Pakistan Wetlands Programme

Pakistan Wetlands GIS Implementation Strategy

Wetlands

The Ministry of Environment's Pakistan Wetlands Programme

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List of Acronyms

AWI	Asia Wetlands Inventory
CBO	Community Based Organisation
CDA	Capital Development Authority
CITES	Convention on International Trade in Endangered Species
CMS	Convention on Migratory Species
DEM	Digital Elevation Model
ENERCON	Energy Conservation Agency
EPA	Environmental Protection Agency
GBIF	Global Biodiversity Information Facility
GIS	Geographic Information System
GPS	Global Positioning System
HWF	Himalayan Wildlife Foundation
IBIS	Indus basin Irrigation Schemes
ICIMOD	International Centre for Integrated Mountain Development
ICT	Information Communication & Technology
IGF	Inspector General of Forests
IUCN	The World Conservation Union
IWRB	International Waterfowl and Wetlands Research Bureau
MCWC	Makran Coast Wetland Complex
MENRIS	Mountain Environment and Natural Resource Systems
NCCW	National Council for Conservation of Wildlife
NGO	Non Governmental Organisation
NRM	Natural Resource Management
NCS	National Conservation Strategy
NWFP	North West Frontier Province
OSP	Ornithology Survey of Pakistan
PDF	Programme Development Fund
PFD	Provincial Forest Department
PFI	Pakistan Forestry Institute
PWGIS	Pakistan Wetlands Geographic Information System
PWP	Pakistan Wetlands Programme
RS	Remote Sensing
RSP	Rural Support Programmes
SDI	Spatial Data Infrastructure
SoP	Survey of Pakistan
SRS	Satellite Remote Sensing
SRWC	Salt Range Wetland Complex
SUPARCO	Pakistan Space and Upper Atmosphere Research Commission
SVDP	Soan Valley Development Project
UNEP	United Nations Environmental Programme
WSPS	Wetlands Survey Programme Section
WWF	World Wide Fund for Nature (a.k.a. World Wildlife Fund)
ZSD	Zoological Survey Department

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Executive Summary

Wetlands are valuable resources for wildlife and provide subsistence to communities. In Pakistan a great variety of wetlands are distributed throughout the country. Geographic Information System is used extensively in natural resource planning and management, all over the world. 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.

The overall goal of the PWGIS implementation strategy is to provide guidelines and framework for the development, implementation and management of Pakistan wetlands GIS. This strategy is developed after a thorough literature review of the available wetlands' inventories. It was concluded that AWI provides comprehensive guidelines for recording information and specification of GIS in context of Pakistan. PWGIS database and inventory will closely follow the guidelines and procedures given in the 'A Manual for an Inventory of Asian Wetlands'.

This document also examines the current state of Wetlands GIS in the country. There is dearth of information in digital format. GIS capacity of conservation organisations in the country was assessed through a SWOT analysis. Results showed that only about 40% of the respondent organisations have professional staff with basic GIS knowledge.

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 Spatial Data Infrastructure will be set up at NCCW for sharing and exchange of the produced datasets. Web-based application will be developed to explore and extract information on the status of wetlands.

Long term sustainability of PWGIS has been discussed in the strategy. This includes establishing a master GIS Laboratory at NCCW and small GIS set ups in the partner organisations. Data will also be disseminate through a web server and in the form a digital atlas of wetlands. GIS and Remote Sensing trainings will be imparted to the staff of conservation agencies in the country.

The financial and technical sustainabilty will be ensured by exploring opportunities (PC-1, donations, sales of products etc). In addition GIS Laboratory of WWF Pakistan will continue to support data processing, wetland mapping and analysis and hands-on trainings to the new relevant staff of NCCW.

1 Introduction

1.1 Background

Pakistan possesses a great variety of wetlands distributed almost throughout the country, from the coastal mangroves and mudflats on the Indus delta to the glacial lakes of the Himalayas (Scott, DA, 1989). The importance of these wetlands was first brought to the notice of the international community at a technical meeting on wetland conservation held in Ankara, Turkey, in October 1967 (Savage, 1968). Between 1971 and 1976, the IWRB sponsored a series of annual mid-winter waterfowl counts which revealed that the Indus Valley was a major wintering ground for a wide variety of waterfowl breeding in central and northern Asia. In 1976 Pakistan became a Contracting Party to the convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention, 1971). At the time of ratification, the Pakistan Government designated nine wetlands for inclusion in the Convention List of wetlands of international importance. By 2002, 19 wetlands of Pakistan have been internationally recognized by Ramsar Convention Bureau as of global importance. These wetlands comprise of unique habitat, species and genomes. Almost 130 million people are permanently and 3-4 million people displaced from other countries are dependant on these wetlands. These wetlands are under pressure due to their economic importance which causes deterioration to its ecological significance. Poverty, human ignorance and mismanagement are some of the major threats to the life of wetlands (PWP Document, 2003), and thus there is a substantial need to conserve these wetlands for the benefit of dependent communities and ecological stability.

In this connection, Project Development Fund (B) Phase of Pakistan Wetlands Project was initiated in year 2000 to prepare an initial baseline information and data of the existing wetlands with the aim to ameliorate the existing conditions of wetlands. A preliminary database of wetlands was established during PDF (B) phase as part of the planning phase of Pakistan Wetlands Programme. The on-going Pakistan Wetlands Programme (PWP) is based on the information produced during the PDF (B) phase of the project. PWP, a seven year project, aims at promoting the conservation of biodiversity of both freshwater and marine wetlands in Pakistan.

During the time period of PWP, the known information of the natural coastal and inland wetlands of the country would be amplified by enhanced GIS based wetlands inventory through field survey work and refining the existing *Wetlands GIS Database.* The expanded PWGIS will serve as a sophisticated and powerful decision making tool for planning and modelling for wetlands conservation and management. It will be used for interrogating and manipulating spatial and other data related to wetlands. Working copies of the established wetland's GIS database will form an integral part of a multifaceted decision support system and will be disseminated to partner conservation organisations/departments and other key agencies engaged in wetlands conservation in Pakistan.

1.2 A Profile of Wetland Ecosystems of Pakistan (Freshwater, Coastal, Marine)

Pakistan possess a great variety of wetlands distributed almost throughout the country, from the coastal mangroves and mudflats on the Indus delta to the glacial lakes of the high Himalayas (Scott, DA, 1989).

The following wetlands classification has been recorded in the Directory of Asian Wetlands in Pakistan.

- **Water storage reservoirs** on large rivers in the northern Punjab, Azad Kashmir and N.W.F.P., constructed mainly for irrigation purposes and the generation of electricity, and now supporting large numbers of wintering waterfowl. Examples include Chashma Barrage, Taunsa Barrage and the Marala, Rasool and Qadirabad Headworks in Punjab Province, Mangla Dam in Azad Kashmir, and Tarbela Reservoir in N.W.F.P.
- **Brackish lakes** with small water catchment areas in semi-arid hill ranges in the north-central part of the country, e.g. Nammal, Khabbaki, Ucchali, Jahlar and Kalar Kahar lakes in the Punjab Province.
- **Brackish Lakes fed by seepage**, e.g. Malugal Dhand and Thanedarwala in N.W.F.P., Kharrar Lake in the Punjab Province, and Phoosna and a number of other lakes in the Sindh Province.
- **Fresh to slightly brackish lakes**, dhands and ponds obtaining their water supply from canals, springs and streams, and managed for specific purposes. Examples include: Patisar Lake in Lal Suhanra National Park, Punjab Province, which was originally maintained as a stop-gap source of water for irrigation; Kinjhar Lake, Sindh Province, and Hub Dam, Sindh/Balochistan, which are maintained as a supply of drinking water for Karachi and irrigation water to agricultural lands in Sindh and Baluchistan and Haleji Lake, Sindh Province, which are maintained as a stop-gap supply of water for Karachi in the event of closure of the Kinjhar pipeline.
- **Small water storage dams** in the sub-montane tracts, e.g. Kandar, Tanda, Baran, Warsak and Darwanzi Dams in the N.W.F.P., Nammal Lake in the Punjab Provione, and Akara Dam and Band Kushdil Khan in Baluchistan Province.
- **Small offshore islands** with nesting site of sea-birds and marine turtles, e.g. Astola and Churna Island in Baluchistan.
- **Saline marshes** which receive their water supply from irrigation canals and have become saline because of the presence of salts in the soil and high rates of evaporation, e.g. Pugri, Kur and Kharki wetlands in the Sindh Province.
- **Freshwater marshes** maintained by seepage from irrigation canals, e.g. Beroon Kirthar Canal and Kund Lake in the Balochistan Province.
- **Deltas and estuaries** with extensive inter-tidal mudflats along the coast of Sindh and Baluchistan.
- **Estuarine mangrove forest** and mangrove swamps, particularly in the Indus Delta and in creeks near Karachi. Areas of rice paddies, flooded agricultural land and seasonally flooded grassland scattered throughout the Indus Flood Plains.

