, people, location, observation and taxon with their defined relationship are incorporated into the model (Fig 2). Inclusion of this model into PWI data model will be useful for analyzing the distribution of organisms and explanation of ecological patterns.

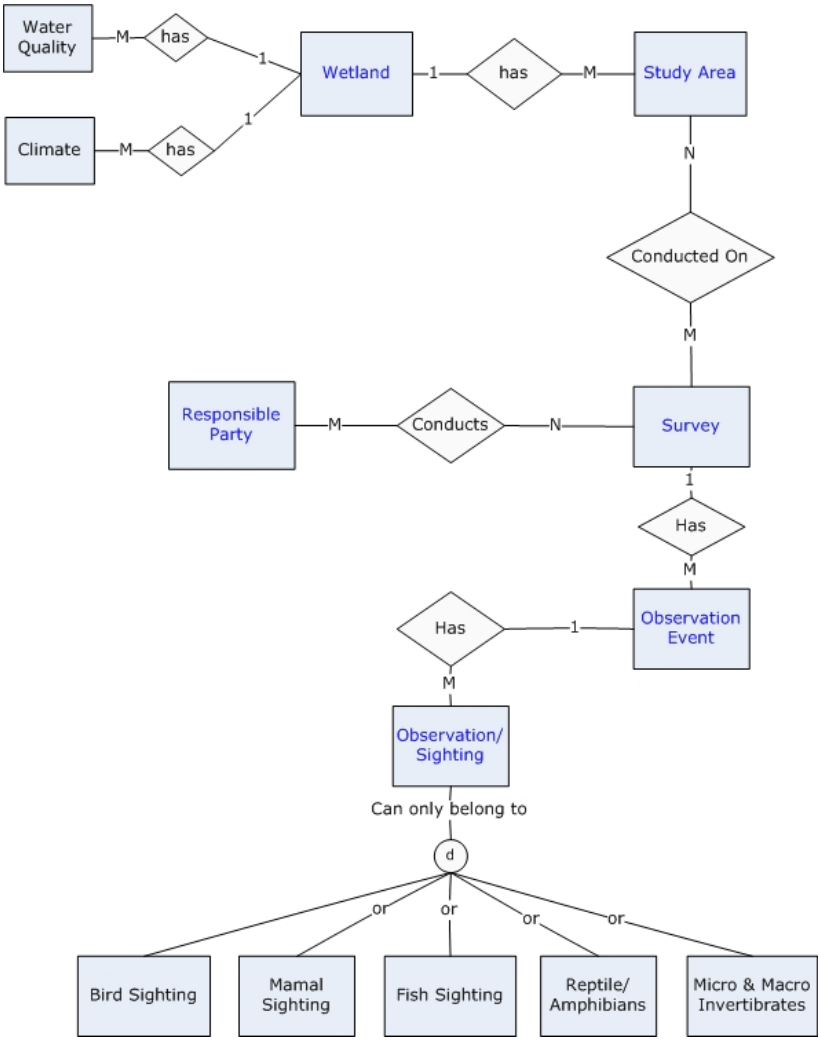

Figure 2: Object Relation Diagram explaining Biological Survey.

Cardinalities:

- One wetland can have one or more than one study area(s)
- Survey(s) conducted on study area(s)
- Res. Party [(individual(s) or organization(s)] conduct survey(s)
- Observation Event(s) [Transact or Fixed point estimation] took place in a Survey event
- Observation(s) will belong to a particular species (taxa)

2.1 Standardised Data Encoding Forms

"A Survey is a coordinated effort to gather presence/absence and possibly other information on taxa or communities within a defined area". PWP's Wetlands Survey Programme Section is conducting surveys to establish baseline information on wetlands conditions. As mentioned above in Section-2 a systematic collection and compilation of field data is critical to analyze and compare data collected in two different times for a particular area. Development of standard data encoding forms for field staff is one of the tools to maintain the standards and consistency in field data collection.

Data encoding forms include eight thematic forms including Birds, Mammal, Fish, Micro & Macro Invertebrates, Reptiles and Amphibians, Vegetation, Water Quality and one Observation Event Descript. Survey Forms used by various experts involved in "Environmental Baseline Survey and Monitoring for Taunsa Barrage Emergency Rehabilitation and Modernization Project" were thoroughly studied for this activity. Observation Event Description form is designed to capture general environmental conditions and it is mandatory to fill-up this form prior to any particular survey activity i.e., Transact or Fixed point estimation. The goal of this activity is to collect and describe biodiversity data in a standardised way however this does not intend to describe all data fields of every biodiversity data collection activity.

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Observation Event Description Form

Page __/___

Survey Title: _____

Study Area Name: _____
Survey Subject: _____
Survey Date: _____ (DD/MM/YY)
Surveyor(s): _____

Topography:
Slope: ☐ Flat ☐ Low ☐ Moderate ☐ High
Aspect: ☐ N ☐ NE ☐ E ☐ SE ☐ S ☐ SW ☐ W ☐ NW
Altitude: _____ (Min/Max)

Weather Conditions:
☐ Sunny ☐ Partly Cloudy ☐ Cloudy ☐ Rain
Temperature: _____°C
Visibility: ☐ Hazy ☐ Clear

Survey Method:
☐ Transact method ☐ Fixed point estimation ☐ Other_____
Transact/Sampling Point Number: _____
GPS:
Starting point N_____ E_____
Finishing point N_____E_____
Time:
Starting time: _____ Finishing time: _____

Primary Habitat type:
☐ Aquatic ☐ Terrestrial ☐ Submerged zone ☐ Other_____
Specific Habitat:
☐ Marshes ☐ Bog/Fens ☐ Swamp ☐ Riparian ☐ Peat ☐ Open Water
☐ Rocky surface ☐ Grassland ☐ Shrubs ☐ Forest ☐ Agriculture
☐ Desert
☐ Other_____

Threats/Problems:
☐ Hunting ☐ Harvesting ☐ Grazing ☐ Drainage ☐ Plant pests
☐ Animal pest ☐ Erosion ☐ Mining ☐ Development
☐Other_____

Assets/Opportunities:
☐ Wildlife species ☐ Endemism ☐ Potential habitat ☐ Ecotourism potential
☐Other_____

OTHERS:
_____
_____
_____

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Data Recording Sheet
Birds Survey

Page ___/___

Date: _____

☐ Transect method ☐ Fixed point estimation ☐ Other_____

Transect/Sampling Point Number: _____

Starting time: _____ Finishing time: _____

Direction: _____ Distance Covered: _____ (If transect)

Surveyor(s): _____

Sr. no.	Common name	Scientific Name	GPS		No. of Individuals seen	Vegetation type	Comments
			N	E			

Notes: _____

Page ___/___

Data recording sheet
Mammals

Date: _____ ☐ Transect method ☐ Fixed point estimation ☐ Other_____

Transect/Sampling Point Number: _____

Starting time: _____ Finishing time: _____

Direction: _____ Distance Covered: _____ (If transect)

Surveyor(s): _____

Sr. no.	Common Name	Scientific Name	GPS		Number of individuals seen		Indirect sign	Foot print measurement	Comments
			N	E	Adult	Young			

Indirect Signs: Hair, scales, scats/dung, foot prints/tracks, Vocalization

Notes: _____

_____

Page ___/___

Data recording sheet
Fishes

Date: _____ ☐ Transect method ☐ Fixed point estimation ☐ Other_____

Transect/Sampling Point Number: _____

Starting time: _____ Finishing time: _____

Direction: _____ Distance Covered: _____ (If transect)

Surveyor(s): _____

Sr. no.	Common Name	Scientific Name	GPS		Number Caught	Number seen but not caught	Total Number	Comments
			N	E				

Notes: _____

_____

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Data recording sheet
Reptiles & Amphibians

Date: _____ ☐ Transect method ☐ Fixed point estimation ☐ Other_____

Transect/Sampling Point Number: _____

Starting time: _____ Finishing time: _____

Direction: _____ Distance Covered: _____ (If transect)

Surveyor(s): _____

Sr. no.	Common Name	Scientific Name	GPS		Number of individuals seen				Search Method (V, N, T)	Comments
			N	E	Adult	Imm	Larva	Egg		

Search Method: Visual, Netting, Torchlight

Notes: _____

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Data recording sheet
Macro & Micro Invertebrates

Page ___/___

Date: _____
Time: _____
Sampling Point Number: _____
Coordinates (GPS): N_____E_____
Surveyor(s): _____

Habitat Type: _____ (Pond, Lake, River Channel)

Aquatic Vegetation: ☐ Rooted emergent ☐ Submerged Floating
☐ Rooted floating ☐ Free floating ☐ Attached algae ☐ Other_____

Macro Invertebrates

Species	No. of Individuals

Macro Invertebrates

Species	No. of Individuals

Page ___/___

Data recording sheet
Water Quality Monitoring

Date: _____
Time: _____
Sampling Point Number: _____
Coordinates (GPS): N_____E_____
Surveyor(s): _____

Habitat Type: _____ (Pond, Lake, River Channel)

Aquatic Vegetation: ☐ Rooted emergent ☐ Submerged Floating
☐ Rooted floating ☐ Free floating ☐ Attached algae ☐ Other_____

Water Quality Monitoring

Temperature: _____ Salinity: _____ pH: _____ Dissolved Oxygen: _____ Electrical Conductivity: _____
Turbidity: _____ Other: _____

Page ___/___

Data Recording Sheet
Vegetation Survey

Transact/Sampling Point Number: _____
Coordinates (GPS): N_____E_____
Soil Type: _____
Grazing Condition: _____
Quadrate Type_____

Dominant Vegetation:
Grasses: _____
Herbs: _____
Shrubs: _____
Trees: _____

Sr. No.	Common Name	Scientific Name	No.	Type G/H/S/T	Comments

(G: Grasses, H: Herbs, S: Shrubs, T: Trees)

Notes:
_____

_____

2.1.1 Data dictionary for Data Encoding Forms

Table 1: Observation Event Description Form Data Dictionary

Field Name	Description	Sample values
Survey Title	Survey of significant wetlands of Pakistan.	Survey of significant wetlands of Pakistan.
Study Area Name	The name of the study area being surveyed.	Bela
Date	The day/month/year (DD/MM/YY) on which the data on the form were gathered in the field. e.g. 10/03/2007.	10/03/2007
Surveyor(s)	The names of the people conducting the survey. The full name is required in a sequence e.g. last name, First name.	Ali, Hassan.
Survey Method	Method used for survey.	Transect method
Transact/Sampling Point Number	Mention the transect number or sampling point or observation event number. e.g. 1, 2, 3, 4…..	1
GPS	Coordinates from GPS-Receiver. Format should be Degree Decimal (DD).	N30.53931 E71.75522
Distance Covered	The distance from the start to the end point of the transect (km).	
Time Start/End	The time at which surveying the specified event starts and finishes.	6:15 A.M
Topography	Recording of different aspect of the surface, and the identification of specific landforms.	
Slope	Describe the measurement of the steepness, incline, and gradient.	Flat or High or Low
Aspect	Direction to which a mountain slope faces.	E, W, S, N
Altitude	Elevation of observation point from a known level.	715m
Weather Conditions	Type of general weather conditions either sunny, cloudy, rainy weather etc.	Sunny
Temperature	The temperature at the start of the survey (degrees Celsius).	15 ^{o}C
Visibility	Visibility conditions either clear of hazy.	Clear
Primary Habitat Type	Habitat type of the survey area e.g. aquatic, barren, forested etc.	Forested
Habitat Description	Describe the specific habitat of the study area. Convey a mental image of the habitat and its features including: land forms, aquatic features, vegetation, soils, associated plant and animal species, natural disturbances etc.	
Riparian/Substrate Description	Trees, Shrubs grasses etc. present at the riparian zone of the aquatic body (Riparian vegetation)	Optional
Threats/Problems	Identify threats/problems of the study area or to species etc.	Over grazing

Assets/Opportunities	Identify assets/opportunities of the study area such as such as intact habitat, wildlife species, endemism, and eco-tourism potential.	
Others	Additional information that may be relevant to the observation	Optional

Table 2: Thematic Data Recording Sheets Data Dictionary

Field Name	Description	Sample velue
Common Name	Common name of the species observed.	Little Egret
Scientific Name	Scientific name of the species observed.	*Egretta garzetta*
No. of Individuals seen	Number of individuals of a species sighted	10
Vegetation Type	Type of vegetation to or around the observation is made.	Aquatic vegetation
Indirect Sign	Observation made other than direct sighting by hair, scales, scats/dung, foot prints/tracks, Vocalization	Foot prints
Foot print Measurement	Measurement of the foot impression of the indirectly sighted species.	
Number Caught	Number of individuals of a fish species captured	20
Number seen but not caught	Number of individuals of a fish species sighted without capturing.	2
Dominant Vegetation	Dominant vegetation type of the study area.	*Acacia modesta,* Santha.
Soil Type	Type of soil of the study area	Sandy loam
Grazing Condition	Heavy grazing, moderate, low grazing or no grazing.	Moderate grazing
Quadrate Type	Type of Quadrate used for assessment	20X20m

3 Metadata Database

Spatial datasets are one of the most essential components of the Pakistan Wetlands Inventory. A national level database may contain thousands of datasets collected from various sources from all around the country. A particular analysis/study may require e.g., 50 datasets covering the same geographic region but compiled by different people/organizations. In such situations the analyst essentially needs to know about "what, when, who, where and how" of the data i.e. the Metadata.

Metadata is the data about data; a common example of metadata that provides information about the publisher and publication date, scale, accuracy, datum and other characteristics of the map.

What: Title and description of the dataset. (Topic)

When: When the dataset was created and the update cycle. (Date or period)

Who: Dataset originator or creator and provider. (Point of contact)

Where: The geographical extent of the data set based on lat / long coordinates (spatial extent), geographical names or administrative areas. (Specific place)

How: How to obtain more information about the set, available formats, access constraints etc.

Answers to questions like: Is best suited data available particular to my study, is it accurate up to my requirements, is it latest one available, require a good understanding of data. In case of personnel change in any organization or institution undocumented data can lose their value. Subsequent workers may have little understanding of the content and usage of the data. Metadata is required for a range of purposes which include and are not limited to the following:

- Metadata supports producers in locating and using their own data resources and data consumers in locating and using data resources produced by others.
- Provides with information of the content, quality and geographic extent of datasets so potential users of existing data can assess its suitability for their own purposes.
- Information about projection specifications, scale, exchange format, compression and file system format that should accompany data transfers to other organizations.
- Summary descriptions of content and quality, as well as contact information that are required for accessing datasets.

3.1 Benefits of Metadata

Data Archive: Data are the most expensive component of a GIS. Metadata is a means of preserving the value of data investments. This is of particular significance to local and regional governments experiencing rapid staff changes.
Data Assessment: GIS data development has shifted form data producers to data consumers. From a consumer perspective, metadata is the truth in labeling required to assess available data products. From the producer's perspective, metadata is a means of declaring data limitations and serves as a form of liability insurance.

Data Management: Metadata enables organizations to retrieve in-house data resources by specific criteria for global edits and annual updates.
Data Discovery: Metadata is the primary means of locating available geospatial data resources. Metadata is a primary public information resource as it is a non-technical means of presenting technical information.
Data Transfer: Metadata is increasingly used by software systems as a means of consumption and by analysts as a means of properly displaying data.
Data Distribution: By building metadata in compliance with national standards, it facilitates participation in the Global Spatial Data Clearinghouse. Participation promotes organization and frees staff from answering data inquiries.
Reduced Data Management Workload: Metadata contain information that can be used to quickly locate and retrieve data resources by specific criteria including: keywords, time period, contacts, data type, entities and attributes, etc
Fewer Inquiries as to Data Availability and Content: Most of the information required by data consumers to locate, evaluate, access, and ingest available data resources is contained within the metadata. As a result, data developers/managers are faced with fewer and more specific data inquiries.
Document Personal Contributions: The initial metadata record produced for a given data set establishes the core content that will persist, with updates, for the life of the data set. This provides data developers, an opportunity to document their efforts and contributions and serves as a tangible performance indicator that may be incorporated into organizational and individual evaluations.