1.3 Institutions involved in wetlands conservation

Until now there exists no specific and separate agency or institute working for the conservation and management of wetlands in Pakistan, however, at the federal level the *Ministry of Environment* has the overall responsibility for coordinating all efforts related to natural resources and environmental management.

Principally the Forestry Wing of Ministry of Environment headed by the office of the *Inspector General of Forests* (IGF), is responsible for overseeing and administering the respective provincial conservation initiatives of biodiversity and forestry, and for national compliance with international obligations to which Pakistan is signatory. The IGF is assisted in these tasks by the National Council for Conservation of Wildlife (NCCW), the Zoological Survey Department (ZSD) and the Pakistan Forestry Institute (PFI).

National Council for Conservation of Wildlife (NCCW) is an attached Department of the Ministry of Environment, established in July 1974. It is working under the guidance of IGF. Its primary objective is to formulate appropriate policies for the conservation of wildlife, coordinate implementation of the policies by the provinces and liaise with International Agencies and Non-Government Societies for conservation of wildlife. It

receives policy guidelines from the Wildlife Board/Council headed by the Minister of Environment with representation of civil society and Provincial Wildlife Departments. It coordinates the efforts of Provincial Wildlife Departments for wildlife conservation and is also primarily responsible for maintaining links with international agencies such as the *Ramsar Bureau.* NCCW coordinates Pakistan's activities in accordance with its international obligations and agreements such as the Convention on International Trade in Endangered Species (CITES), Convention on Migratory Species (CMS) of Wild Fauna and Ramsar Convention on Wetlands. NCCW also controls the trade in endangered species of wild animals as per the provision of the international Conventions.

Zoological Survey Department was established in Pakistan in June, 1948, under the Ministry of Food & Agriculture as a counterpart of the Zoological Survey of India. In December 1972, the Zoological Survey Department was transferred from the administrative control of the Ministry of Food & Agriculture to the Ministry of Science and Technology. In November 1979, the department was again transferred to the Ministry of Food, Agriculture and Cooperatives. In November 1995, the Department was placed in newly created Ministry of Environment. ZSD monitors the fauna of the country, maintains records of important biota, and also advises the government on all zoological matters including conservation, management, export and import of wildlife, and imparts education and creates public awareness about wildlife conservation.

Pakistan Forest Institute is a research and training institute and offers graduate and post graduate training in forest management. Management of protected areas, wildlife and wetlands are mostly governed by the respective provincial/territorial wildlife departments/agencies, and enforcement of restrictions on resource use is also included in their mandate and has been trying to involve community in the conservation and management of these resources.

Provincial Forest Departments (PFDs) are responsible for the planning and management of forest resources, thus forest use in wetland areas is also principally regulated by the PFDs. They provide licenses for commercial extraction of wood and impose fines on violations of the regulations governing grazing and timber felling in government forests. Recently forest departments have initiated joint forest management approaches due to the increasing importance of community participation in forest management mainly in NWFP and Punjab.

Provincial/Territorial Fisheries Departments are responsible for awarding fishing contracts and monitoring harmful fishing practices.

Provincial Agriculture Departments provide agricultural extension services, and the livestock Departments supply advice for the maintenance of livestock, control of stock, diseases etc.

Provincial Irrigation Departments have the responsibility of managing the network of irrigation heads, canals and associated reservoirs that make up the Indus Basin Irrigation Schemes (IBIS) and a small scale irrigation works in other parts of the country.

Pakistan Navy and Coast Guards control, for strategic reasons, substantial wetland areas mainly along the Sindh coastal belt including jurisdiction over parts of the MCWC.

Other agencies consist of the Rural Support Programmes (RSP) at national and provincial levels. These provide credit and training to low income households for a range of income generating projects to reduce poverty. Several NGOs and CBOs also operate in these sites notably the SVDP in the SRWC and the OSP CIWC. The IUCN, HWF, Houbara Foundation and WWF are working closely with wetlands. IUCN has played a strong role in

strategy formation for biodiversity conservation while WWF has been an active partner in implementing community based conservation initiatives.

In Pakistan, wetlands are generally either Government or communal property except SRWC where private land claims exist on portions of area occupied by the lakes. Land in the vicinity of wetlands, especially agricultural land, is mainly privately owned but registered by the Land Revenue Department. The Pakistan Navy and the Coast Guards are active in the wetlands of the coastal area including MCWC.
According to a survey conducted in June 2001, none of the governmental agencies, engaged in wetlands conservation at federal, provincial or territorial level, had access to GIS data to facilitate their conservation programmes or associated decision making. The main reason is that there is no such consolidated and comprehensive GIS based information and data available on the status of wetlands.

1.4 GIS-based Wetlands Inventory of Pakistan

GIS-based Pakistan Wetlands Inventory is one of outcomes of PWP. This is the first ever attempt of its kind in Pakistan to systematically map the wetlands resources with their biological and socio-ecological significance.

1.4.1 Current status of GIS-based wetlands inventory in Pakistan

Before the Project Development Fund (B) Phase of PWP, most of the Information on the status of wetlands was in the form of unpublished reports. According to the PWP document very little information is available in the form of a superficial list attached to the draft Wetlands Action Plan (2001). Whereas, some descriptive details of about 48 wetlands are found in the Directory of Asian Wetlands Inventory (1989). However no comprehensive digital GIS database of the related parameters is available for such information. Nonetheless, only geographic coordinates of Ramsar sites have been systematically recorded so far. In the coastal areas of Pakistan several studies have been conducted on the mapping and change analysis of Mangroves forests by WWF-P and SUPARCO.

The Geographic Information System of Pakistan's Wetlands would, therefore, thoroughly and scientifically collect (primary and secondary datasets) and collate the information and datasets in the form of Pakistan Wetlands Geographic Information Systems (PWGIS).

1.4.2 The requirement of relevance of inventory in the national and international context

Pakistan has diverse wetland ecosystems with rich biodiversity. These wetland resources are distributed almost throughout the landscape of the country. The degree of extent of these wetland ecosystems is from the high mountains (Alpine wetlands) in the north to the plains and coastal areas in the south occurring in Punjab, Sindh and Balochistan provinces.

Many life forms of flora and fauna are dependant on these wetlands resources and their existence as a life support system is vital for the continuation of both biological and ecological life of the three major ecosystems i.e. terrestrial, aquatic and marine. These resources ultimately act as a major food supply and livestock sources for the surrounding communities.

There is an unbreakable link among wetlands, and their biodiversity in terms of wild fauna and flora, agriculture, livestock and human beings. The degrading conditions of these wetland ecosystems certainly affect the related biodiversity which interns alters

the whole ecosystem leading to the rise of poverty in the surrounding dependent communities. To arrest the problem of wetlands degradation and related wetland resources, an accurate and meaningful inventory on the existing bio-physical and socio-ecological status of wetlands is essential for the planning and sustainable management of these resources. Such an inventory should be in such a comprehensive form which could accommodate information of all other related fields so that an integrated management approach could be achieved in the future.

Currently, there is no well established standardised inventory based on geo-information for wetlands, forests, wildlife, fisheries, livestock, and agriculture in the country and those that exist have has limited scope and scattered structure. The PWI is aimed at gathering information not only on wetlands but also on the related social and ecological issues. The information system will be accessible to government, public, and private organisations/agencies for the utilisation in their decision making for natural resources management and planning. Pakistan Wetlands Inventory, at national level, has to provide a standard platform where the relevant departments and agencies from any part of the country can share and access the relevant data and information.