3.2 Spatial Metadata Standards

The more standardized the structure and content of information, the more effectively it can be used by both humans and machines. A metadata standard is simply a common set of terms and definitions that are presented in a structured format. As we move into the age of spatial data infrastructures, knowledge about data is essential, allowing users to locate, evaluate, extract, and employ geospatial data. Diverse communities with a common understanding of metadata will be able to manage, share, and reuse each other's geographic data, making global interoperability a reality. Currently there are two major standards in handling spatial data which are described below:

3.2.1 FGDC

The Content Standard for Digital Geospatial Metadata (CSDGM) is the US Federal Metadata standard. The Federal Geographic Data Committee originally adopted the CSDGM in 1994 and revised it in 1998. According to Executive Order 12096 all Federal agencies are ordered to use this standard to document geospatial data created as of January, 1995. The standard is often referred to as the FGDC Metadata Standard and has been implemented beyond the federal level with State and local governments adopting the metadata standard as well.

3.2.2 ISO 19115 standard

The Technical Committee TC211 of the International Standard Organization has prepared an ISO19100 series of normative documents concerning geographic information. In this context, the ISO19115 standard (ISO, 2002) defines an extensive set of general-purpose metadata elements which provide information on the "what, when, who, where and how" of geographic datasets. More than 400 metadata elements are available to accommodate appropriate

information to characterize datasets properly so that users are enabled to discover them with search engines and determine whether data in a holding will be of use to them. Mandatory and conditional element of the dataset are given below in the Table 3.

Table 3: ISO 19115 Core Metadata Elements

Mandatory Elements(M)	Conditional Elements(C)
Dataset title Dataset reference date Dataset language Dataset topic category Spatial Resolution of Dataset Abstract Metadata point of contactMetadata date stamp	Dataset responsible party Geographic location by coordinates Dataset character set Distribution format Spatial representation type Reference system Lineage statement On-line resource Metadata file identifier Metadata standard name Metadata standard version Metadata language Metadata character set

3.2.3 PWI Metadata Schema

A metadata schema for Pakistan Wetlands Inventory has been defined according to ISO 19115 standards (Figure 3). This schema necessarily includes the mandatory elements of core metadata of ISO 19115. The packages included metadata entity information, identification information, reference system information, spatial representation information, Extent information, data quality, constraint information and content information.

Why ISO 19115: Although the FGDC and ISO 19115 content standards were developed at separate times with different goals, the nature of geospatial metadata is such that certain terms or concepts used to describe the data are invariably used no matter what the standard is. As such, many metadata fields in the FGDC-CSDGM may be considered to be similar or parallel to fields that have been identified for ISO 19115. ISO 19115 provides a clear procedure for description of digital geographic datasets so that user of the data can know characteristics of the data they are holding or accessing. More than 400 metadata elements are available to accommodate appropriate information to characterize datasets properly. In addition to mandatory metadata elements there is a support to incorporate additional elements necessary for characterization of the datasets.

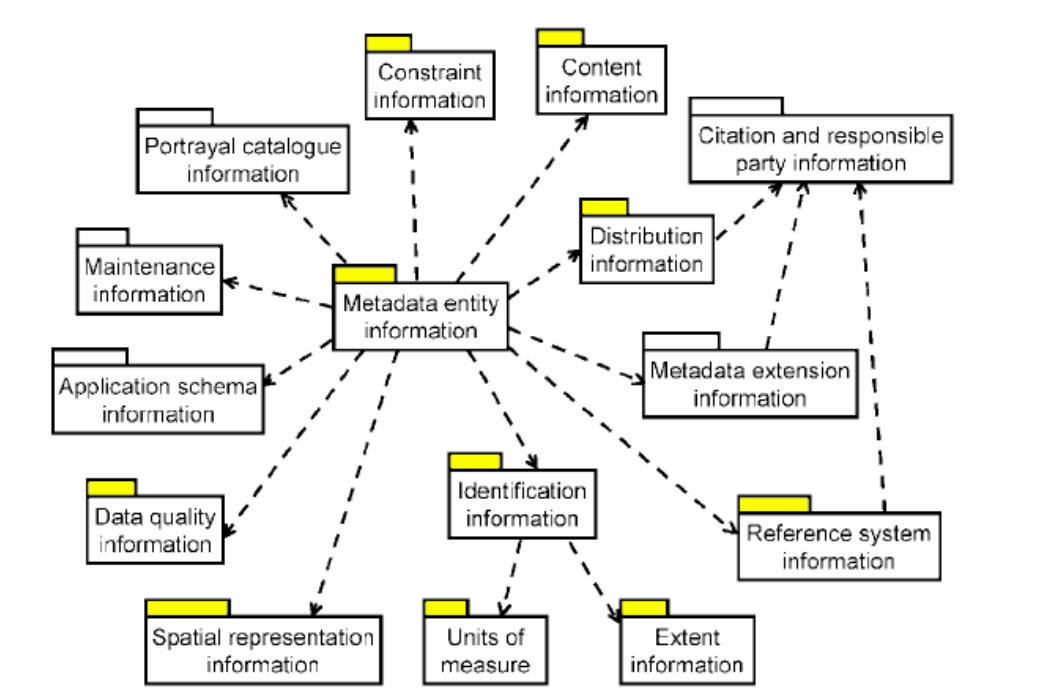

Figure 3: ISO 19115: 2003 metadata packages (the elements incorporated in PWI data model are marked in yellow).

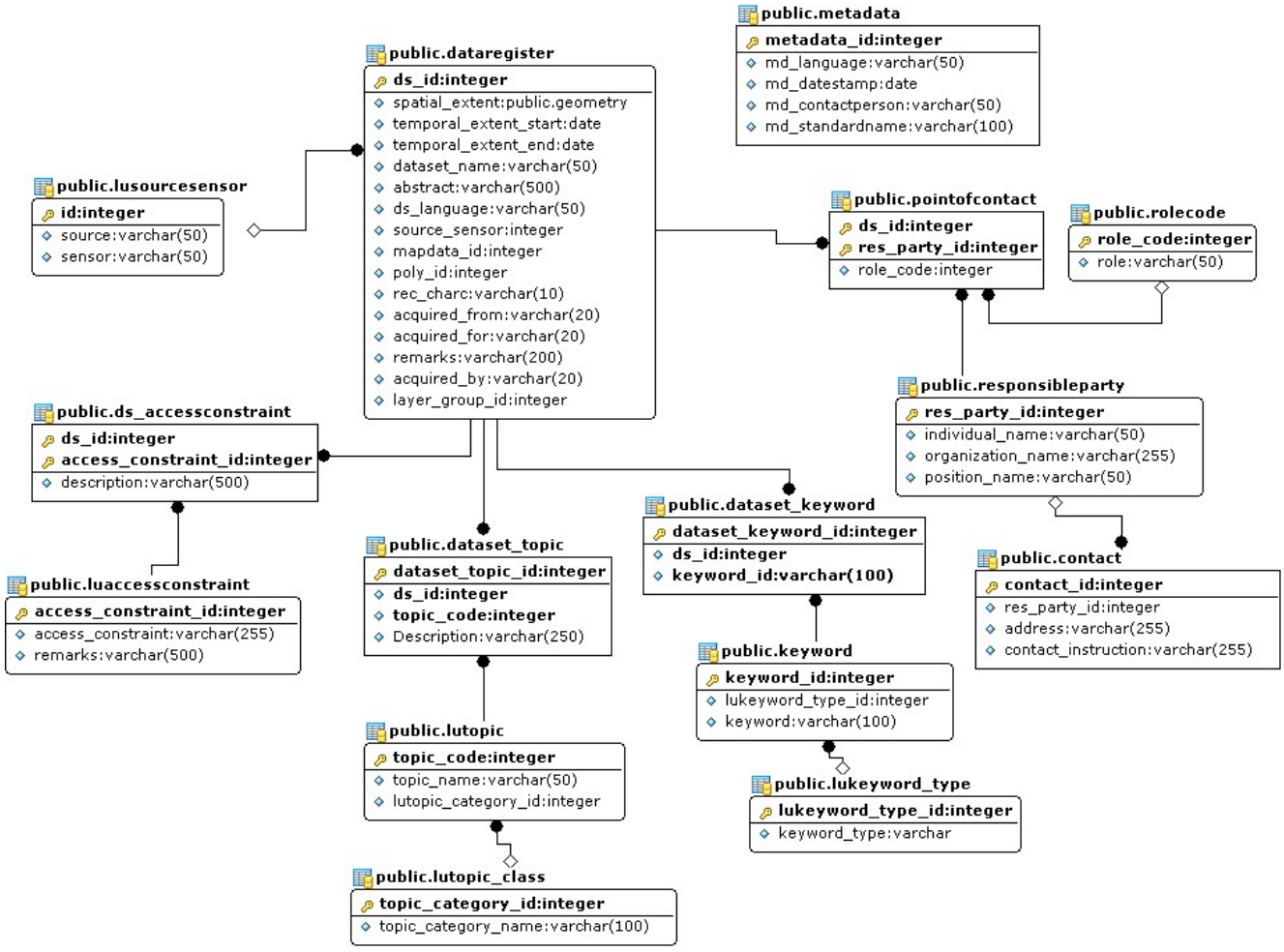

Figure 4: ERD Diagram of Metadata component

4 Pakistan Wetlands Inventory Relational Database

4.1 PWI Data Model

National wetlands inventories are developed to map the extent and characteristics of wetlands as country level database. Pakistan Wetlands Inventory (PWI) is being developed, aims to promote the sustainable conservation of freshwater and marine wetlands and associated important biodiversity.

GIS-based Wetlands Inventory of Pakistan is being developed as part of the Pakistan Wetlands Programme. Taking into account the Programme structure and inventory needs three main components, environmental characteristics of the Wetlands, time-series biological survey observations collected through field surveys and spatial datasets related to wetlands generated through massive GIS data building activity were identified(Qamer, 2007). Standardised data models for these three components, were studied respectively *A Manual for Asian Wetlands Inventory*, *Observational Data Standards by Taxonomic Database Working Group* and *Geograpic Information – Metadata ISO 19115* (Finlayson et al, 2002; TDWG, 2006; ISO, 2002;). In addition, Ramsar Information Sheet (RIS) was thoroughly studies to accommodate all socio-ecological parameters necessary for wetlands evaluation. A comprehensive database, PWI data model, was designed by modifying and integrating them together to serve the specific needs of the inventory (Figure 5).

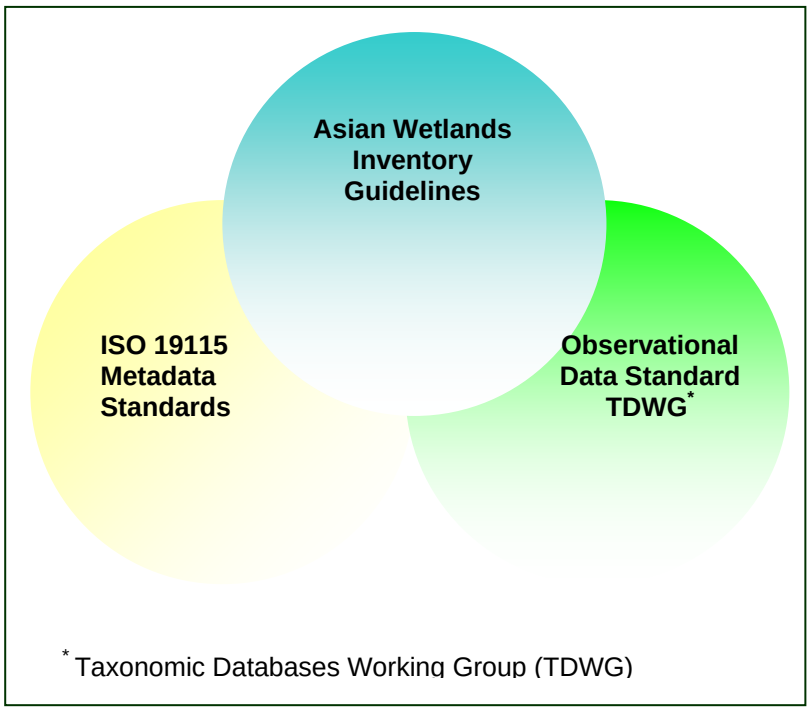

Figure 5: Reference studies integrated into PWI data model.

Current PWI data model incorporate the systematic gathering of field obsevations under the PWP's Wetlands Surveys Programme Section (WSPS). The model can effectively store information gathered from multiple survey events at different wetland sites (locations) involving various partner organizatons.

4.2 PWI Data Dictionary

PWI data model is a logical model to assimilate all the information produced by the *Wetlands Survey Programme* and *Pakistan Wetlands GIS* during their respective data buiding activity.

Firstly, the model is describle through data flow diagram of core components which illustrate the interaction between the components. A textual explaination of each component is given in paragraphs below. Further, a list of entities is given in Table 4 and a comprehensive ERD diagram is given in Figure 7.

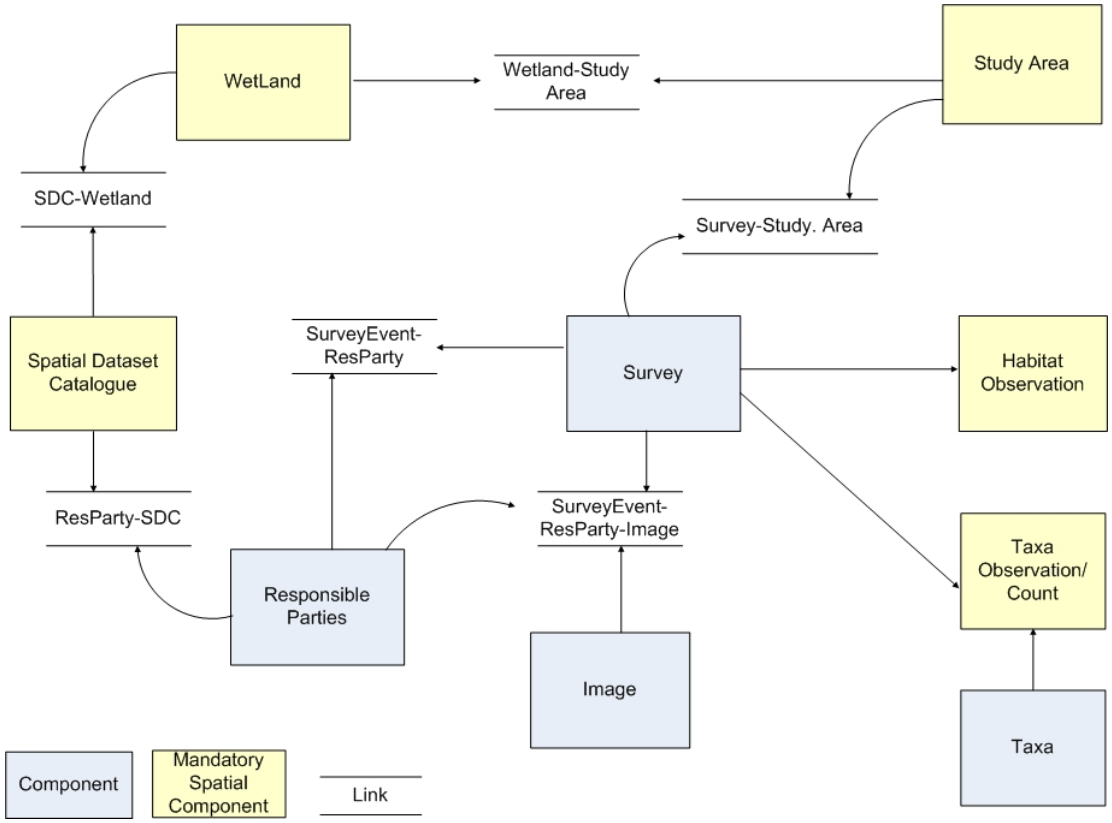

Figure 6: Overview diagram showing the main components of the model.

4.2.1 Wetlands

This part of the model contains information about wetlands and their respective environmental and climatic parameters which mainly include unique identification, name, boundary, wetlands classification and climatic conditions.

4.2.2 Spatial Dataset Catalogue

This part provides the means to track the information about the spatial datasets acquired or generated during the study by the responsible parties. These datasets may include satellite images, paper maps, digitized vector data, digital elevation models etc. A comprehensive ISO 19115 metadata standard will be coupled with this component to keep the track of quality, extent (temporal and spatial), resolution, accuracy, constraints etc of the dataset.

4.2.3 Responsible Party

This component will keep track of a person, organization, or a platform that performs actions in PWGIS activities. These may include authors, owners, and participants in events etc.

4.2.4 Study Area

A geographical map-able location that is location of Survey event (transact or fixed point counting). Sites are usually expressed verbally with relation to geographically stable points or reference (i.e., towns, mountains, roads, etc) and ideally a site should be expressible in term of Geo coordinates (either as point, or line, or polygon). This component will also include Geometric Location table which will necessarily consist of geo-coordinated locations about objects, observations and boundaries and will be stored in spatial database as feature.

4.2.5 Survey Event and Observation

These two parts collectively keep the track of the biological observations. The survey event includes information time and location that an observation took place and the information about the people who were involved. This means many observations can take place in a single survey event. Spatial locations can be recorded both for the survey event and can be stored in table of Geometric Location in location component. Observation will include habitat observation and taxa observation/count. Habitat observation is description of physical and biotic environment at the time and place of observation and taxa observation is identification of species from systematic index both for fauna and flora.

4.2.6 Taxa

Grouping of organisms given a formal taxonomic name such as species, genus, family. A comprehensive list of Taxa of Pakistan will be compiled in an inhouse exercise.

4.2.7 Image

This is photo databank which keeps track of photo, sketch or movie taken during a particular survey event at a particular location (site) with its contributing transactor’s information.

4.3 Database Schema

4.3.1 Tables Description

Table 4: List of Relational Data Tables of Integrated Database

Table	Description
Contact	Stores the contact information of a particular responsible party.
DataRegister	Table that stores information about datasets from different partner organizations (Responsible Parties)
dataregister_wetland	Relates a DataRegister to a wetland or more than one wetlands
dataset_keyword	Contains information that describes the keyword describing the content of a dataset.
dataset_topic	Contains information that describes the subject or content of a dataset.
ds_accessconstraint	Access constraints applied to assure the protection of privacy or intellectual property, and any special restriction or limitation on obtaining the resource.
imagelibrary	Contains information about digital images taken in a survey.
imagelibrary_surveyevent_resparty	Relates the image library to a survey event and a responsible party which is having or contributing the digital image.
keyword	Lookup table containing keywords about a dataset.
luaccessconstraint	List of access constraints or access levels.
lukeyword_type	
lulayergroup	List of GIS layer groups.
lusourcesensor	
lutopic	List of topics Helps in categorizing the datasets.
lutopic_class	
metadata	Root entity which defines metadata about a resource or resources.

Table	Description
observation	Characterizes the evidence for the presence or absence of an organism or set of organisms through a data collection event at a location. It stores the what, where, when, how, how of biological observation.
observation_event	Observation Event(s) take place in a Survey event. Observation Event can be Transact or Fixed point estimation.
pointofcontact	Dataset participating with the role code. Storing responsible parties with their roles on specific datasets.
referencesystem	
resparty_surveyevent	Relates a responsible party with a survey event.
responsibleparty	A person, organization, or a platform that performs actions in PWP survey activities. Responsible party is an individual or an organization.
rolecode	
study_area	A geographical, map able location. Study Area is usually expressed verbally with relation to geographically stable points or reference. Wetland can spread over a very large area. Wetland can consist of more than one specific environment (study areas).
survey	A coordinated effort to gather presence/absence and possibly other information on taxa or communities within a defined area.
surveyevent_study_area	Relates the surveyevent with study area.
taxa	Stores the information about species like CommonName, Genus, Scientific Name, Class, Order, Family etc
taxaalternatename	Stores the alternative specie Names. One specie can have more than one alternative names.

Table	Description
wetland	Stores information about general characteristics of wetland and connects other components of the system.
wetland_climate	Containing climatic information about a specific wetland in a specific year. Stores information like average rainfall, average temperature, climate type etc.
wetland_water_quality	Containing water quality parameters specific to wetland at different point locations (Lat, Long). Stores information like ph, contamination, sedimentation, conductivity, disolved oxygen, turbidity etc

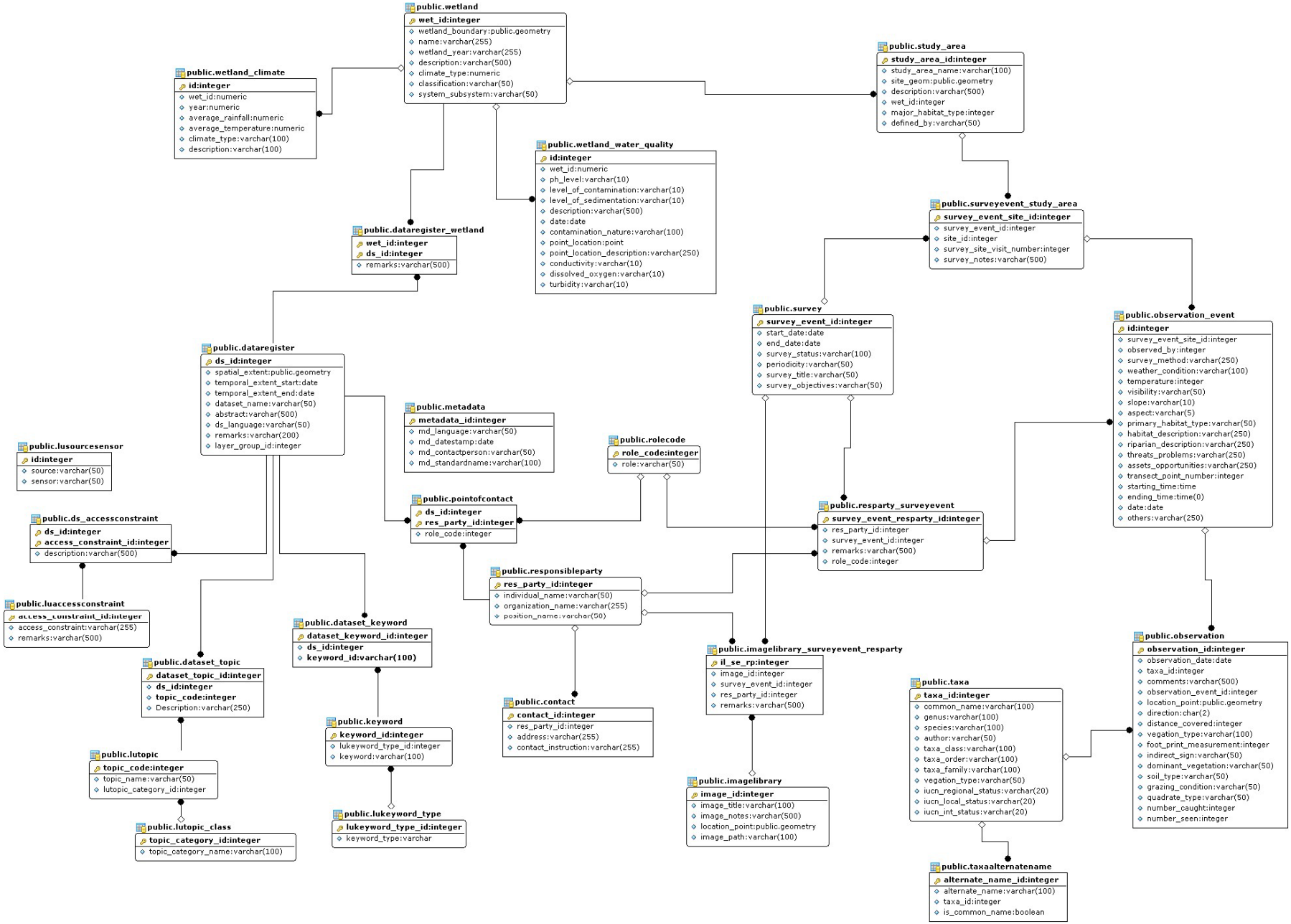

Figure 7: ERD Diagram of PWI data model

4.3.2 Tables Structure

Table: contact

Descriptions

Stores the contact information of a particular responsible party.

Fields

PK	FK	Name	Data type	Description
✓		contact_id	integer	Auto generated Id
	✓	res_party_id	integer	Foreign Key from Responsible Party, identifying the detailed contact information.
		address	varchar(255)	Complete postal Address of Responsible Party
		contact_instruction	varchar(255)	Instructions about the Responsible party's contact.

Definition

```
CREATE TABLE "public"."contact" (
  "contact_id" SERIAL,
  "res_party_id" INTEGER,
  "address" VARCHAR(255),
  "contact_instruction" VARCHAR(255),
  CONSTRAINT "Contact_pkey" PRIMARY KEY("contact_id"),
  CONSTRAINT "Contact_fk" FOREIGN KEY ("res_party_id")
    REFERENCES "public"."responsibleparty"("res_party_id")
    ON DELETE NO ACTION
    ON UPDATE NO ACTION
    NOT DEFERRABLE
) WITHOUT OIDS;
```

Table: DataRegister

Descriptions

Table that stores information about datasets from different partner organizations (Responsible Parties)

Fields

PK	FK	Name	Data type	Description
✓		ds_id	integer	Auto generated id
		spatial_extent	public.geometry	Boundary enclosing the dataset expressed as a closed set of geographic coordinates (latitude, longitude) of the polygon.

		temporal_extent_start	date	Starting date for the content of the dataset.
		temporal_extent_end	date	Ending date for the content of the dataset.
		dataset_name	varchar(50)	The ordinary name of the dataset.
		abstract	varchar(500)	A brief narrative summary of the content of the dataset.
		ds_language	varchar(50)	Language of the Dataset.
		remarks	varchar(200)	
	✓	layer_group_id	integer	

Definition

```
CREATE TABLE "public"."dataregister" (
  "ds_id" SERIAL,
  "spatial_extent" "public"."geometry",
  "temporal_extent_start" DATE,
  "temporal_extent_end" DATE,
  "dataset_name" VARCHAR(50),
  "abstract" VARCHAR(500),
  "ds_language" VARCHAR(50),
  "remarks" VARCHAR(200),
  "layer_group_id" INTEGER,
  CONSTRAINT "datasetextent_pkey" PRIMARY KEY("ds_id"),
  CONSTRAINT "enforce_dims_dataset_geom" CHECK (ndims(dataset_geom) = 2),
  CONSTRAINT "enforce_geotype_dataset_geom" CHECK ((geometrytype(spatial_extent) =
'MULTIPOLYGON'::text) OR (spatial_extent IS NULL)),
  CONSTRAINT "enforce_srid_dataset_geom" CHECK (srid(dataset_geom) = -1),
  CONSTRAINT "dataregister_fk1" FOREIGN KEY ("layer_group_id")
    REFERENCES "public"."lulayergroup"("layer_group_id")
    ON DELETE NO ACTION
    ON UPDATE NO ACTION
    NOT DEFERRABLE
) WITHOUT OIDS;
```

Table: dataset_keyword

Descriptions

Contains information that describes the keyword describing the content of a dataset.

Fields

PK	FK	Name	Data type	Description
✓		dataset_keyword_id	integer	Auto generated identifier
	✓	ds_id	integer	FK. Dataset to be attached with the keyword

	✓	keyword_id	varchar(100)	FK. The keyword, attached with the Dataset.

Definition

```
CREATE TABLE "public"."dataset_keyword" (
  "dataset_keyword_id" SERIAL,
  "ds_id" INTEGER NOT NULL,
  "keyword_id" VARCHAR(100) NOT NULL,
  CONSTRAINT "dataset_keyword_pkey" PRIMARY KEY("dataset_keyword_id"),
  CONSTRAINT "dataset_keyword_fk" FOREIGN KEY ("ds_id")
    REFERENCES "public"."dataregister"("ds_id")
    ON DELETE NO ACTION
    ON UPDATE NO ACTION
    NOT DEFERRABLE,
  CONSTRAINT "dataset_keyword_fk1" FOREIGN KEY ("keyword_id")
    REFERENCES "public"."keyword"("keyword_id")
    ON DELETE NO ACTION
    ON UPDATE NO ACTION
    NOT DEFERRABLE
) WITH OIDS;
```

Table: dataset_topic

Descriptions

Contains information that describes the subject or content of a dataset.

Fields

PK	FK	Name	Data type	Description
✓		dataset_topic_id	integer	FK. Topic ID from luTopic table.
	✓	ds_id	integer	FK. From dataregister table
	✓	topic_code	integer	FK. From topic table.
		Description	varchar(250)	Description of dataset topic.

Definition

```
CREATE TABLE "public"."dataset_topic" (
  "dataset_topic_id" SERIAL,
  "ds_id" SERIAL,
  "topic_code" INTEGER NOT NULL,
  "Description" VARCHAR(250),
  CONSTRAINT "dataset_topic_pkey" PRIMARY KEY("dataset_topic_id"),
  CONSTRAINT "dataset_topic_fk" FOREIGN KEY ("ds_id")
    REFERENCES "public"."dataregister"("ds_id")
    ON DELETE NO ACTION
    ON UPDATE NO ACTION
    NOT DEFERRABLE,
  CONSTRAINT "dataset_topic_fk1" FOREIGN KEY ("topic_code")
    REFERENCES "public"."lutopic"("topic_code")
```

```
    ON DELETE NO ACTION
    ON UPDATE NO ACTION
    NOT DEFERRABLE
) WITH OIDS;
```

Table: ds_accessconstraint

Descriptions

Access constraints applied to assure the protection of privacy or intellectual property, and any special restriction or limitation on obtaining the resource.

Fields

PK	FK	Name	Data type	Description
✓	✓	ds_id	integer	
✓	✓	access_constraint_id	integer	
		description	varchar(500)	Description about access constraint on a specific dataset.

Definition

```
CREATE TABLE "public"."ds_accessconstraint" (
  "ds_id" INTEGER NOT NULL,
  "access_constraint_id" INTEGER NOT NULL,
  "description" VARCHAR(500),
  CONSTRAINT "DS_accessConstraint_pkey" PRIMARY KEY("ds_id",
"access_constraint_id"),
  CONSTRAINT "ds_accessconstraint_ds_id_key" UNIQUE("ds_id"),
  CONSTRAINT "DS_accessConstraint_fk" FOREIGN KEY ("ds_id")
    REFERENCES "public"."dataregister"("ds_id")
    ON DELETE NO ACTION
    ON UPDATE NO ACTION
    NOT DEFERRABLE,
  CONSTRAINT "DS_accessConstraint_fk1" FOREIGN KEY ("access_constraint_id")
    REFERENCES "public"."luaccessconstraint"("access_constraint_id")
    ON DELETE NO ACTION
    ON UPDATE NO ACTION
    NOT DEFERRABLE
) WITHOUT OIDS;
```

Table: imagelibrary

Fields

PK	FK	Name	Data type	Description
✓		image_id	integer	
		image_title	varchar(100)	Title or name of image. A small tag line describing

				content of image.
		image_notes	varchar(500)	Remarks about image.
		location_point	public.geometry	point location where image is taken.
		image_path	varchar(100)	Physical path of the image directory containing that image.

Definition

```
CREATE TABLE "public"."imagelibrary" (
  "image_id" SERIAL,
  "image_title" VARCHAR(100),
  "image_notes" VARCHAR(500),
  "location_point" "public"."geometry",
  "image_path" VARCHAR(100),
  CONSTRAINT "ImageLibrary_pkey" PRIMARY KEY("image_id")
) WITHOUT OIDS;
```

Table: keyword

Descriptions

Lookup table containing keywords about a dataset.