Wetlands ecosystem of Pakistan has also trans-boundary and international importance as they greatly support great number of migratory birds and waterfowl. Therefore, the mapping of wetlands and their environmental parameters should be in line with the international standards and guidelines in order to facilitate data exchange, comparison and ease of updating. In this context the GIS based inventory would follow those standards and guidelines on the delineation, mapping and database development of AWI. The AWI uses a strategic and hierarchical approach to collect information and takes advantage of new technologies of data collection, storage and dissemination. The PWGIS will closely follow the AWI methods and guidelines so that to synchronise it with the international standards.

1.5 Goal and objectives of the PWGIS Implementation Strategy

The overall goal of the PWGIS implementation strategy is to provide guidelines and a framework for the development, implementation and management of GIS-based PWI and to support the relevant partners to ensure their participation in this process.

Objectives of writing the strategy document before the start of full-scale activities are:

- To identify the gaps in existing GIS capacity of PWP partner organizations in term of human resource and infrastructure;
- To produce standardised protocols of GIS/RS techniques to be applied for the development of PWGIS.
- To discuss the means of dissemination of information gathered during the inventory development;
- To describe the envisaged approach to enhancement of capacity of the government and non-government organizations for sustainable utilization of GIS tools/techniques and;
- To act as a guiding force for the follow up activities to support the National Wetlands Conservation Strategy.

2 Approach to the development of Pakistan Wetlands Inventory

PWGIS Implementation Strategy is being developed to facilitate the process of establishing the inventory of Pakistan's wetlands. In this regard literature produced by some of the national and international organisations was reviewed to seek out their methods on the wetland resource management and the methods of making GIS based inventories.

There is no comprehensive and concrete geo-information and /or data available on the existing resources of wetland ecosystems in the country. Only non-spatial information in the form of reports and documents on some known wetlands are available. The Directory of Asian Wetlands (Scott, D.A., 1989) consists of a separate chapter on Pakistan wetlands where most of the descriptions are taken from a report based on the wetland datasheets and other information provided by relevant departments. In the Directory of Asian Wetlands, only 48 wetlands have been discussed with some description on relevant parameters in addition to their geographical locations (Lat/Long) in the form of a hard copy map.

Internationally, there are several wetlands inventory methods such as Mediterranean Wetlands Initiative (MedWet) Inventory, United States National Wetland Inventory, Uganda National Wetlands Programme and Ecuador Wetland Inventory which have been adapted according to the environmental conditions of that particular national or continental regions (see Appendix 2 for detailed description of each inventory method). These inventories were reviewed to acquire wetland data and information according to the standards and framework compatible with international standards. This will help to make the data comparison, exchange and sharing easy in the future. During the course of literature review it was concluded that AWI provides comprehensive guidelines for recording the inventory, information and specification of GIS.

AWI is developed by the Wetland International. Wetland International has conducted this study to demonstrate the completeness and adequacy of existing inventory base and it was revealed by the study that the existing inventory base was inadequate (Finlayson *et al*., 2002). It was further stated that the lack of standardised, systematic approach to wetland inventory across the Asian region has made it impossible to accurately assess the extent, pressures and degree of degradation of Asian wetlands. Recognising this urgent need, the Contracting Parties (CPs) of the Ramsar Convention called on participating governments to collaborate with the Wetlands International to review and further develop existing models for wetland inventory. Responding to this call, the AWI programme was initiated by Wetlands International in 1999.

The principle purpose of the AWI is to delineate and map the wetland resources of Asia, and to store this information in a GIS. The key features are that it is hierarchical and map-based with outputs at four levels of detail (Figure 1). The level of detail is related to the scale of the maps that are contained within a standardised Geographic Information system format with a minimum core data set. In the AWI four scales of mapping has been proposed. These are:

- 1:500,000 to 1:1000 000 scale maps for major river basins, coastal regions or inlands
- 1:250 000 to 1:500 000 scale maps for sub-basins and coastal sub-regions
- 1:100 000 to 1:250 000 scale maps for wetland complexes
- 1:10 000 to 1:50 000 scale maps for wetland habitats

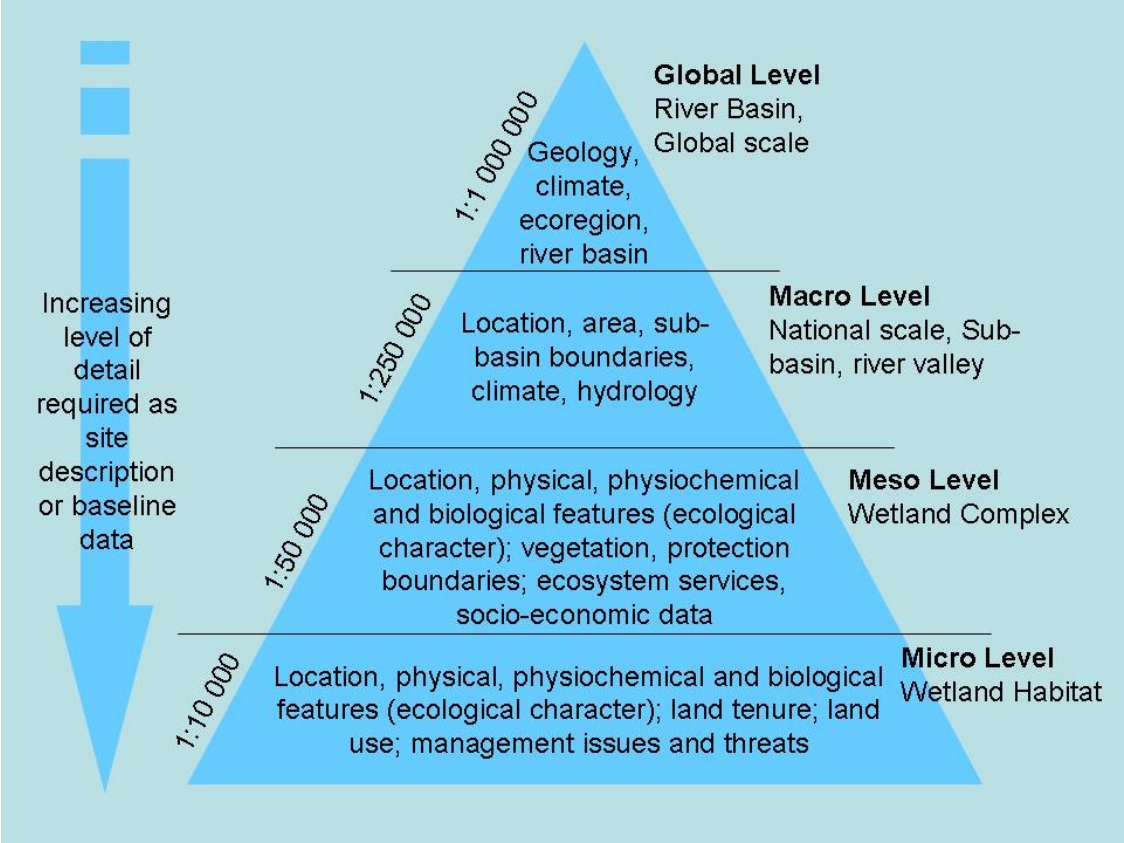

Figure 1: Hierarchical approach to wetland inventory, adapted from Finlayson *et al*., (2002) modified for Pakistani situation.

In AWI, information management of spatial datasets, databases and GIS techniques are the critical component. Extraction, analysis and management of information as an information management system comprised of three elements namely relational database, GIS software and datasets and the metadata. These aspects of the AWI will be followed in the establishment of PWGIS.

2.1 Framework for Pakistan Wetlands Inventory

There are several approaches that could be taken for the development of a state-wide wetland inventory. However, AWI is most suitable approach as its strategic and hierarchical structure will help to collect multi-scalar information and provide the advantage of new technologies of data collection, storage and dissemination. Additionally, by following the AWI methods and guidelines will help to synchronise it with international inventories. It is suggested that PWI should follow level 2, 3 and 4 of AWI as macro, meso and micro levels respectively (to represent sub-basin, wetland complex and local wetland habitat) in order to maintain its hierarchical approach.