Fields

PK	FK	Name	Data type	Description
✓		keyword_id	integer	
	✓	lukeyword_type_id	integer	
		keyword	varchar(100)	

Definition

```
CREATE TABLE "public"."keyword" (
  "keyword_id" SERIAL,
  "lukeyword_type_id" INTEGER,
  "keyword" VARCHAR(100),
  CONSTRAINT "keyword_pkey" PRIMARY KEY("keyword_id"),
  CONSTRAINT "keyword_fk" FOREIGN KEY ("lukeyword_type_id")
    REFERENCES "public"."lukeyword_type"("lukeyword_type_id")
    ON DELETE NO ACTION
    ON UPDATE NO ACTION
    NOT DEFERRABLE
) WITH OIDS;
```

Table: lukeyword_type

Descriptions

There is no description for table lukeyword_type

Fields

PK	FK	Name	Data type	Description
✓		lukeyword_type_id	integer	
		keyword_type	varchar	

Definition

```
CREATE TABLE "public"."lukeyword_type" (
  "lukeyword_type_id" INTEGER NOT NULL,
  "keyword_type" VARCHAR,
  CONSTRAINT "lukeyword_type_pkey" PRIMARY KEY("lukeyword_type_id")
) WITH OIDS;
```

Table: lulayergroup

Descriptions

List of GIS layer groups.

Fields

PK	FK	Name	Data type	Description
✓		layer_group_id	integer	
		layer_group_name	varchar(50)	
		description	varchar(500)	

Definition

```
CREATE TABLE "public"."lulayergroup" (
  "layer_group_id" SERIAL,
  "layer_group_name" VARCHAR(50),
  "description" VARCHAR(500),
  CONSTRAINT "lulayergroup_pkey" PRIMARY KEY("layer_group_id")
) WITH OIDS;
```

Table: lutopic

Descriptions

There is no description for table lutopic

Fields

PK	FK	Name	Data type	Description
✓		topic_code	integer	

		topic_name	varchar(50)	
	✓	lutopic_category_id	integer	

Definition

```
CREATE TABLE "public"."lutopic" (
  "topic_code" SERIAL,
  "topic_name" VARCHAR(50),
  "lutopic_category_id" INTEGER,
  CONSTRAINT "topic_category_code_pkey" PRIMARY KEY("topic_code"),
  CONSTRAINT "lutopic_fk" FOREIGN KEY ("lutopic_category_id")
    REFERENCES "public"."lutopic_class"("topic_category_id")
    ON DELETE NO ACTION
    ON UPDATE NO ACTION
    NOT DEFERRABLE
) WITH OIDS;
```

Table: lutopic_class

Descriptions

There is no description for table lutopic_class

Fields

PK	FK	Name	Data type	Description
✓		topic_category_id	integer	
		topic_category_name	varchar(100)	

Definition

```
CREATE TABLE "public"."lutopic_class" (
  "topic_category_id" SERIAL,
  "topic_category_name" VARCHAR(100),
  CONSTRAINT "topic_category_pkey" PRIMARY KEY("topic_category_id")
) WITH OIDS;
```

Table: metadata

Descriptions

Root entity which defines metadata about a resource or resources.

Fields

PK	FK	Name	Data type	Description
✓		metadata_id	integer	
		md_language	varchar(50)	Language in which the metadata is stored.
		md_datestamp	date	Date on which the metadata record was created.

		md_contactperson	varchar(50)	The person or organization primarily responsible for the intellectual content of the resource.
		md_standardname	varchar(100)	Name of the metadata standard (including profile name) used

Definition

```
CREATE TABLE "public"."metadata" (
  "metadata_id" SERIAL,
  "md_language" VARCHAR(50),
  "md_datestamp" DATE,
  "md_contactperson" VARCHAR(50),
  "md_standardname" VARCHAR(100),
  CONSTRAINT "metadata_pkey" PRIMARY KEY("metadata_id")
) WITH OIDS;
```

Table: observation

Descriptions

Characterizes the evidence for the presence or absence of an organism or set of organisms through a data collection event at a location.

Fields

PK	FK	Name	Data type	Description
✓		observation_id	integer	
		observation_date	date	The day/month/year (DD/MM/YY) on which the data on the form were gathered in the field. e.g. 10/03/2007.
	✓	taxa_id	integer	
		comments	varchar(500)	
	✓	observation_event_id	integer	
		location_point	public.geometry	Coordinates from GPS-Receiver. Format should be Degree Decimal (DD) i.e. lat long e.g. N30.53931 E71.75522
		direction	char(2)	Direction of the observer. E, W, N, S, EW etc
		distance_covered	integer	The distance from the start to the end point of the transect (km).
		vegation_type	varchar(100)	Type of vegetation to or around the observation is made. e.g.

				Aquatic vegetation
		foot_print_measurement	integer	Measurement of the foot impression of the indirectly sighted species.
		indirect_sign	varchar(50)	Observation made other than direct sighting by hair, scales, scats/dung, foot prints/tracks, Vocalization
		dominant_vegetation	varchar(50)	Dominant vegetation type of the study area. e.g. Acacia modesta, Santha.
		soil_type	varchar(50)	Type of soil of the study area e.g. Sandy loam
		grazing_condition	varchar(50)	Heavy grazing, moderate, low grazing or no grazing.
		quadrate_type	varchar(50)	Type of Quadrate used for assessment e.g. 20X20m
		number_caught	integer	Number of individuals of a fish species captured
		number_seen	integer	Number of individuals of a fish species sighted without capturing.

Definition

```
CREATE TABLE "public"."observation" (
  "observation_id" SERIAL,
  "observation_date" DATE,
  "taxa_id" INTEGER,
  "comments" VARCHAR(500),
  "observation_event_id" INTEGER,
  "location_point" "public"."geometry",
  "direction" CHAR(2),
  "distance_covered" INTEGER,
  "vegation_type" VARCHAR(100),
  "foot_print_measurement" INTEGER,
  "indirect_sign" VARCHAR(50),
  "dominant_vegetation" VARCHAR(50),
  "soil_type" VARCHAR(50),
  "grazing_condition" VARCHAR(50),
  "quadrate_type" VARCHAR(50),
  "number_caught" INTEGER,
  "number_seen" INTEGER,
  CONSTRAINT "Observation_pkey" PRIMARY KEY("observation_id"),
  CONSTRAINT "observation_fk" FOREIGN KEY ("observation_event_id")
    REFERENCES "public"."observation_event"("id")
    ON DELETE NO ACTION
    ON UPDATE NO ACTION
    NOT DEFERRABLE,
```

```
  CONSTRAINT "taxaobservation_fk" FOREIGN KEY ("taxa_id")
    REFERENCES "public"."taxa"("taxa_id")
    ON DELETE NO ACTION
    ON UPDATE NO ACTION
    NOT DEFERRABLE
) WITHOUT OIDS;
```

Table: observation_event

Descriptions

Observation Event(s) take place in a Survey event. [Transact or Fixed point estimation]

Fields

PK	FK	Name	Data type	Description
✓		id	integer	
	✓	survey_event_site_id	integer	
	✓	observed_by	integer	
		survey_method	varchar(250)	Method used for survey. e.g. Transact method, fixed point method or other.
		weather_condition	varchar(100)	Type of general weather conditions either sunny, cloudy, rainy weather etc
		temperature	integer	The temperature at the start of the survey (degrees Celsius). Units: degree Centigrade
		visibility	varchar(50)	Visibility conditions either clear of hazy.
		slope	varchar(10)	Describe the measurement of the steepness, incline, and gradient. It can be Flat or High or Low or moderate.
		aspect	varchar(5)	Direction to which a mountain slope faces. e.g. E, W, S, N
		primary_habitat_type	varchar(50)	Habitat type of the survey area e.g. aquatic, barren, forested, Grass, shrub etc
		habitat_description	varchar(250)	Describe the specific habitat of the study area. Convey a mental image of the habitat and its features including: land forms, aquatic features, vegetation, soils, associated plant and animal species, natural disturbances etc.
		riparian_description	varchar(250)	Trees, Shrubs grasses etc. present at the riparian zone of the

				aquatic body (Riparian vegetation)
		threats_problems	varchar(250)	Identify threats/problems of the study area or to species etc. Information about Grazing, logging, mining, plantations, erosion, development etc
		assets_opportunities	varchar(250)	Identify assets/opportunities of the study area such as such as intact habitat, wildlife species, endemism, and eco-tourism potential.
		transect_point_number	integer	Mention the transect number or sampling point or observation event number. e.g. 1, 2, 3, 4…..
		starting_time	time	The time at which surveying the specified event starts.
		ending_time	time(0)	The time at which surveying the specified event ends.
		date	date	The day/month/year (DD/MM/YY) on which the data on the form were gathered in the field. e.g. 10/03/2007.
		others	varchar(250)	Additional information that may be relevant to the observation

Definition

```
CREATE TABLE "public"."observation_event" (
  "id" SERIAL,
  "survey_event_site_id" INTEGER,
  "observed_by" INTEGER,
  "survey_method" VARCHAR(250),
  "weather_condition" VARCHAR(100),
  "temperature" INTEGER,
  "visibility" VARCHAR(50),
  "slope" VARCHAR(10),
  "aspect" VARCHAR(5),
  "primary_habitat_type" VARCHAR(50),
  "habitat_description" VARCHAR(250),
  "riparian_description" VARCHAR(250),
  "threats_problems" VARCHAR(250),
  "assets_opportunities" VARCHAR(250),
  "transect_point_number" INTEGER,
  "starting_time" TIME WITHOUT TIME ZONE,
  "ending_time" TIME(0) WITHOUT TIME ZONE,
  "date" DATE,
  "others" VARCHAR(250),
  CONSTRAINT "HabitatObservation_pkey" PRIMARY KEY("id"),
  CONSTRAINT "habitatobservation_fk" FOREIGN KEY ("survey_event_site_id")
```

```
    REFERENCES "public"."surveyevent_study_area"("survey_event_site_id")
    ON DELETE NO ACTION
    ON UPDATE NO ACTION
    NOT DEFERRABLE,
  CONSTRAINT "habitatobservation_fk2" FOREIGN KEY ("observed_by")
    REFERENCES "public"."resparty_surveyevent"("survey_event_resparty_id")
    ON DELETE NO ACTION
    ON UPDATE NO ACTION
    NOT DEFERRABLE
) WITHOUT OIDS;
```

Table: pointofcontact

Descriptions

Dataset participating with the role code. Storing responsible parties with their roles on specific datasets.

Fields

PK	FK	Name	Data type	Description
✓	✓	ds_id	integer	
✓	✓	res_party_id	integer	
	✓	role_code	integer	

Definition

```
CREATE TABLE "public"."pointofcontact" (
  "ds_id" INTEGER NOT NULL,
  "res_party_id" INTEGER NOT NULL,
  "role_code" INTEGER,
  CONSTRAINT "PointOfContact_pkey" PRIMARY KEY("ds_id", "res_party_id"),
  CONSTRAINT "PointOfContact_fk" FOREIGN KEY ("ds_id")
    REFERENCES "public"."dataregister"("ds_id")
    ON DELETE NO ACTION
    ON UPDATE NO ACTION
    NOT DEFERRABLE,
  CONSTRAINT "PointOfContact_fk1" FOREIGN KEY ("res_party_id")
    REFERENCES "public"."responsibleparty"("res_party_id")
    ON DELETE NO ACTION
    ON UPDATE NO ACTION
    NOT DEFERRABLE,
  CONSTRAINT "PointOfContact_fk2" FOREIGN KEY ("role_code")
    REFERENCES "public"."rolecode"("role_code")
    ON DELETE NO ACTION
    ON UPDATE NO ACTION
    NOT DEFERRABLE
) WITHOUT OIDS;
```

Table: responsibleparty

Descriptions

A person, organization, or a platform that performs actions in PWP survey activities.

Fields

PK	FK	Name	Data type	Description
✔		res_party_id	integer	
		individual_name	varchar(50)	
		organization_name	varchar(255)	
		position_name	varchar(50)	

Definition

```
CREATE TABLE "public"."responsibleparty" (
  "res_party_id" SERIAL,
  "individual_name" VARCHAR(50),
  "organization_name" VARCHAR(255),
  "position_name" VARCHAR(50),
  CONSTRAINT "Responsibleparty_pkey" PRIMARY KEY("res_party_id")
) WITHOUT OIDS;
```

Table: study_area

Descriptions

A geographical, mapable location. Study Area is usually expressed verbally with relation to geographically stable points or reference.

Wetland can spread over a very large area.
Wetland can consist of more than one specific environments(study areas).

Fields

PK	FK	Name	Data type	Description
✔		study_area_id	integer	
		study_area_name	varchar(100)	The name of the study area being surveyed. e.g. Bela
		site_geom	public.geometry	Site Boundary.
		description	varchar(500)	
	✔	wet_id	integer	
		major_habitat_type	integer	
		defined_by	varchar(50)	

Definition

```
CREATE TABLE "public"."study_area" (
```

```
  "study_area_id" SERIAL,
  "study_area_name" VARCHAR(100),
  "site_geom" "public"."geometry",
  "description" VARCHAR(500),
  "wet_id" INTEGER,
  "major_habitat_type" INTEGER,
  "defined_by" VARCHAR(50),
  CONSTRAINT "Site_pkey" PRIMARY KEY("study_area_id"),
  CONSTRAINT "site_fk1" FOREIGN KEY ("wet_id")
    REFERENCES "public"."wetland"("wet_id")
    ON DELETE NO ACTION
    ON UPDATE NO ACTION
    NOT DEFERRABLE
) WITHOUT OIDS;
```

Table: survey

Descriptions

A coordinated effort to gather presence/absence and possibly other information on taxa or communities within a defined area.

Fields

PK	FK	Name	Data type	Description
✓		survey_event_id	integer	
		start_date	date	
		end_date	date	
		survey_status	varchar(100)	
		periodicity	varchar(50)	
		survey_title	varchar(50)	Survey of significant wetlands of Pakistan.
		survey_objectives	varchar(50)	

Definition

```
CREATE TABLE "public"."survey" (
  "survey_event_id" SERIAL,
  "start_date" DATE,
  "end_date" DATE,
  "survey_status" VARCHAR(100),
  "periodicity" VARCHAR(50),
  "survey_title" VARCHAR(50),
  "survey_objectives" VARCHAR(50),
  CONSTRAINT "SurveyEvent_pkey" PRIMARY KEY("survey_event_id")
) WITHOUT OIDS;
```

Table: taxa

Descriptions

There is no description for table taxa

Fields

PK	FK	Name	Data type	Description
✓		taxa_id	integer	
		common_name	varchar(100)	Common name of the species observed. e.g. Little Egret
		genus	varchar(100)	
		species	varchar(100)	
		sub_species	varchar(100)	
		author	varchar(50)	
		taxa_class	varchar(100)	
		taxa_order	varchar(100)	
		taxa_family	varchar(100)	
		vegation_type	varchar(50)	

Definition

```
CREATE TABLE "public"."taxa" (
  "taxa_id" SERIAL,
  "common_name" VARCHAR(100),
  "genus" VARCHAR(100),
  "species" VARCHAR(100),
  "sub_species" VARCHAR(100),
  "author" VARCHAR(50),
  "taxa_class" VARCHAR(100),
  "taxa_order" VARCHAR(100),
  "taxa_family" VARCHAR(100),
  "vegation_type" VARCHAR(50),
  CONSTRAINT "Taxa_pkey" PRIMARY KEY("taxa_id")
) WITHOUT OIDS;
```

Table: wetland

Descriptions

Stores information about general characteristics of wetland and connects other components of the system.