The first levels of inventory, Global Level, is relatively complete in the form of Global Lakes and Wetlands Database (GLWD), G200 Ecoregions by WWF US and at national level by WWF Pakistan during preliminary assessment of wetlands of Pakistan under PDF (B) phase project, however details are lacking in levels 2, 3 and 4.

The description of what should be collected under PWI at the desired level is explained in the following appendices;

Macro (1:250 000) for sub-basins and coastal sub-regions (see Appendix 7)
Meso (1:50 000) for wetland complexes (see Appendix 8)
Micro (1:10 000) for wetland habitats (see Appendix 9)

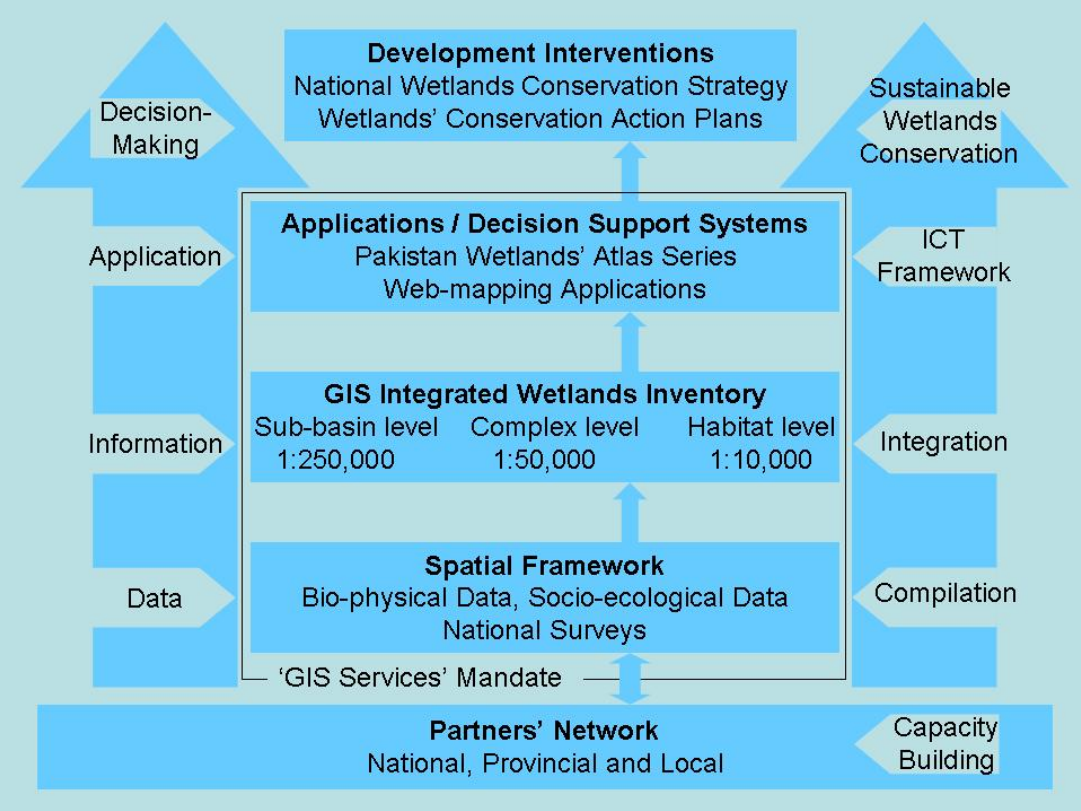

Figure 2: Framework of Pakistan wetlands GIS

2.1.1 Overall objective

National scale wetlands inventory should address five primary points given below:

- It will be designed to ensure the collection of **long-term data**, which will allow establishment of patterns of temporal variance in wetland condition.
- It will be **issue based** (e.g environmental flows, salinity, biota), and be easily adapted to assess and monitor the major threatening processes and significant biotic features.
- It will be **multi-scalar** (from local wetland habitat to sub-basin or river valley level) so as to provide appropriate information at required level of planning and decision-making.
- It will be **broad scale** (spread across Pakistan) so as to maximise the value of the program to stakeholders.
- It would also focus on measuring **ecological character** as a means of assessing **wetlands**

2.2 Partners' and stakeholders' GIS capacity assessment

As mentioned in the section 1.5, it is important to identify the in existing GIS capacity of PWP partner organizations. A questionnaire (Appendix 3) was designed to carry out SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis of partners and stakeholders. The SWOT also includes the questions on the available spatial datasets and databases with the respective organisation and the mechanism for sharing these resources. This questionnaire with a covering letter describing its survey purpose (Appendix 4: List of partners/stakeholders) was sent to relevant partners/stakeholders working at the national, provincial and territorial jurisdiction of the country. Summarised results of SWOT analysis are given in Appendix 6.

3 Spatial Data Development and Implementation

One of the core objective of implementing PWGIS in PWP is to enhance the role of spatial data in decision making by sharing it with users and researchers in the country. To achieve this, we need to proceed in a systematic way i.e.

- Scale dependent spatial data development for PWI
- Describing spatial data i.e. Metadata
- Spatial data cataloguing
- Spatial data visualisation through online mapping applications
- Spatial data products, its access and delivery

Before explaining the scale dependent spatial data development, there is a need to discuss issues related with raster and vector data standards.

3.1 Vector Data and Maps Standards

3.1.1 Base Maps

Updated base maps are important to compile multi-scalar wetland inventory. For this purpose GIS community always rely on the Survey of Pakistan topographic map sheets prepared at the scale of 1:50 000 and scale 1:250 000. However, all of these maps are not available for the entire Pakistan under public domain. Around 60% of these map sheets are restricted for private sector usage. However most of these cmaps are available to the government departments. In addition, the GIS Lab. of WWF Pakistan has complete coverage of Russian military maps at the scale of 1:100 000 which were originally developed from SoP maps but later corrected from the ortho-images using SPIN-2 satellite data. In case of unavailability of the SoP maps in any area, these Russian maps will be used.

3.1.2 Pakistan Wetlands Inventory Map Series

Survey of Pakistan standardised map catalogue of scale 1:1 000 000, 1:250 000, 1:50 000 and 1:10 000 will be followed. A standard 1:1 000 000 scale map covers larger area around Pakistan and falls under global level mapping as per AWI standards. A standard 1:1 000 000 scale map sheet (named in numeric figures) covers 4° x 4° area which is further divided into 16 equal units of 1° x 1°. These sheets are named in alphabetic order from A to P with respective 1:1 000 000 scale numeric prefix. For 1:50 000 scale maps, degree grid will further divided into 16 equal interval maps at 15' x 15' interval. Each of these sheets will further divide into 9 equal intervals of 5'' x 5'' maps at 1:10 000 scale.

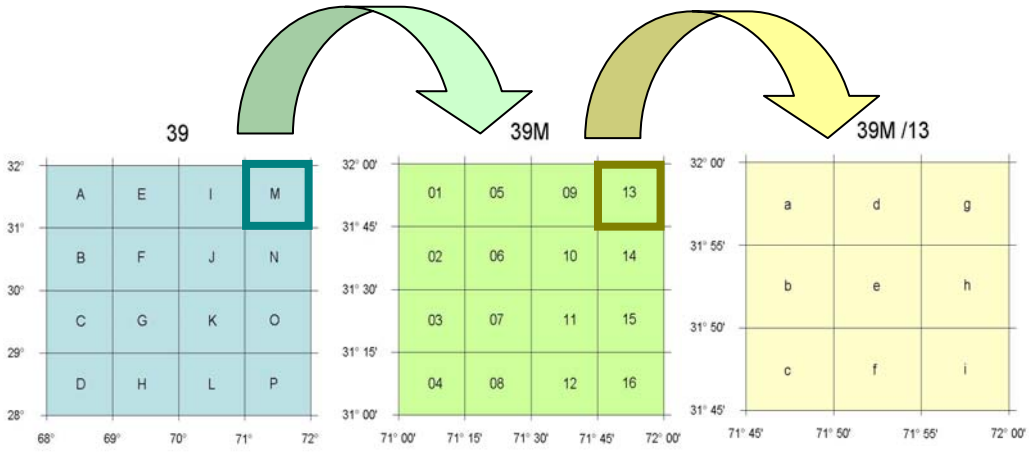

Figure 1: Pakistan Wetlands Inventory Map series catalogue showing extent and scale for (a) 1:250 000, (b) 1:50 000 and (c) 1:10 000 maps

The above model would be followed for wetland maps of the entire country. There are around 120 sheets of 1° grid to cover entire Pakistan which will show all the delineated wetlands (in the format as developed by WWF US for the Global Lakes and Wetlands Database) as well as basin/sub-basin boundaries. For the wetland complexes, ¼° grid sheets at the scale of 1:50 000 will be developed to plot the detailed inventory of wetlands. Larger scale of 1:10 000 will be used to map the wetland habitat of the selected sites.