Fields

PK	FK	Name	Data type	Description
✓		wet_id	integer	
		wetland_boundary	public.geometry	Polygon

		name	varchar(255)	Name of the wetland.
		wetland_year	varchar(255)	The declaration year of the wetland.
		description	varchar(500)	The general description about the wetland
		climate_type	numeric	Foriegn Key identifying the climate
		classification	varchar(50)	
		system_subsystem	varchar(50)	

Definition

```
CREATE TABLE "public"."wetland" (
  "wet_id" SERIAL,
  "wetland_boundary" "public"."geometry",
  "name" VARCHAR(255),
  "wetland_year" VARCHAR(255),
  "description" VARCHAR(500),
  "climate_type" NUMERIC,
  "classification" VARCHAR(50),
  "system_subsystem" VARCHAR(50),
  CONSTRAINT "p_pkey" PRIMARY KEY("wet_id"),
  CONSTRAINT "enforce_dims_the_geom" CHECK (ndims(the_geom) = 2),
  CONSTRAINT "enforce_geotype_the_geom" CHECK ((geometrytype(the_geom) =
'MULTIPOLYGON'::text) OR (the_geom IS NULL)),
  CONSTRAINT "enforce_srid_the_geom" CHECK (srid(the_geom) = -1)
) WITHOUT OIDS;
```

Table: wetland_climate

Descriptions

Containing climatic information about a specific wetland in a specific year.

Fields

PK	FK	Name	Data type	Description
	✓	wet_id	numeric	
		year	numeric	
		average_rainfall	numeric	
		average_temperature	numeric	
✓		id	integer	
		climate_type	varchar(100)	Climate Type; Tropical monsoon climate, Tropical wet and dry, Dry arid (desert), Dry semiarid (steppe), Humid, Marine, Dry

				winters (Mid-latitude Climate), Dry summers (Mid-latitude Climate), Wet all seasons or (Mid-latitude Climate)
		description	varchar(100)	

Definition

```
CREATE TABLE "public"."wetland_climate" (
  "wet_id" NUMERIC,
  "year" NUMERIC,
  "average_rainfall" NUMERIC,
  "average_temperature" NUMERIC,
  "id" SERIAL,
  "climate_type" VARCHAR(100),
  "description" VARCHAR(100),
  CONSTRAINT "wetland_year_data_pkey" PRIMARY KEY("id"),
  CONSTRAINT "wetland_year_data_fk" FOREIGN KEY ("wet_id")
    REFERENCES "public"."wetland"("wet_id")
    ON DELETE NO ACTION
    ON UPDATE NO ACTION
    NOT DEFERRABLE
) WITH OIDS;
```

Table: wetland_water_quality

Descriptions

Containing water quality parameters specific to wetland at different point locations (Lat,Long).

Fields

PK	FK	Name	Data type	Description
	✔	wet_id	numeric	
		ph_level	varchar(10)	The concentration of mineral salts dissolved in water.(Neglibe, intermediate, high)
		level_of_contamination	varchar(10)	The level of pollution in water by harmful environmental contaminants (Neglibe, intermediate, high)
		level_of_sedimentation	varchar(10)	The level of the deposition or settling of soil particles suspended in water. (Neglibe, intermediate, high)
		description	varchar(500)	The general description about water quality.

		date	date	
		id	integer	
		contamination_nature	varchar(100)	natue of harmful environmental contaminants and description about their source.
		point_location	point	The point (lat and long) where the observation about water quality is taken
		point_location_description	varchar(250)	
		conductivity	varchar(10)	
		dissolved_oxygen	varchar(10)	
		turbidity	varchar(10)	

Definition

```
CREATE TABLE "public"."wetland_water_quality" (
  "wet_id" NUMERIC,
  "ph_level" VARCHAR(10),
  "level_of_contamination" VARCHAR(10),
  "level_of_sedimentation" VARCHAR(10),
  "description" VARCHAR(500),
  "date" DATE,
  "id" SERIAL,
  "contamination_nature" VARCHAR(100),
  "point_location" POINT,
  "point_location_description" VARCHAR(250),
  "conductivity" VARCHAR(10),
  "dissolved_oxygen" VARCHAR(10),
  "turbidity" VARCHAR(10),
  CONSTRAINT "wetland_water_quality_pkey" PRIMARY KEY("id"),
  CONSTRAINT "wetland_water_quality_fk" FOREIGN KEY ("wet_id")
    REFERENCES "public"."wetland"("wet_id")
    ON DELETE NO ACTION
    ON UPDATE NO ACTION
    NOT DEFERRABLE
) WITH OIDS;
```

5 Database Implementation

PWI data model includes numerous spatial elements/entities. To tightly couple spatial information with non spatial entities an open source spatial database Postgres/PostGIS was used. Some of the main features of this platform include proven reliability and respect, no cost (open source), supports most of the SQL standard, ability to add new data-types, GiST index / Index extensions, easy to add custom functions. This database also gives the possibility to directly access its server side functions using PHP. This direct access through PHP will greatly help in implementation of web application for the inventory.

Relevant literature was thoroughly studied for the decision of the spatial data infrastructure of the inventory. A summary of the study is presented below.

5.1 Loosely Coupled Approach – Conventional GIS

In conventional GIS implementations, spatial data and related attribute information are stored separately. The attribute information in a database (or flat file), while the spatial information in a separate, proprietary, GIS file structure. Many current GISs separate descriptive data management from geospatial data management. ArcInfo (ESRI), MGE, TiGRis (Intergraph) are well known GISs that follow this approach.

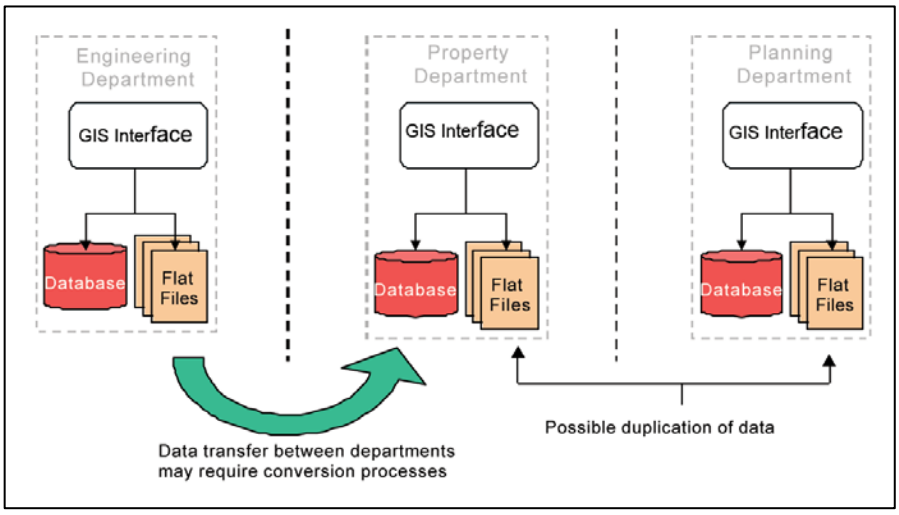

Figure 8: An overview of loosely coupled GIS (Oracle Spatial, 2003).

This approach has some inherent weaknesses such as coexistence of heterogeneous data models, results in difficulties in modeling, use, and integration. A partial loss of basic DBMS functionality such as recovery techniques, query, and optimization (Rigaux, *et al.,* 2000). In last few years these commercial vendors have realized this disadvantage and started offering coupled database solutions while remaining within their present data frame. One such example is GeoDatabase based on MS-Access format by ESRI.

5.2 Integrated Approach-Spatial Databases

A spatial database is a database that is optimized to store and query data related to objects in space, including points, lines and polygons. While typical databases can understand various numeric and character types of data, additional functionality needs to be added for databases to process spatial data types. These are typically called *geometry* or *feature* (Wikipedia, spatial database).

GIS provides a rich set of operations over few objects and layers, whereas a spatial database management system (SDBMS) provides simpler operations on a set of objects and set of layers. SDBMS inherit the traditional DBMS functionality of providing a concurrency control mechanism to allow multiple users to simultaneous access shared spatial data, while preserving the consistency of the data (Shekhar and Chawala, 2002).

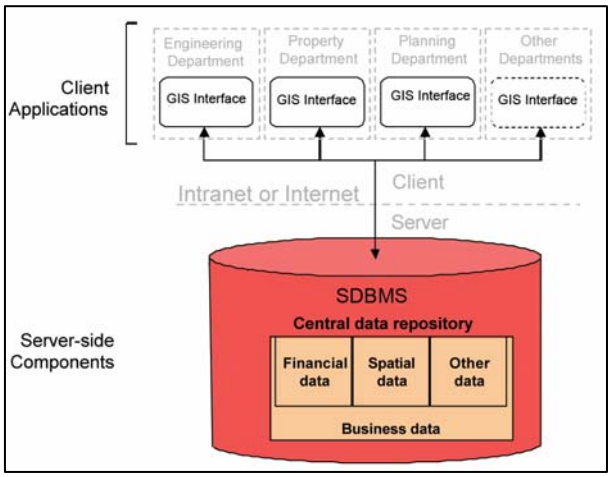

Figure 9: An overview of a Spatial Database management System (Oracle Spatial, 2003).

The evolution of the abbreviation GIS over the last two decades; in I980s GIS was Geographic Information System, in the 1990s Geographic Information Science was the preferred phrase, and now the trend is toward Geographic Information Services (Shekhar and Chawala, 2002). Spatial databases were developed when people started treating spatial information as first class database objects. Functionalities provided by the Spatial Database Management System (SDBMS) are the backbone of the ongoing Geographic Information Services industry. It also significantly lowers the development time of client applications spatial querying using SQL.

Most of the major commercial DBMS offer an extension for managing and querying spatial data solutions. These include ESRI ArcSDE (on top of several different Databases) Oracle Spatial, IBM DB2 Spatial Extender, Informix Spatial DataBlade, MS SQL Server (with ESRI SDE), Geomedia on MS and PostgreSQL.

5.2.1 Spatial Database Engine (SDE)

ArcSDE is the gateway to the DBMS for ESRI's client applications. Without ArcSDE, customer sites are limited in what they can do with their spatial databases (ESRI's ArcSDE FAQ). Thus Spatial Database Engine (SDE) from ESRI is software that enabled spatial data to be stored , managed, and retrieved from commercial DBMSs such as Oracle, MicrosoftSQL Server. From GIS point of view, SDE provide a solution for managing and providing access to spatial data. It is fully integrated with ESRI applications including ArcInfo, ArcViewGIS, and ArcExplorer.

5.2.2 Oracle Spatial Database

Oracle spatial is an integrated set of functions and procedures that enables spatial data to be stored, accessed, and analyzed quickly and efficiently in an Oracle database. Oracle spatial completes the implementation of OpenGIS Consortium RFP1-simple feature guideline. It is targeted to applications such as basic land management by government agencies, utility infrastructure, energy exploration and distribution, and data warehousing. It is sold as an option to *Oracle8i.* Oracle spatial provides a spatial data type SDO_GEOMETRY. Basic data types of this model are Point, Line String and N-Point Polygon. There are other, more complex elements, including collection of one or more elements called Geometries. A Layer is a collection of Geometries having similar attributes such a state boundaries, roads or rivers. The standard query language of oracle is extended with functions/operators on SDO_GEOMETRY so as to allow spatial queries, as well as queries mixing regular relational (descriptive) attributes and spatial attributes (Kothuri, et al., 2004).

5.2.3 MYSQL

MYSQL 4.1 introduced limited spatial functionality in MYSQL which now is also available in version 5. MYSQL spatial functionality is still very limited. It only works in MYISAM table type, which means no support for transactions. In general MYSQL spatial capabilities look as if they are still in an early development phase.

5.2.4 PostgreSQL/PostGIS

PostgreSQL is an open source, highly robust SQL92 compliant database system. Post GIS can be compared favorably to other known database management systems. It contains almost all of the features that one can find in other commercial or open source databases along with some additions (Stones and Mathew, 2001). Its main features include (PostgreSQL FAQ): Transactions, Subselects, View, Foreign Key Referential Integrity, sophisticated locking, user defined types, inheritance, rules and multiversion concurrency control.

PostgreSQL/PostGIS is currently the most advanced Open Source DBMS system available that supports to manage huge amounts of data. PostgreSQL supports replication, clustering and load balancing, in case one needs high availability and higher performance for more concurrent users. It is extensible using the builtin PL/pgSQL procedural language and many other programming and scripting languages. PostgreSQL is available for 34 platforms, incl. virtual any Unix system, Linux, MacOSX and soon also Windows. PostgreSQL is secure, relatively easy to administer and has a number of client GUI tools for different platforms.

Table 5: PostgreSQL specifications (Stones and Mathew 2001).

Feature	Specification
Maximum Database Size	64 TB on all operating systems
Maximum Table Size	64 TB on all operating systems
Maximum Number of indexes	Unlimited
Maximum Row Size	Unlimited in 7.1 and later
Maximum Field Size	1GB in 7.1 and later

Maximum Number of Columns in a table	1600

PostgreSQL is maintained, improved, and supported by a stable Global Development Group, and a large number of contributors. Source code is available for download, and anonymous CVS access is possible. It is licensed under BSD license, allowing truly free modifications and redistribution of binaries. Server-side user defined functions can be written in several languages, including PHP, C, SQL, PL/pgSQL, Tcl, and Perl.

PostGIS is an open source extension to PostgreSQL that supports spatial geometry, spatial queries and simple analysis. It can be used as a backend spatial database for geographic information system (eg. GRASS) or Web Mapping Server (e.g. Minnesota Mapserver). The geometry data format follows the OpenGIS "Simple Features Specification for SQL SimpleFeaturesSQL, which supports "POINT", "MULTIPOINT", "LINESTRING", "MULTILINESTRING", "POLYGON", "MULTIPOLYGON", and “GEOMETRYCOLLECTION". PostGIS allows for simple and complex spatial queries and spatial indices. Many of the functions are OpenGIS compliant. PostGIS comes with a ESRI shapefile loader and accepts OpenGIS simple features geometry.

Table 6: Geometry definition in WKT-Format (OGC, 1999).

Geometry Type	SQL Text Literal Representation	Comment
Point	`'POINT (10 10)'`	a `Point`
LineString	`'LINESTRING ( 10 10, 20 20, 30 40)'`	a `LineString` with 3 points
Polygon	`'POLYGON ((10 10, 10 20, 20 20, 20 15, 10 10))'`	a `Polygon` with 1 exterior ring and 0 interior rings
Multipoint	`'MULTIPOINT (10 10, 20 20)'`	a `MultiPoint` with 2 point
MultiLineString	`'MULTILINESTRING ((10 10, 20 20), (15 15, 30 15))'`	a `MultiLineString` with 2 linestrings
MultiPolygon	`'MULTIPOLYGON ( ((10 10, 10 20, 20 20, 20 15, 10 10)), ((60 60, 70 70, 80 60, 60 60 ) ))'`	a `MultiPolygon` with 2 polygons
GeomCollection	`'GEOMETRYCOLLECTION (POINT (10 10), POINT (30 30), LINESTRING (15 15, 20 20))'`	a `GeometryCollection` consisting of 2 `Point` values and a `LineString` value

PostgreSQL seems more stable and desireable as compare to other solutions for spatial data repository.

5.3 Overview of Web-Application based on PWGIS Integrated Database

The database designed in this component will be deployed in Web-based information architecture (Deliverable 4.1B). Web-based applications are applications that require just a a browser (i.e., internet explorere, mozilla) to function. The server-side application logic runs on a centralized web server in the data center. Any platform that supports a browser can access a web server. The user interface of the application is composed of web pages.

Each web page, like the screens of traditional applications, presents information to the user. The information normally comes from a database server and enabling the user to view, modify or delete the authorized contents.

PWI application will be build on the same client server architecture which will greatly support geographically distributed organisational structure of the Pakistan Wetlands Programme.

The present PWGIS Integrated database built in PostgreSQL/PostGIS will provide platform to develop a need specific online GIS by integrating it with web mapping services of UMN-Mapserver through PHP and JavaScript. This comprehensive application will allow viewing, editing and analyzing the spatial and non-spatial data of Pakistan Wetlands Inventory. An overview of the components and service is given in Figure 10 below.