3.2 Satellite images and raster data standards

3.2.1 Satellite data processing

It is imperative to process satellite data to a certain standard where it meets basic requirements of spatial details (resolution), positional accuracy and seasonal coherence. Same way, other raster datasets like DEM and its derivatives like slope and aspect datasets should be of same resolution to optimise its use with satellite images for analytic solutions such as vegetation terrain modelling.

Steps important to maintain raster data quality are following:

- Identification of appropriate resolution satellite data for hierarchal levels, for small scale maps prefer to acquire images whose swath is wider so as to handle less number of scenes for any analysis
- For vegetation mapping, use scene/data acquired during maximum vegetation vigour, e.g., in the plains post monsoon data while in the mountains early summer data is easier to analyse.
- Prefer to acquire full scene images instead of a cut on Area of Interest (AOI) as it facilitate image rectification easier.
- Prefer to apply ortho-rectification instead of geo-rectification as it provides positional accuracy better than standard rubber sheeting rectification.

3.2.2 Evaluation, acquisition and procurement of spatial data

Suitable and accurate spatial data and information makes work easy, saves time and cost, and gives accurate and target oriented results. It is, therefore, imperative to analyse and explore opportunities of the availability of suitable, good quality data before the actual work starts. In this connection all the available earth imaging satellite are searched for wetlands ecoregion mapping. It should be to acquire remote sensing

data that is good in terms of time/season, free of clouds and other distortions so that to reduce processing time. The satellite data would be evaluated and used according to the scale of mapping different wetlands e.g. medium resolution data from (SPOT-4 or TERRA based HRV or ASTER sensors) will be used for the delineation of wetlands landcover at 1:50,000 scale while high-resolution data (from SPOT-5, QuickBird or IKONOS satellites) will be used for the delineation of wetland habitat mapping at 1:10,000 scale. Nonetheless, following SRS data (Table 1) is recommended to be acquired for different scale specific wetland ecosystems.

Table 1: Specifications of RS satellites data available in the market

Satellite	Sensor	Spatial (m)	Swath Width (km)	Price		
				Archive	Tasking	
					Normal	Priority
TERRA	ASTER*	15 - 90	60 x 60	91US$ 80$***	Free but depends upon the approval of research proposal	
Quick Bird	QB*	0.6	16.5 x 16.5	22.50$/Km2	Yet to inquire	
		2.4		24.0 $/Km^2 (Bundled)		
IKONOS	IKONOS*	1	11.3 x 11.3 13.8 x 13.8**	16$/Km^2	20$/Km^2	
		4		16$/Km^2 18$/Km^2 (bundled)	20$/Km^2 24$/Km^2	
SPOT-5	HRV*	2.5 -5	60 x 60	189,000 PKR	Yet to inquire	
		10 - 20		314,000 PKR		
IRS-1C/1D	IRS-1C*	5	70 x 70	110*** Euro	Yet to inquire	
	LISS-3	23.5	142 x 142	200*** Euro	Yet to inquire	
		70.5	148 x 148			
	WiFS	188	774 x 774	110*** euro	Yet to inquire	
OrbView-3	OV-3*	1	8 x 8	14$/km^2	Yet to inquire	
		4		14$/Km^2 37$/Km^2 (stereo pan)		
EO-1	Hyperion	30m	7.7 x 7.7	250$	2500$	
	ALI	10m	37 x 37	250$	2500$	
		30m			2800$ (bundled)	
EROS	EROS*	1.8m	12.5 x 12.5	1500$	Same	Same
ALOS	AVNIR-2	10m	70 x 70	Launch expected in Jan 2006 Looking forward to develop partnership with International agencies working on wetlands		
	PRISM*	2.5m	70 x 70			

* Stereo capable
** During stereo mode
*** FTP download option
**** Band width 10 nm

A complete coverage of Russian Topographic Map-sheets for Pakistan at scale 1:100,000 are available with WWF Pakistan. These maps together with Topographical Map-sheets of the Survey of Pakistan (SoP) (to be acquired through PWP) would be used for the extraction of topographical and cadastral information. The maps will be scanned at 300dpi resolution, geo-referenced and digitized for information extraction of drainage, wetlands catchments and sub catchments, road network, main habitations, contour heights, infrastructure etc and sub-catchments of wetlands. The scale of digitized features would be kept according to the nature of wetland ecosystems on national, regional and individual wetland basis. This procedure will be further supported by using any available maps of wetlands, vegetation maps or any other relevant geo-information/data.

3.2.3 Preferred raster resolution

High resolution data are always good but their use is limited for large scale mapping however to develop national scale inventory, medium to low resolution images are needed which are optimised for multi-scalar mapping. Similarly, for elevation models 90m resolution SRTM data is universal and needs corrections before using it in PWI. The preferred raster resolutions are;

- For macro-level inventory, use data from TERRA or SPOT-4 satellite onboard sensors ASTER or HRV which ranges from 15m to 90m and 10m to 20m respectively. The swath of data (60km x 60km) is sufficient to cover entire Pakistan though data processing such as data mosaic would be much tedious and difficult to achieve colour balance for the entire mosaic
- For macro-level, process latest images to make mosaics at 1° x 1° level for the entire country, if data are not available or available with could cover for some part with the degree grid then make montage of latest data with the existing mosaic of circa 2000-01 based LANDSAT ETM+ data to fill in gaps
- For meso-level inventory, use data from HRV sensor onboard SPOT-5 satellite which is available at resolution from 2.5m to 5m and 10m. Prefer to use same data multi-spectral and panchromatic images to develop high resolution merge.
- At meso-level, make 15' x 15' mosaics, use same approach of making montage with either latest ASTER or SPOT-4 data or otherwise use LANDSAT ETM+ data
- At micro-level, it is recommended to use the highest spatial resolution data e.g. IKONOS or QuickBird.
- Make 5'' x 5'' mosaics for micro level mapping and use same approach for filling gaps due to missing datasets

3.3 Scale-specific spatial data

The spatial data will be maintained the proposed map series format mentioned in the section 3.1.2. This will help the programme to keep updating by incorporating latest satellite images as and when received and processed. To maintain a good track of different map versions, it is suggested to follow similar mechanism as adopted during software upgrading. With every considerable improvement (for updating of base data and new vector layers), map version will increse one full number (i.e. from version 1.3 to version 2). However, with the minor correction like spellings of habitations version could be increased in tenth unit value i.e. from version 1.3 to version 1.4). In addition to this, map sheets should be stored in PDF format and its older versions should be kept online for reference purposes.

3.3.1 River valley/sub-basin level maps at 1:250 000 scale

Reprint topographic map sheets (around 120 maps at 1:250 000) updated from latest satellite image (from Aster or SPOT-4 and montage with LANDSAT ETM+ mosaic

where new data are missing/eroded). These maps should show following layers of data and information.

- Basin/sub-basin boundary with updated ASTER/SPOT-4 satellite images in the back drop
- Wetland complex boundaries
- Annotation of Individual wetlands/rivers
- Annotation of individual protected areas and other ecologically significant sites like reserve forests or community based hunting sites etc.
- Major cities and villages/communities
- Province/district boundaries

A sample map (Figure 4) is showing the mosaic of Landsat ETM+ and latest Aster data for the Indus River. Above suggested layers will be added. It will be developed as updated SoP map sheet at the given scale having similar information like it.