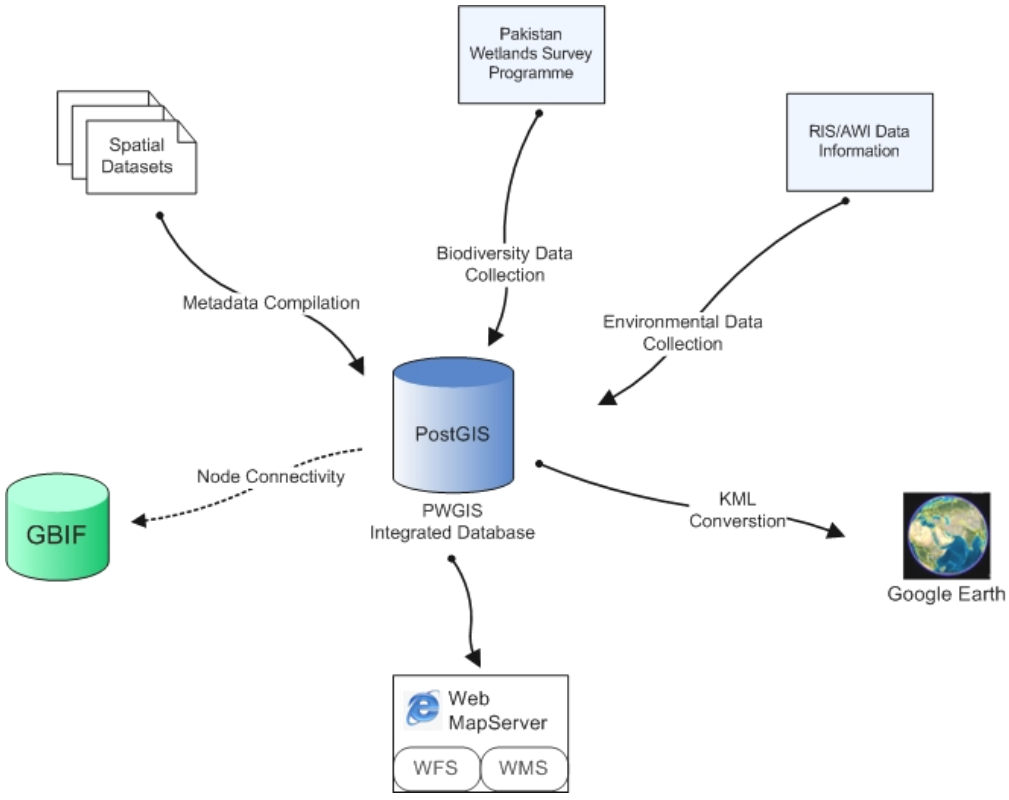

Figure 10: PWI Web application overview diagram

Standards, and protocols adopted for the information system are approved by the relevant international bodies both in biological and technological perspective. This standard compliance will enable connectivity with global biodiversity portals like GBIF and visualization of PWI data records over the Google Earth.

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Appendix 1: Information Sheet on Ramsar Wetlands (RIS) 2006-2008 Version

Categories approved by Recommendation 4.7 (1990), as amended by Resolution VIII.13 of the 8th Conference of the Contracting Parties (2002) and Resolutions IX.1 Annex B, IX.6, IX.21 and IX. 22 of the 9th Conference of the Contracting Parties (2005).

Notes for compilers:

1. The RIS should be completed in accordance with the attached *Explanatory Notes and Guidelines for completing the Information Sheet on Ramsar Wetlands*. Compilers are strongly advised to read this guidance before filling in the RIS.

2. Further information and guidance in support of Ramsar site designations are provided in the *Strategic Framework and guidelines for the future development of the List of Wetlands of International Importance* (Ramsar Wise Use Handbook 7, 2nd edition, as amended by COP9 Resolution IX.1 Annex B). A 3rd edition of the Handbook, incorporating these amendments, is in preparation and will be available in 2006.

3. Once completed, the RIS (and accompanying map(s)) should be submitted to the Ramsar Secretariat. Compilers should provide an electronic (MS Word) copy of the RIS and, where possible, digital copies of all maps.

FOR OFFICE USE ONLY.
DD MM YY
Designation date Site Reference Number

1. Name and address of the compiler of this form:

2. Date this sheet was completed/updated:

3. Country:

4. Name of the Ramsar site:
The precise name of the designated site in one of the three official languages (English, French or Spanish) of the Convention. Alternative names, including in local language(s), should be given in parentheses after the precise name.

5. Designation of new Ramsar site or update of existing site:

This RIS is for (tick one box only):
a) Designation of a new Ramsar site; or
b) Updated information on an existing Ramsar site

6. For RIS updates only, changes to the site since its designation or earlier update:

a) Site boundary and area

The Ramsar site boundary and site area are unchanged:

or
If the site boundary has changed:

i) the boundary has been delineated more accurately; or
ii) the boundary has been extended; or
iii) the boundary has been restricted**

and/or

If the site area has changed:
i) the area has been measured more accurately; or
ii) the area has been extended; or
iii) the area has been reduced**

** **Important note**: If the boundary and/or area of the designated site is being restricted/reduced, the Contracting Party should have followed the procedures established by the Conference of the Parties in the Annex to COP9 Resolution IX.6 and provided a report in line with paragraph 28 of that Annex, prior to the submission of an updated RIS.

b) Describe briefly any major changes to the ecological character of the Ramsar site, including in the application of the Criteria, since the previous RIS for the site:

7. Map of site:
Refer to Annex III of the Explanatory Note and Guidelines, for detailed guidance on provision of suitable maps, including digital maps.

a) A map of the site, with clearly delineated boundaries, is included as:

i) **a hard copy** (required for inclusion of site in the Ramsar List);

ii) **an electronic format** (e.g. a JPEG or ArcView image);

iii) **a GIS file providing geo-referenced site boundary vectors and attribute tables.**

b) Describe briefly the type of boundary delineation applied:
e.g. the boundary is the same as an existing protected area (nature reserve, national park, etc.), or follows a catchment boundary, or follows a geopolitical boundary such as a local government jurisdiction, follows physical boundaries such as roads, follows the shoreline of a waterbody, etc.

8. Geographical coordinates (latitude/longitude, in degrees and minutes):
Provide the coordinates of the approximate centre of the site and/or the limits of the site. If the site is composed of more than one separate area, provide coordinates for each of these areas.

9. General location:
Include in which part of the country and which large administrative region(s) the site lies and the location of the nearest large town.

10. Elevation: (in metres: average and/or maximum & minimum)

11. Area: (in hectares)

12. General overview of the site:
Provide a short paragraph giving a summary description of the principal ecological characteristics and importance of the wetland.

13. Ramsar Criteria:
Tick the box under each Criterion applied to the designation of the Ramsar site. See Annex II of the *Explanatory Notes and Guidelines* for the Criteria and guidelines for their application (adopted by Resolution VII.11). All Criteria which apply should be ticked.

1	2	3	4	5	6	7	8	9

14. Justification for the application of each Criterion listed in 13 above:
Provide justification for each Criterion in turn, clearly identifying to which Criterion the justification applies (see Annex II for guidance on acceptable forms of justification).

15. Biogeography (required when Criteria 1 and/or 3 and /or certain applications of Criterion 2 are applied to the designation):
Name the relevant biogeographic region that includes the Ramsar site, and identify the biogeographic regionalisation system that has been applied.

a) biogeographic region:

b) biogeographic regionalisation scheme (include reference citation):

16. Physical features of the site:
Describe, as appropriate, the geology, geomorphology; origins - natural or artificial; hydrology; soil type; water quality; water depth, water permanence; fluctuations in water level; tidal variations; downstream area; general climate, etc.

17. Physical features of the catchment area:
Describe the surface area, general geology and geomorphological features, general soil types, and climate (including climate type).

18. Hydrological values:
Describe the functions and values of the wetland in groundwater recharge, flood control, sediment trapping, shoreline stabilization, etc.

19. Wetland Types

a) presence:
Circle or underline the applicable codes for the wetland types of the Ramsar "Classification System for Wetland Type" present in the Ramsar site. Descriptions of each wetland type code are provided in Annex I of the *Explanatory Notes & Guidelines*.

Marine/coastal:

A	B	C	D	E	F	G	H	I	J	K	Zk(a)

Inland:

L	M	N	O	P	Q	R	Sp	Ss	Tp	Ts	U	Va	Vt	W	Xf	Xp	Y	Zg	Zk(b)

Human-made:

1	2	3	4	5	6	7	8	9	Zk(c)

b) dominance:
List the wetland types identified in a) above in order of their dominance (by area) in the Ramsar site, starting with the wetland type with the largest area.

20. General ecological features:
Provide further description, as appropriate, of the main habitats, vegetation types, plant and animal communities present in the Ramsar site, and the ecosystem services of the site and the benefits derived from them.

21. Noteworthy flora:
Provide additional information on particular species and why they are noteworthy (expanding as necessary on information provided in 14, Justification for the application of the Criteria) indicating, e.g., which species/communities are unique, rare, endangered or biogeographically important, etc. ***Do not include here taxonomic lists of species present - these may be supplied as supplementary information to the RIS.***

22. Noteworthy fauna:
Provide additional information on particular species and why they are noteworthy (expanding as necessary on information provided in 12. Justification for the application of the Criteria) indicating, e.g., which species/communities are unique, rare, endangered or biogeographically important, etc., including count data. ***Do not include here taxonomic lists of species present - these may be supplied as supplementary information to the RIS.***

23. Social and cultural values:

a) Describe if the site has any general social and/or cultural values e.g., fisheries production, forestry, religious importance, archaeological sites, social relations with the wetland, etc. Distinguish between historical/archaeological/religious significance and current socio-economic values:

b) Is the site considered of international importance for holding, in addition to relevant ecological values, examples of significant cultural values, whether material or non-material, linked to its origin, conservation and/or ecological functioning?

If Yes, tick the box and describe this importance under one or more of the following categories:

i) sites which provide a model of wetland wise use, demonstrating the application of traditional knowledge and methods of management and use that maintain the ecological character of the wetland:

ii) sites which have exceptional cultural traditions or records of former civilizations that have influenced the ecological character of the wetland:

iii) sites where the ecological character of the wetland depends on the interaction with local communities or indigenous peoples:

iv) sites where relevant non-material values such as sacred sites are present and their existence is strongly linked with the maintenance of the ecological character of the wetland:

24. Land tenure/ownership:
a) within the Ramsar site:

b) in the surrounding area:

25. Current land (including water) use:
a) within the Ramsar site:

b) in the surroundings/catchment:

26. Factors (past, present or potential) adversely affecting the site's ecological character, including changes in land (including water) use and development projects:
a) within the Ramsar site:

b) in the surrounding area:

27. Conservation measures taken:

a) List national and/or international category and legal status of protected areas, including boundary relationships with the Ramsar site:
In particular, if the site is partly or wholly a World Heritage Site and/or a UNESCO Biosphere Reserve, please give the names of the site under these designations.

b) If appropriate, list the IUCN (1994) protected areas category/ies which apply to the site (tick the box or boxes as appropriate):

Ia; Ib; II; III; IV; V; VI

c) Does an officially approved management plan exist; and is it being implemented?:

d) Describe any other current management practices:

28. Conservation measures proposed but not yet implemented:
e.g. management plan in preparation; official proposal as a legally protected area, etc.

29. Current scientific research and facilities:
e.g., details of current research projects, including biodiversity monitoring; existence of a field research station, etc.

30. Current communications, education and public awareness (CEPA) activities related to or benefiting the site:
e.g. visitors' centre, observation hides and nature trails, information booklets, facilities for school visits, etc.

31. Current recreation and tourism:
State if the wetland is used for recreation/tourism; indicate type(s) and their frequency/intensity.

32. Jurisdiction:
Include territorial, e.g. state/region, and functional/sectoral, e.g. Dept of Agriculture/Dept. of Environment, etc.

33. Management authority:
Provide the name and address of the local office(s) of the agency(ies) or organisation(s) directly responsible for managing the wetland. Wherever possible provide also the title and/or name of the person or persons in this office with responsibility for the wetland.

34. Bibliographical references:
Scientific/technical references only. If biogeographic regionalisation scheme applied (see 15 above), list full reference citation for the scheme.

Please return to: Ramsar Convention Secretariat, Rue Mauverney 28, CH-1196 Gland, Switzerland
Telephone: +41 22 999 0170 - Fax: +41 22 999 0169 - e-mail: ramsar@ramsar.org

Appendix 2: Description of AWI macro (sub-basin) level datasheet

Data collection at macro level focuses on sub-basins and coastal sub-regions within each of the major river basins, coastal regions and islands (like Astola, Bundal or Churna) determined at global level. Depending on the size of the areas concerned one or more sub-basins of a major river basin or island can be regarded as a single unit. Macro level datasheet should be accompanied by a GIS-based map (scale approx. 1:250 000) of the sub-basin or coastal sub-region for which the inventory is being compiled. 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.

Components of macro level datasheet are;

Name and code of sub-basin or coastal sub-region
Each sub-basin or coastal region should be identified by a discrete name (using the name of the largest river draining the area) and a code (e.g. numeric). However, the unique code initially used for the major river basins or islands in which the sub-basins or coastal regions are located, always remains the same.

Geographic location
The location of a sub-basin or coastal sub-region is defined using standard geographical coordinates. Using an appropriate map 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.

It is preferred that a centroid identifying the geometric centre of the subbasin or coastal sub-region is also included. The centroid can be obtained from GIS based maps and can be useful for quickly identifying the location of the area and possible sources of information from maps and remotely sensed imagery.

Climatic characteristics
Using the sub-classes of the Koeppen classification as a basis describe the distribution of rainfall and temperature in the sub-basin or coastal sub-region, noting the name of the official recording station(s). This information (e.g. the range and mean annual precipitation and air temperatures) should be obtained from an official recording service. If this is not the case this should be noted in the datasheet. Information on mean air temperatures and precipitation is also available on the LOICZ coastal typology database (http://www.nioz.nl/loicz).

Physical features
i) Type of region
State whether the area of interest is one of the following:
- Sub-basin (or group of sub-basins) of a primary river basin;
- Coastal sub-region; or
- Aggregation of small offshore islands.

ii) Altitudinal range
The altitudinal range of the area is defined by providing the minimum and maximum heights above (or below) the local height datum (available from the national land survey service) for sea level. These data are recorded in metres (m) and are normally available from topographical maps, orthophotographs and/or national and regional land information services.

iii) Wetland area and type
Using Table 2 as a guide, record the spatial extent of wetland (in km^2) and calculate the proportion of the area that is occupied by wetlands (in %) by using existing maps on the WWF (http://www.wwfus.org/ecoregions/index.htm.) and the World Resources Institute (http://www.wri.org/wri/watersheds/watersheds.html) web sites, or by locating surrogate data in the form of topographic maps, soil maps or maps of land capability units that are commonly housed by government organisations and aid agencies. The area calculations required can be obtained either with the aid of a planimeter, from a grid placed over a map of appropriate scale, or electronically using GIS applications.

Table 7: Surface area of wetland in region.

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

In the case of wetlands which assume 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 join they form second order streams; and when two second order streams join they form third order streams; and so on).

iv) Geological characteristics
Describe the specific geological zones/features of the area, noting that these should be a more detailed sub-set of the information presented in the Level 1 datasheet.

v) Water regime
With reference to published data or sources such as the LOICZ coastal typology database (http://www.nioz.nl/loicz), provide data on Mean Annual Runoff (MAR) and seasonality of inflows. For coastal sub-regions and islands the LOICZ database can be used for information on both tidal range and river discharge.

Vegetation
Describe the major vegetation zones/features of the area, noting that in the very least, this should be more detailed than the information presented at global level datasets. Source of such data include Forest Sector Master Plan 1992 forest cover data.