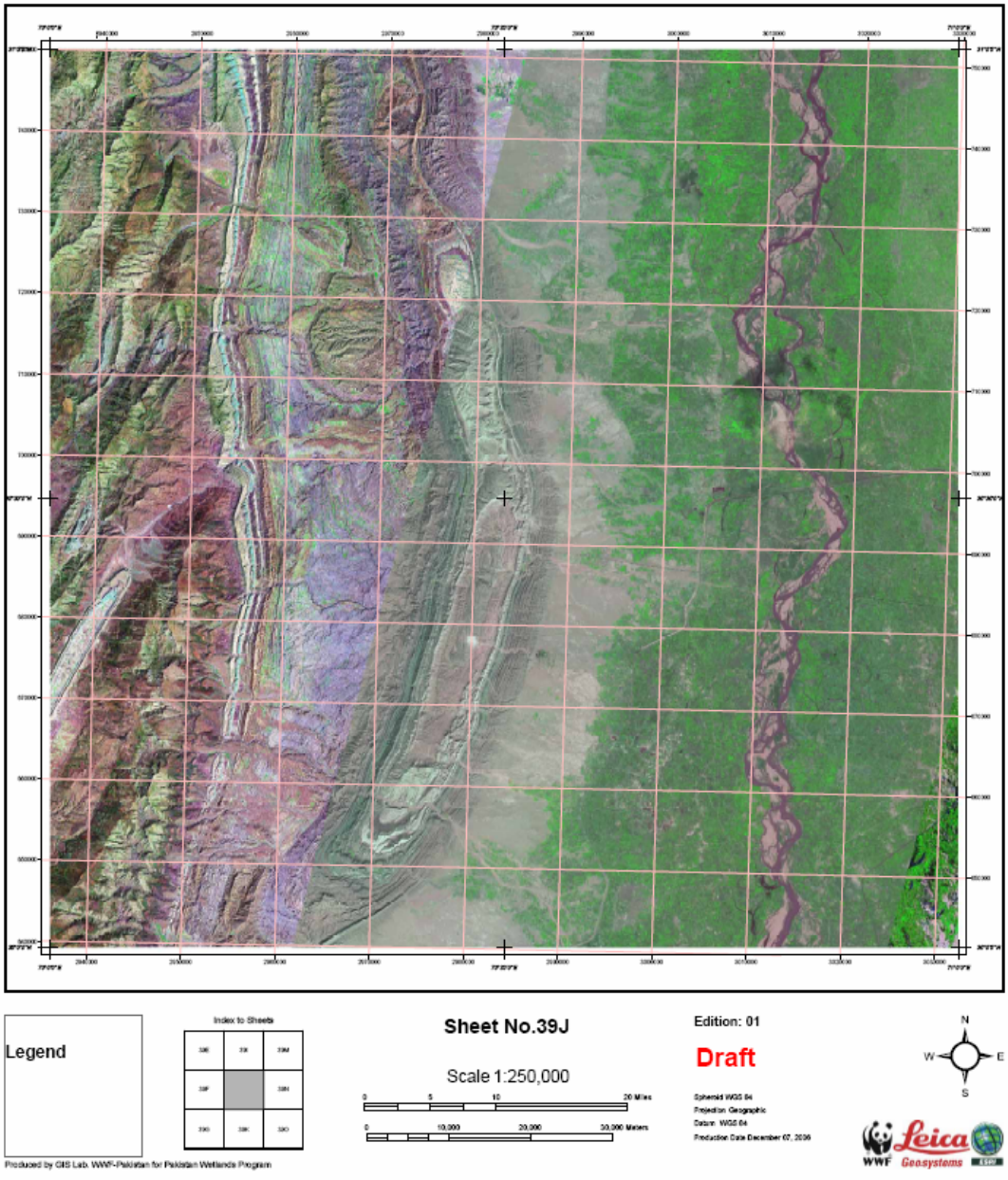

Figure 2: A sample map at 1:250 000 scale, to be developed for the entire Pakistan to maintain PWI at macro level

3.3.2 Wetland complex at 1: 50 000 scale

Reprint topographic sheets at 1:50 000) for only wetland complexes using medium resolution satellite images from SPOT-5 to be shown with following layers;

- Individual rivers and/or lakes banks and boundaries
- Wetland complex boundaries
- Generic landcover from satellite image classification/wetland habitat classification (source: FSMP 1992)
- Delineated boundaries of Protected areas
- Major village/communities
- Roads/tracks
- District and Tehsil boundaries

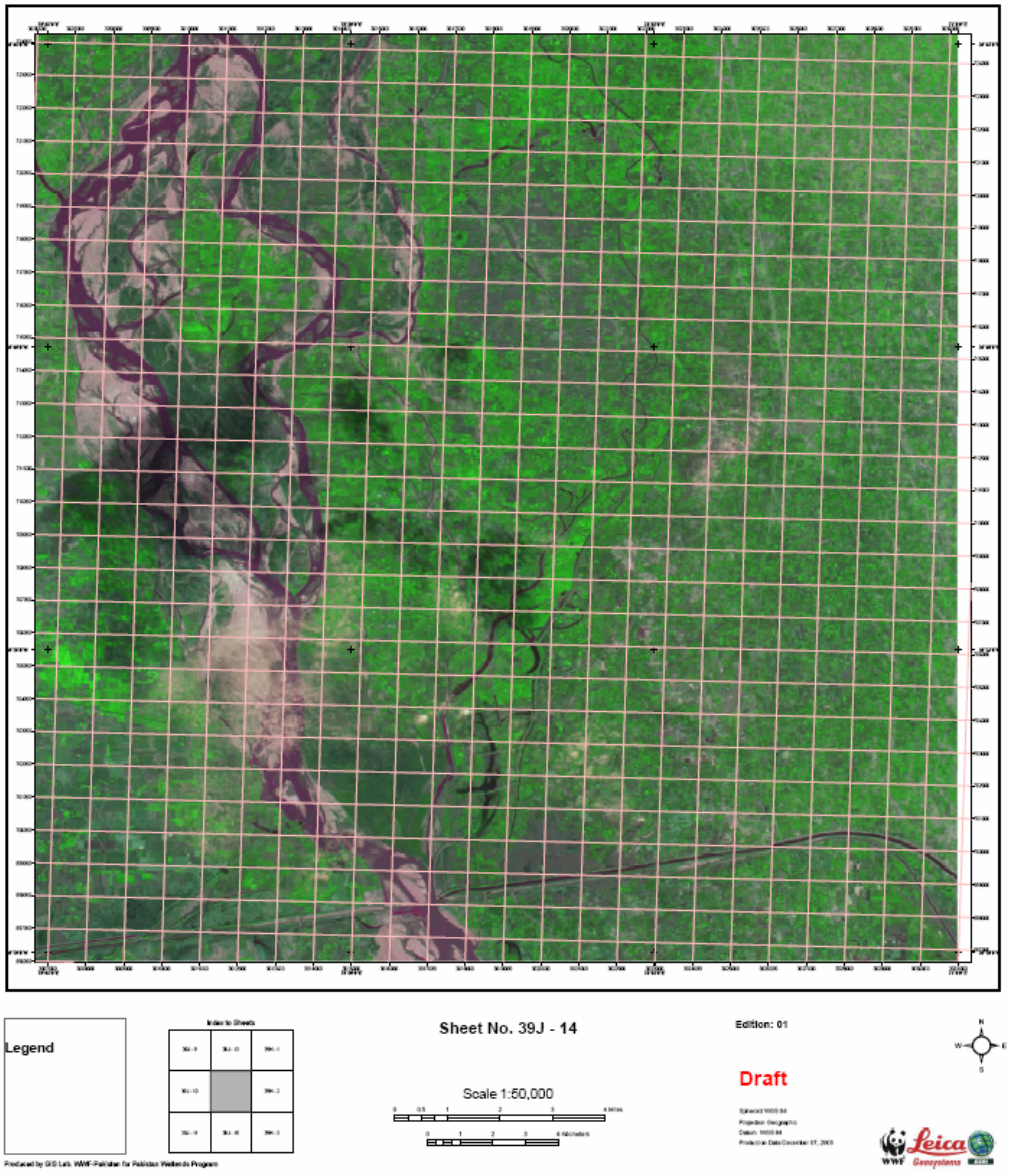

Figure 3: A sample map at 1:50 000 scale, to be developed for the four wetland complex to maintain PWI at meso level

This sample map shown in Figure 5 indicates latest ASTER satellite image based map of otherwise restricted map sheet (i.e. 39J/14) due to strategic position of Taunsa barrage which is also a ramsar site. In ideal circumstances, the base layer should be based medium resolution SPOT-5 data at 2.5m to 5m resolution. As the final map layout will be similar to SoP GT sheet, this map will ultimately supplement to the restricted SoP map.