Wetland goods and services
Expanding on the wetland values identified at global level describe the goods and services that are provided by wetlands in the area of interest by using the information presented in Table 3 as a guide. Where possible indicate which of the goods and services are the most important in the region (using hearsay if necessary) and try to establish whether they differ from one area to another depending on whether it is developed, undeveloped or developing.

Table 8: Categorisation of region-wide goods and services of wetlands

Goods and services	Example
Freshwater	Water storage, streamflow regulation, groundwater recharge, drought relief
Food, fibre and fuel	Rice, reeds, peat

Goods and services	Example
Other biological products	$CaCO_3$ from reefs, wildlife trade, harvestable resources (fish /shrimp ponds, livestock grazing, timber)
Biological regulation	Food chain support, pollination, control of invasives
Nutrient cycling and soil fertility	Agricultural production
Atmospheric and climate regulation	Regulation of global carbon cycles
Human health control	Water quality improvement
Waste processing and detoxification	denutrification, pathogen removal and waste assimilation
Flood, storm and erosion protection	Flood peak reduction and erosion control (shoreline and bank stabilisation)
Cultural and amenity services	Heritage, recreation, ecotourism and education, water transport

Management issues and threats

Expanding on the management issues and threats identified at global level identify the specific reasons for the loss and degradation of wetlands in the nominated region. The threats concerned are referred to as 'proximate drivers' in the MA framework (Table 4) and are regarded as the forces that have direct influence on the ecosystem services described earlier (section 5.2.6 above).

Table 9: Proximate drivers of management issues and threats (adapted from: MA Conceptual Framework).

Primary driver	Proximate driver	Examples
Biophysical	Climate change	Shoreline erosion, rise in sea surface temperature, saline intrusion
	Desertification	Drying up of inland wetlands that formerly acted as water storage areas
	Species introduction and biotic invasion	Invasive plants and animals that subsequently become declared weeds, pests or vermin
Economic	Natural resource extraction	Mining, fishing, logging, salt recovery, sand, gravel and shell extraction
Technology	Industrialisation and urbanisation	Mangrove removal, swamp reclamation, waterfront residential development, dredging
	Pollution	Water and air pollution, acid rain, leachates, toxicity, pesticide usage
	Waste disposal systems	Sewage treatment plants, retention ponds, solid waste landfill sites
Demographic	Land and water use	Landscape fragmentation, cover change, dewatering
	Agricultural production systems	Irrigation, fertilisers, soil degradation, rice cultivation
Socio-political	Disease emergence and drug resistance	Spread of malaria, schistosomiasis, liver fluke, onchocersiasis, pesticide usage

Jurisdiction

Each sub-basin or coastal sub-region should be described in terms of its national and local jurisdiction. Country codes of the International Organisation of Standardisation (ISO) (www.iso.org) should be used to show national jurisdiction and the names of Provinces,

Counties and City administration units stated under each relevant ISO Country code. In addition, jurisdiction in terms of public or private land ownership could be stated here.

Datasheet completion
Name and address of compiler:
Family name:
Other names:
Title (Ms, Mrs, Mr, Dr or Professor): Institute/Agency/Organisation:
Postal address (street name and number, town/city, country, postal code):
Telephone number (country code, local code, number):
Fax number (country code, local code, number):
Email address:
Datesheet completed / updated: The date the datasheet was completed/updated should be stated (e.g. 02 October 2001).

Appendix 3: Description of AWI meso (wetland complex) level datasheet

Meso level data collection focuses on defining and describing 'wetland complexes' within the sub-basin or coastal sub-regions identified at macro level. The larger the river basin the larger the number of sub-basins (or sub-catchments) within it. Wetland complexes can be either entire sub-catchments, large, individual wetlands (of various types), or a number of smaller discrete wetlands (sometimes only a few hectares in size) that are hydrologically linked because they lie within the same sub-catchment. The watersheds between wetland complexes serve to distinguish the sub-catchments involved. The meso level datasheet should be accompanied by a GIS-based map (scale 1:50 000) of the wetland complex.

Depending on the regional topography, both river basins and coastal regions can contain wetland complexes. Understandably they exhibit some fundamentally different features and require different data fields. These differences are recognised and the AWI database contains separate data fields, where necessary, for wetlands in river basins and those in coastal zones.

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 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.

Name and code of wetland complex

Using the procedure followed for macro level, each wetland complex must be identified by a name and code. A subsidiary code (using decimal places) can be used to further define the primary code ascribed at meso level. Alternatively, 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 for the wetland complex exists, the name of the Province, County or other administrative unit in which the complex is located should be used.

Geographic location

The size and location of a wetland complex will play a significant role in determining how the geographic location of the complex is recorded. It is important to define the extent of the wetland complex, through recording the location of its extremities. At a minimum, the upper left and the lower right extremities of the complex must be recorded. Alternatively, a series of coordinates defining the shape / outline of the complex may be recorded.

In most cases, it is recommended that a projected coordinate system, such as the Lambert Conformal Conic (LCC) system (Pak Zone I or IIA as used by SoP), be used to record the coordinates of the extremities. 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 complex is defined. It also assists with area and distance calculations.

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, such as the boundary of two projected system zones running through the complex, it is recommended that a geographic coordinate system be used. In such a situation, the coordinates should be recorded as 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.

Climatic characteristics
Record the following general information, noting the location of the recording station (name, latitude and longitude, altitude): average rainfall, temperature range (including average temperatures), relative humidity (9 am and 3 pm), prevailing winds and evaporation (Class A pan).

Ecological character
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, physicochemical and biological features of the complex.

i) Physical features
Altitudinal range
Record the altitudinal range of the wetland complex by defining its minimum and maximum heights above (or below) sea level (in metres). This information is normally available from topographical maps, orthophotographs and/or national and regional land survey or mapping services. For wetland complexes in coastal regions the LOICZ coastal typology database (http://www.nioz.nl/loicz) can also be used.

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

Currents, waves and sediment movement in a coastal area
In the case of a wetland complex in a coastal sub-region there are four extremely important forces (currents, tides, wind and waves) that exert an important influence on sediment movement in the area (e.g. longshore drift of marine sediments). Therefore, it is advisable to record any information that exists about distributive forces of this nature. Information on the dominant wave direction and the prevailing wind direction relative to the coastline is generally available from the local Port Authority, Department of Transportation, or the LOICZ coastal typology database (http://www.nioz.nl/loicz). The position and shape of inlets, shoals and sandspits, as seen from aerial photographs, also provide a good indication of the environmental factors influencing coastal sand transport in the region.

Erosional status
Describe the susceptibility of complexes in coastal regions to erosion (wave-, wind-, storm-, or current-induced) using the categories suggested by Heydorn and Tinley (1980) and shown in Table 5.

Table 10: Erosional status of coastal landforms and wetland complexes

Erosional status	Definition / example

Erosional status	Definition / example
Eroding	Areas where the action of the sea is eroding the land substrate, e.g. cliffs, dunes, or beaches
Accreting	Areas where the predominant landform is depositional, e.g. beach, intertidal mudflat and where further sedimentation is active
Stable	Areas where the predominant landform is balanced by erosion and accretion

Soil types
Search for existing soil maps of the complex and describe the dominant soil type(s) within the area using standardised soil classifications for the area. Depending on the size of the wetland complex the FAO digital soil map of the world (http://www.fao.org/ag/guides/subject/p.htm) and the LOICZ coastal typology database (http://www.nioz.nl/loicz) can serve as additional sources of such information.

Water regime
For wetland complexes in the coastal zone the tidal range should be recorded using locally available tidal chart data to give both the maximum (Spring) and minimum (Neap) tidal variation. Using such data the coastal region can then be classified into sectors experiencing either small, moderate or large tidal ranges (Table 6).

Table 11: Classification of coastal regions according to tidal range experienced (after Hayes 1977)

Category	Tidal range
Micro-tidal	< 2 m
Meso-tidal	2–4 m
Macro-tidal	> 4 m

For inland wetland complexes describe the mean annual run-off generated by the catchment. If measuring weir data are 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 iii), differentiate between the extent of the stream orders concerned.

Groundwater
With the role of groundwater in wetland hydrology being a very important relationship and many wetland complexes being located in groundwater discharge areas, it is advisable to search for and record any information about the hydrogeology of the area in which the complex is situated. Such 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 formations, subterranean flow paths, the base flows of rivers that drain the region, springs and seepage zones.

ii) Physico-chemical features
Water quality
Where water quality data are available 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. Such data can be drawn from existing reports and liaison with the local water authority or ministries (e.g. 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). 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 7. Generally compliance to legal discharge standards is rarely observed in developing countries, the relevance may well be questionable. If insufficient data are available this should be stated.

Table 12: **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

iii) 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 complex

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

Species and associations of biological significance

Use information on the WWF (http://www.wwfus.org/ecoregions/index.htm) and IUCN (http://iucn.org/redlist/2000/index.html) websites for assessing the species of biological importance in the complex. 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, it should be stated. Other biodiversity databases containing information on the status of species poorly represented in the 2000 IUCN Red List of Threatened Species include those for fish (http://www.fishbase.org/search) and plants (UNEP-WCMC Threatened Plant Database http://www.wcmc.org.uk/species/plants/plants.by.taxon.htm). For the purpose of determining species of National significance supported by the area other local data sources include National Red Data Books (if available) and local experts.

Habitat(s)

In preparation for, or in anticipation of, launching Level 4 of the AWI procedure (section 5.4) name / list the habitats which are found in the complex using the Ramsar classification for guidance and provide the area of each habitat in hectares (ha). In the event of a habitat classification system being used other than the Ramsar classification, provide the bibliographic details and date of the classification adopted. Where no existing classification is available, group similar vegetation assemblages where these are known to support the same fauna species.

Population demographics

With the aid of government statistics (census data), describe the characteristics of the human population in the wetland complex noting 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 (the categories developed by Hecker et al 1996 for the MedWet inventory were towns with population <1 000; 1000 – 10 000; 10 000 – 100 000; > 100 000) or as the number of inhabitants per km^2 (Table 8). For wetland complexes in coastal regions use the LOICZ coastal typology database (http://www.nioz.nl/loicz) for information on population density. Where possible describe the number of people occupying the complex (population, age structure, seasonal variation in numbers, long term trends) and the principle activities of people living in the complex (agricultural, grazing, aquaculture, forestry etc.).

Table 13: 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

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 9 can be used as a guide, noting where appropriate, whether or not these are undertaken for subsistence or for commercial purposes, and by using mainly traditional or modern techniques.

5.3.7 Jurisdiction

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).

Table 14: Classification of major land and water uses of wetland complexes

Land / water uses	Examples
Cropland	Sugarcane, cereals
Grazing	Cattle, sheep, goats, horses, camels
Improved grazing	Pastures for dairy cattle
Horticulture	Vegetables, bananas, flowers
Urban	Infrastructure (roads, railways, etc.)
Settlement	Residential areas
Construction	Reed harvesting, mangrove poles
Fishing	Nursery stock, shellfish, finfish
Aquaculture	Shellfish, prawns/shrimps, finfish
Forestry	Timber / woodchip / pulp
Fuel	Peat, timber / charcoal
Hunting	Invertebrates, frogs, reptiles, birds, mammals
Water supply	Surface storage, groundwater recharge/discharge

Land / water uses	Examples
Transport	Barge, ferry, houseboat, harbours
Extractive industry	Minerals, peat, oil/gas, sand/gravel or salt extraction
Energy	Hydro-electric power, peat farming
Conservation	Natural or cultural heritage
Recreation)	Active (golf courses) or passive (birdwatching

Management issues and threats

Using Table 4 (Macro Level) as a guide, for each wetland complex describe the management issues that specifically confront local communities as users of the system (Table 10) (e.g. overfishing, illegal hunting, declines 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 of surrounding croplands, eutrophication, upstream use of the river system that supplies water to the complex). Describe the management practices / plans (if any) being employed / developed by agencies working in the area. Record the number of people interviewed, the names and status of the informants.

Where the utilisation of a wetland complex presents risks to human health, the type of disease carrying organisms living in the wetland (e.g. mosquitoes, liver fluke, snails) and the incidence of disease within the human population (in %) should also be described.

Where wetland complexes are subject to natural threats (e.g. from climate change, subsidence, storm surges, erosion) describe the underlying reasons for and extent of the habitat loss or degradation that is evident.

Table 15: Management issues and threats to wetland complexes

Proximate driver	Examples of management issues and threats
Climate change	Flooding of residential areas, roads and infrastructure, erosion / siltation, salinisation of water supplies.
Desertification	Irrigation, reclamation, water diversion and wetland drainage.
Species introduction and biotic invasion	Alien invasive species and environmental weeds, vermin and pest animals.
Natural resource extraction	Agriculture, tree planting, grazing, fishing, fuel, forage, thatch, hunting, aquaculture, forestry, mining.
Industrialisation and urbanisation	Erosion / erosion control, flooding / flood control, vegetation clearance and fire, sedimentation, infrastructure / housing, quarrying / sand mining, hunting disturbance, recreational activities, agricultural expansion.
Pollution	Expansion of existing and development of new industries without adequate regulation and planning controls.
Waste disposal systems	Solid waste, siltation, faecal contamination, mining wastes, pesticides, fertilisers, salinisation.
Land and water use	Poor awareness by the general community and policy makers of wetland values; low level of community participation in conservation.
Agricultural production	Ownership and access to land and resources; questions

Proximate driver	Examples of management issues and threats
systems	of stewardship, traditional rights and attitudes of new settlers.
Disease emergence and drug resistance	Increasing population and pressure due to poverty; urban or rural expansion; poorly resourced government agencies, shortage of trained personnel; conflicts with other agencies; weak legislation or without political support .

Datasheet completion
Name and address of compiler : The name and address of the compiler should be stated as shown in the datasheet
Datesheet completed / updated: The date the datasheet was completed should be stated (e.g. 02 October 2001).

Appendix 4: Description of AWI micro (wetland habitat) level datasheet

Micro level data collection focuses on defining the 'wetland habitats' which occur within the wetland complexes identified at meso level. Even if present within the same complex, wetland habitats do not necessarily have the same characteristics such as water regimes or ecological characteristics. The resources they provide and requirement of the management intervention also vary.

Micro level datasheet should be accompanied by a GIS-based map at a suitable scale (e.g. 1:10 000 to 1:25 000 depending on the extent of the habitats concerned). 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, micro level data become **the core dataset** relating to the primary interests of the managers of a particular wetland habitat or individual site.

5.4.1 Name and code of wetland habitat

A name and code for each habitat must be devised. 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 / dialects are used for the same site) use them all. Where no name for the wetland habitat exists, the descriptive qualifiers / typology used by the Ramsar Convention can be used in conjunction with the wetland classification proposed in Table 28.

Geographic location

It is important to define the extent of the wetland habitat as accurately as possible. At a minimum, the coordinates representing the upper-left and lower-right extremities must be recorded. Alternatively, a series of coordinates defining the boundary of the habitat may be entered.

It is recommended that the coordinates be recorded using a projected coordinate system, such as the Lambert Conformal Conic (LCC) system. In such a system, the coordinates would typically be recorded as metres of Eastings and Northings. The use of such a system enhances the ability to extract additional information, particularly those items relating to area calculations.

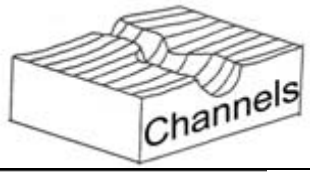
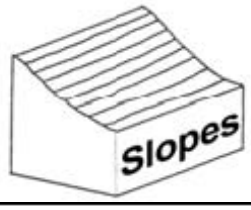
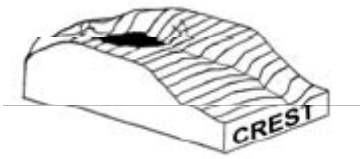
Those responsible for entering data must specify the type of projected coordinate system used e.g. WGS 1984 LCC projection, including the coordinate map grid in which the habitat is situated.

Climatic characteristics

Noting the location of the nearest meteorological recording station (name, latitude and longitude, altitude, period of record) describe the average and range of rainfall, noting the wettest and driest months; monthly temperature range, 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 (Class A pan) evaporation; the prevailing winds and time of the year when the wind regime changes. In each case provide the source and date of the information utilised.

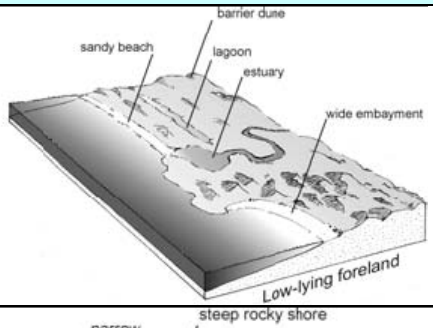
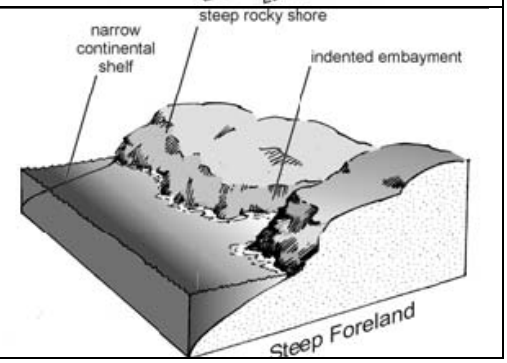
Ecological character
i) Physical features
Geomorphic setting
Describe the landform (or cross-sectional geometry) of the habitat using the terms supplied in Table 11. Generally there are at least 5 basic landform types that determine the occurrence of wetlands and, whilst each are intergradational, it is important to describe the entire landform in which the habitat is situated and not just parts of it (Semeniuk & Semeniuk, 1995).

Table 16: Categories of landforms that are host to wetlands (adapted from Semeniuk & Semeniuk, 1995 and from 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 'channeled flats'.	
Slopes	Slopes are areas with a gradient of greater than 1% which may be concave or convex.	
Hills / highlands	Hills / highlands are generally convex areas on the top of mountains, hills or similarly raised areas.	

In the case of a wetland habitat in a coastal region the landforms that are host to wetlands are more complex and do not lend themselves as easily as inland wetlands to categorisation. Nevertheless, the terms supplied in Table 12 (after Heydorn and Tinley, 1980) provide a provisional means of doing so.

Table 17: Categories of landforms that are host to wetlands in coastal regions (adapted from Heydorn & Tinley, 1980).

Landform	Definition	
Low lying	Wide coastal embayments, sandy beachfronts, salt marshes, mangrove swamps, deltas, lagoons and estuaries, often associated with regions where the continental shelf is wide.	
Steep/mountainous	Steep rocky shores, deep heavily indented embayments, and seacliffs, pebble shores often associated with regions where the continental shelf is narrow.	

Altitudinal range

Record the altitude of the habitat (in metre Above Height Datum (AHD)) by ascertaining its minimum and maximum height above (or below) sea level. This information is normally available from topographical maps, orthophotographs and/or national and regional land survey or mapping services.

Spatial

Define the areal extent of the habitat using the scale shown in Table 13. In addition, obtain the following spatial data:

- *surface area* ——measure the surface area using either a planimeter; a grid placed over a map of appropriate scale; or 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 (drawn from remotely sensed data) can act as a source of information about the variation in wetland extent, but aerial photographs (where available) are otherwise the most 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.

Table 18: Terms for defining the spatial extent of a wetland complex (adapted from Semeniuk 1995)

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

Basin morphology
Bathymetry
Record any existing information about the depth of the basin (i.e. maximum depth and, where known, the average depth). If such 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).

Inlet stability
In the case of an estuary mouth or the entrance to a land-locked bay, record any information about the width and position of the entrance, noting in particular whether it is permanently or periodically open. If so, with the aid of vertical aerial photographs, establish whether there is any evidence of flood- or ebb- tide deltas (i.e. inner and outer bars) in the mouth region because such features greatly influence tidal exchange in the system concerned. If the mouth is normally closed (as it would be in the case of a lagoon) provide information on the height and width of the bar and, through consultation with local communities, establish whether or not artificial breaching of the bar occurs.

Currents, waves and sediment movement in a coastal area
Record any site specific information about the dominant wave direction and the prevailing wind direction relative to the coastline. Using aerial photographs describe the position and shape of inlets, shoals and sandspits (coastal sand transport) in the region.

Erosional status
Describe the susceptibility of the habitat to erosion (wave-, wind-, storm-, or current-induced) using the categories shown in Table 5 (dor meso level).

Soil types
Using existing soil maps and/or reports describe the dominant soil type(s) within the habitat of interest. 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 / 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 / textural method of classifying the substrata in situ may need to be used, noting that core samplers may be necessary where the water depth is in excess of approx. 1.5 m (Table 14).

Table 19:**Texture based substrate classification (adapted from Begg 1984)**

Textural class	Texture / general appearance	Percentage composition	
		% 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 hardly 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

Footnote: n/a = not applicable

Water regime

For wetland habitats in the coastal zone the tidal range should be recorded using locally available tidal chart data to give both the maximum (spring) and minimum (neap) tidal variation AHD. For inland (non-tidal) wetland habitats 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; the period(s) of inundation and the area flooded. The source of inflow should be recorded (e.g. sea, river, groundwater, spring, rainfall only, artificial) and both the inflow and outflow recorded as permanent, seasonal, intermittent, episodic, or none.

Table 20:Categories of non-tidal water regimes for wetland habitats (adapted from Semeniuk & Semeniuk 1995)*

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.

* Noting:

- *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

If available, record information on the depth of the water table and on seasonal variation in the water table depth in the near vicinity of the wetland habitat.

ii) Physico-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 21: 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
Where known, 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. 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.

Table 22: 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

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.

Table 23: 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 +

Transparency

Provide the annual range of water transparency, as recorded with a 20-30 cm diameter Secchi disc, 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 according to the transparency categories shown in Table 19.

Table 24: 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

Whilst the term ‘colour’ should not be confused with ‘transparency’, it should be noted that the ‘opaque’ category can be subdivided into:
‘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 phosphorus (ortho-phosphate and total phosphorus) concentrations 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 according to the categories shown in Table 20. If insufficient data are available this should be stated.

Table 25: General relationship of wetland productivity to average concentrations of total phosphorus (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 phosphorus the test is based on the classic molybdenum blue colorimetric test for 'weakly coordinated' phosphate, otherwise known as orthophosphate, or filterable reactive phosphorus (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 the groundwater in unconfined shallow aquifers in the general area.

iii) Biological features

a) Vegetation

Dominant assemblages

Using Table 21 as a guide, 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 the regional / state level. For open water areas indicate the stable state, i.e. whether the water body is macrophyte or phytoplankton dominated.

Table 26: Example format for categorisation of vegetation assemblages (example from Tasek Bera, Malaysia)

Vegetation assemblage	Total area in wetland (Ha)	% 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) which indicates 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 & 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 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 live in water'.

Table 27: Example format for categorisation of plant species (after Finlayson et al 1989)

Species & common name	Growth Strategy	Growth Form
Eleocharis sphacelata *Cyperus platystylis* *Fimbristylis denudata*	Perennial	Aquatic emergent sedge
Eleocharis dulcis	Geophytic perennial	Aquatic emergent sedge
Nymphoides indica	Perennial	Aquatic floating-leaved herb
Myriophyllum dicoccum	Annual	Aquatic emergent herb

Species & common name	Growth Strategy	Growth Form
Dysophylla stellata *Limnophila gratioloides*		
Oryza meridionalis	Annual	Aquatic emergent grass
Sesbania cannabina	Annual	Aquatic emergent shrub
Melaleuca cajuputi	Perennial	Aquatic / terrestrial tree

Note: species listed do not necessarily occur in Pakistan.

Alien invasive species and environmental weeds

List alien invasive species and environmental weed species, 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

Using Table 23 as a guide 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.

Table 28. Example format for recording plant species and assemblages of conservation significance (example from Tasek Bera, Malaysia)

TAXON	TAXONOMIC GROUP	DISTRIBUTION	STATUS	LEVEL
Cryptocoryne purpurea	Araceae	endemic to Tasek Bera	Not Determined	

The UNEP-WCMC Threatened Plants Database: http://www.wcmc.org.uk/species/plants/plants.by.taxon.htm is a useful reference in that it contains information on the status of plant species of conservation significance throughout the world.

Vegetation cover

Using aerial photographs or cover maps of the habitat, normally obtainable from the offices of local planning authorities and / or governmental agricultural or forestry services, describe the 'vegetation cover' by estimating the relative proportions of vegetation cover and open water by using the categories proposed by Semeniuk & Semeniuk (1995).

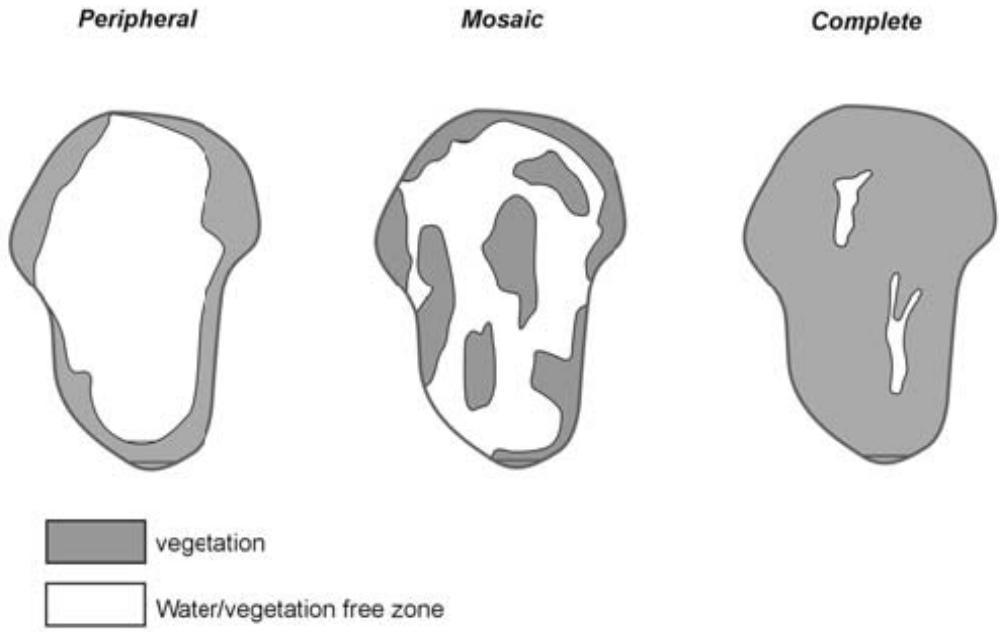


Figure 11: Categories of vegetation cover (after Semeniuk *et al*., 1990).

These are illustrated in fig 11 above. 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 aerial extent of the vegetation cover is greater than 90%, the cover can be considered as 'complete'.

b) Fauna
Dominant assemblages and species
In order to provide some information about the species' richness and diversity for each of the main taxonomic groups (i.e. invertebrates, vertebrates — mammals, reptiles, amphibians, birds, fish, etc) a list of animal species associated with the site is developed. This must include invasive/alien species and species considered as pests.

Species of conservation significance
Using Table 24 as a guide, list species of conservation significance (endangered species first, followed by vulnerable and low risk species) including those protected under national or state legislation as threatened.

As done in the case for species of conservation significance at meso level, use the '2000 IUCN Red List of Threatened Species' (http://iucn.org/redlist/2000/index.html) to determine internationally important and endangered species supported by the habitat. Some of the species are placed in the 'data deficient' category by IUCN because of lack of research conducted on them. Such species should not be ignored, this is in fact a very sensitive category from a conservation prespective, therefore, such species should be highlighted and any information gathered should be recorded.

For fish species the following can also be used (http://www.fishbase.org/search). For the purpose of determining species of National significance supported by the habitats of interest other local data sources include National Red Data Books (if available) and local experts.

Table 29: Example format for recording animal species and assemblages of conservation significance (example from Tasek Bera, Malaysia)

Taxon	Taxonomic group	Distribution	Status	Level
Scleropages formosus	Pisces; Osteoglossidae	SE Asia	Endangered	Global (IUCN 2000)
Balantiocheilos melanopterus	Pisces; Cyprinidae	SE Asia	Endangered	Global (IUCN 2000)

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 (key species, largest concentrations, etc.) 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 / increased over time.

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

Table 30: Example format for the tabulation of population abundance data (a) and information on breeding populations (b)

(a)

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

(b)

Species	Number of breeding records

Alien invasive and vermin/pest species

List and describe the alien invasive and vermin/pest species (it is important to note that some species might be considered as pests but they might be protected and/or ecologically significant such as bats. It is critical to define what is actually a pest and

what is considered as pest by people) present in each habitat, indicating which species are introduced or exotic.

c) Habitats

Using the most widely accepted existing habitat classification scheme tabulate the habitats of the wetland and, 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 31: 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 rushes and reeds	Waterbirds	Numerous surveys (50+) have been conducted over the period 1965 – present
River channel	Fish	August 1994

d) Biological significance of the habitat

Use the criteria for identifying wetlands of international importance defined by the Ramsar Convention (http://www.ramsar.org/key_criteria.htm) to describe the biological importance of the habitat. The Ramsar Convention presents eight criteria to assess the importance of a wetland habitat with a specific emphasis on birds and fish (Table 27).

Table 32: 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 bio-geographic 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 bio-geographic 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 water birds.
6	regularly supports 1% of the individuals in a population of one species or subspecies of water bird.
7	supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are

Criterion	Description
	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.

Use the 'Waterfowl Population Estimates' (http://www.wetlands.org/IWC/WPE2toc.htm) to determine population estimates of waterbirds that meet criteria of internationally important sites.

Habitat classification

The AWI manual is focussed on collecting the core data that may be required, amongst other things, to classify a wetland habitat. Users of the manual are entitled to use whatever classification system they prefer. However, it is strongly recommended that, in the first instance, each site is classified using the terminology provided in Table 29 by combining the landform type (Table 12) with the water regime (Table 16). If required, water chemistry (e.g. salinity), nature of the bottom materials (e.g. sand, mud, clay), and vegetation (e.g. organisation, structure and floristics) can be used at a later stage to augment the primary units defined.

Table 33: Classification of the 13 basic wetland categories formed by combining landform and hydroperiod attributes (after Semeniuk & Semeniuk 1995)

Hydroperiod / landform
Permanently inundated basin
Seasonally inundated basin
Intermittently inundated basin
Seasonally waterlogged basin
Permanently inundated channel
Seasonally inundated channel
Intermittently inundated channel
Seasonally waterlogged channel
Permanently inundated flat
Seasonally inundated flat
Seasonally waterlogged flat
Seasonally waterlogged slope
Seasonally waterlogged highlands

The technical basis for the abovementioned classification system proposed is widely accepted. In addition, it provides useful mapping units and highlights an important natural resource management principle, namely that of conserving each of the recognised wetland types for the sake of preserving the ecosystem diversity of a particular landscape (Semeniuk & Semeniuk, 1995). The classification proposed provides a non-genetic framework on which to base further detailed work and is sufficiently robust to account for the variability of determinants such as climatic differences across the geographic regions of Asia.

Self-emergent wetlands (e.g. mound springs, some raised bogs and geothermal wetlands) are not catered for in the classification proposed above. However, such wetlands are rarely encountered.

Wetland goods and 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 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.

Land and water use
Describe and, where possible, map the manner in which the habitat is used by local people noting 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 etc.).

Describe the land and/or water use made of the habitat by local communities by refining expanding upon the data collated earlier at Level 3 (Table 10) noting, where appropriate, whether or not these are undertaken for subsistence or for commercial purposes and using mainly traditional or modern techniques.

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 / plans (if any) being employed / developed by agencies working in the area and record the number of people interviewed, 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.

Monitoring and management programmes
Provide details of any existing of 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) / organisation(s) responsible).

Datasheet 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: The date the datasheet was completed should be stated (e.g. 02 October 2001).