3.3.3 Individual wetland habitat at 1: 10,000 scale

Reprint topographic map sheet at 1:10 000 using 9 division of meso level map i.e. 1:50 000 for the selected wetlands (either lies within complexes, or any ramsar sites or other ecologically significant lakes as identified by PWP). These maps should show following layers of information;

- Detailed wetlands habitat (based on species level)
- All villages/habitation location and annotation
- Boundaries of protected areas
- Roads/tracks

- Tehsil and revenue boundary

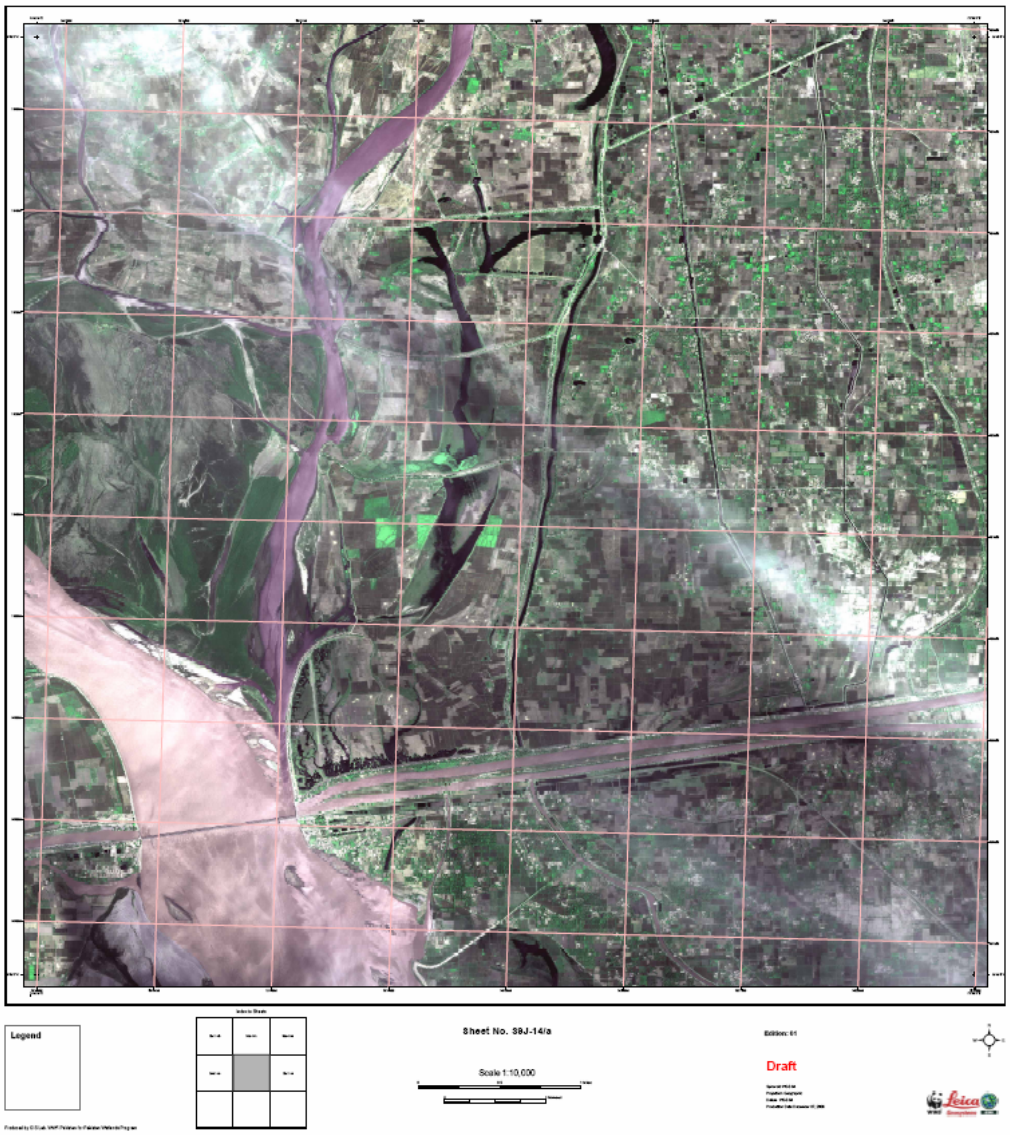

Figure 4: A sample map at 1:10 000 scale, to be developed for individual wetland habitat of selected wetlands to maintain PWI at micro level

The sample map (Figure 6) is showing latest 0.6m high resolution QuickBird satellite image based map (i.e. 39J/14c) which otherwise is non-existent in SoP map series catalogue at the scale of 1:10 000.

3.4 Field data collection during baseline surveys

Based on the previous experience of the GIS laboratory it has been observed that the collection and provision of geo-data from different subject consultants has not been in accordance with the requirements of the GIS interface. Most of the filed surveys have been conducted in isolation and without the consultation of GIS personnel. This situation has led to wastage of resources and delays in the delivery of results. Also it has always been an issue to reinterpret, translate and put the data into the spatial format. To bridge this communication gap, synchronize information and data, and bring into the line of GIS, it is imperative to establish the standard procedures for field data collection.

GIS laboratory of WWF-Pakistan will be in regular contact with the PWP subject specialists to develop meaningful data encoding forms for the acquisition of field data. It

will assist GIS personnel in the handling of data interpretation for certain spatial and non-spatial data parameters, improving data processing and presentation.

GIS personnel will be having regular meetings and discussions with each subject specialist, through the Survey Coordinator of PWP, during or prior to the filed survey to define the rules and design standard formats of data encoding forms. The purpose is to adjust the collected data according to the requirements of geo-database, and to ensure conformity and uniformity of spatial database. Further to this, regular contacts would be kept with the relevant partners and stakeholders to accommodate their needs of data.

3.5 PWI data model and its database implementation

An initial data model of the PWI has been defined which is primarily based on AWI. Three main components, environmental characteristics, time-series biological survey observations and spatial datasets related to wetlands were identified. Standardised data models for these three components, were studied respectively i.e. *A Manual for Asian Wetlands Inventory*, *An information model for biological collections* and *Geograpic Information – Metadata ISO 19115*. A comprehensive database, PWI data model, was designed by modifying and integrating them together to serve the specific needs of the inventory.

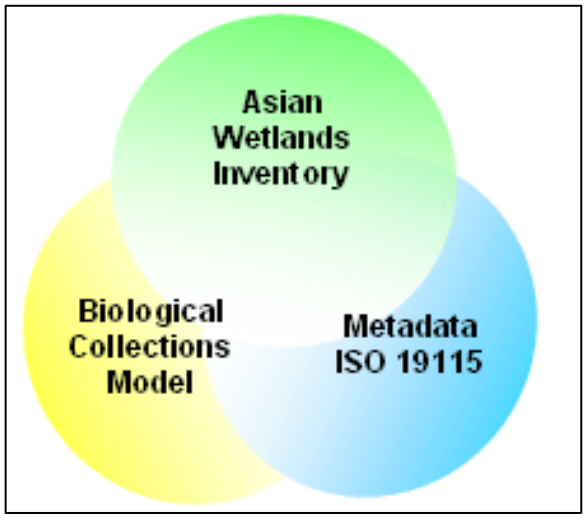

Figure 5: Reference studies integrated into PWI data model

PWI data model incorporates the systematic gathering of field obsevations under the PWP's WSPS. The model can effectively store information gathered from multiple survey events at different wetland sites (locations) involving various partner organisatons.

PWI data model includes numerous spatial elements/entities. To tightly couple spatial information with non spatial entities an open source spatial database, Postgres/PostGIS will be 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. Moreover, same database platform is being deployed by the international organizations like Global Biodiversity Information Facility (GBIF) and UNEP Geo Data Portal in their data storage and data dissemination applications.

In conventional GIS, data are stored in file structure into directories while a spatial database is a database that is optimized to store and query/retrieve data related to objects in space, including points, lines and polygons. 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).

3.6 Pakistan Wetlands Spatial Data Infrastructure

The term Spatial Data Infrastructure (SDI) is used to denote the relevant base collection of technologies, policies and institutional arrangements that facilitate the availability and access to spatial data (Henricksen, B 2006). The SDI provides a basis for spatial data discovery, evaluation, and application for users and providers within all levels of government, the commercial sector, the non-profit sector, the academia and by citizens in general.

The geo-information (ecological and bio-physical data) and maps of wetlands developed during the consultancy services will be stored in a format compatible GIS for easy access, retrieval and update. A Spatial Data Infrastructure will be setup at NCCW by defining the procedure for sharing and exchange of the produced datasets and facilitating this process by providing related tools/technologies. An efficient mechanism has to be devised to store the acquired datasets and information, and a mechanism to access and disseminate these spatial datasets.

3.6.1 Web based mapping application development

The development of user-friendly decision making tools is the most important and interesting way to explore and extract information on the status of any particular wetland. Through these tools, one can identify and judge the existing conditions by setting a set of desired criteria. These decision tools can consist of a number of spatial queries through which the geo-datasets will be searched according to the desired criteria.

A web browser based application will be developed on the data of the inventory. Increasingly, browser based application are taking over the desktop applications because of the multifaceted benefits of this architecture including server based application management and wide access from any remote area. Application for the PWI will also be built on built on the same client server architecture. This architecture will greatly support geographically distributed organizational structure of the PWP.

3.6.2 Digital Atlas of wetlands

In order to provide interoperable, open and cost effective data and information services to PWP users group (partners, stakeholders and to general public users within and outside the PWP), the PWI datasets will be written on to a CD-ROM with the name of "*Digital Atlas of Wetlands".* The CD-ROM will contain all the collected and processed data and information in the shape of vector and raster/grids along with their non-spatial data.

To view and access these datasets, special standard GIS software such as ESRI's ArcPublisher®, Map Book modules and ERDAS Imagine Virtual Delivery® are recommended.

ArcReader programme is also suggested to be used for viewing, querying, displaying and identifying geographic datasets of Atlas; and to pan and zoom through multiple map layers and also printed with this programme.

3.6.3 Spatial data update, upgrade, revise and exchange

At national level, the geo-datasets will be distributed through the establishment of a master GIS lab at NCCW and regional GIS labs in partner's institutes; development of a digital atlas of wetlands on CD-ROM and web accessible; and Web-based Map Server; and building the partners GIS capacity for handling GIS data

Internationally, the wetlands geo-spatial datasets accessibility will be launched after broad based initial discussions with Ramsar and Wetland International on the development and mechanism of data distribution and accessibility. Thus their requirements and suggestions would be incorporated in the development and dissemination mechanism of PWI in order to achieve the compatibility and coherence of the data with other Asian wetland inventories in the region. For this purpose, contacts will be established with RBWI.

A central repository of the final spatial database of PWI would be at NCCW. Thus the proposed spatial database will be accessible on-line from the NCCW to all relevant partners for their ready use with the capability of storing and retrieving of information/data from the established mechanism. However, a specific log-in system is under consideration for the registered users only where they could be able to access specific sets of data and of particular nature.

4 Sustainability of Pakistan Wetlands Spatial Data Infrastructure

4.1 Support in establishment of GIS Labs

4.1.1 Facilitating NCCW based comprehensive WIS Lab

GIS Laboratory of WWF Pakistan will extend its services to facilitate the NCCW in the establishment of a master and comprehensive GIS laboratory. This GIS Lab will work as a central repository where the collected and processed data will be stored and shared with the PWP partners and other interested stakeholders of PWP.

GIS Lab will be equipped with the required geo-spatial technologies software (e.g., Arc GIS, ERDAS Imagine), Hardware (e.g., computers, scanners, servers and printers/plotter), and skilled GIS staff. In the domain of geo-spatial software, ArcView GIS will be installed in the NCCW GIS lab as the main data processing platform due to its wider use and applications in the public and private sectors. It will facilitate and make easy data exchange, sharing, integration and production for its wider use of PWP partners and stakeholders. Further it is very user friendly software and can be used as main GIS training software in the GIS training programme.

For satellite data processing, ERDAS Imagine software will be the main RS software to be purchased and installed in the concerned GIS lab. It is a widely used software in many public and private agencies, and is also the main satellite data processing platform in the WWF GIS facility.

In total six computer systems will be purchased. These computers will be primarily used for spatial data processing and Analysis. However, during training period, these computers will be used for conducting GIS/RS training sessions for the capacity building of nominated candidates of PWP partners. During training session and/or data processing, the systems could be used by research students for conducting their post graduate research studies.

A server will be set up to work as main data storage facility where all the processed data of wetlands would be kept.

4.1.2 Support in establishment of GIS Labs with identified regional partner institutions

Ease of data collection, update, access and dissemination are crucial to the future success of PWGIS. Wetlands information and data are quite diverse and region specific which may be difficult to be processed, analysed in the central NCCW GIS lab due to the initial shortage of resources in the central lab. Thus to expedite data collection and processing, small GIS setup are considered to be established in the partners identified in the PWP project document.

In total, apart from the central NCCW GIS set up, a number (6-7) of small GIS set ups would be established in the identified partner agencies/organisations to take advantage of geospatial technologies and geospatial data of wetlands ecosystems in their respective regions.

This small size GIS set ups would serve to collate, create and maintain geospatial data of wetlands in their respective jurisdictions. These set ups would also be used to

deliver and receive geospatial data from and to the central GIS lab. GIS labs of all partner organisations will be connected to the central server based ArcView GIS platform minimising the cost of software purchase and human resource and time. This internet based ArcView GIS can also be used as online training resource for the capacity building of the concerned staff of partners.

Partners' laboratories will work as regional data repository maintaining and storing region specific wetlands datasets, thus this processed data will be shared with the central GIS lab and other partner laboratories via web based applications.

4.2 Capacity-building in spatial data use and handling

Institutional development and capacity building are major activities under the PWGIS services contract. The objective is to introduce GIS/RS and GPS technologies to the staff of PWP partner organisations, important stakeholders and NGOs.

4.2.1 Training of government line departments

There is an immense importance to enhance the skills of the concerned staff in computing, GIS and Remote Sensing by providing them hands-on trainings in these disciplines. This will build the skills of relevant staff of the government line agencies in GIS data handling and use, a comprehensive GIS training programme will be chalked out. Prior to the conduction of training programme, a comprehensive training needs assessment exercise will be conducted to find out the gaps within the existing knowledge base, the assessment of existing skills, cost effective methods for sharing them, the requirements for upgrading of skills and the acquisition for new and specialised skills.

In light of the training needs assessment, different level of training programme with specific durations will be identified and implemented with the cooperation and support of national and international training institutes like Pakistan Forest Institute, National University of Science and Technology, ITC of the Netherlands, ICIMOD of Nepal.

Activities to accomplish this task would include:

- Developing level wise GIS/RS/GPS training modules of different durations to address the specific needs of partners;
- Imparting training courses on regular intervals;
- accreditation from HEC and to establish linkages with HEC certified educational institutes to conduct certified courses.

4.2.2 Training of NGOs and other partners

NGOs and private sectors also have an important role in wetlands management activities. Currently the understanding capabilities of NGOs and private sector regarding GIS/RS knowledge and skills are in the embryonic stage and require at least basic hands-on training on use of GIS. Therefore, it is also envisaged to include these sectors in the proposed training courses to get them acquainted with how to use and implement GIS/RS techniques in wetlands management. Relevant staff from NGOs and other private sectors would be identified and their training needs and resources would be assessed to chalk out a necessary training programme.

4.3 Financial and technical support

The long term sustainability of PWGIS requires adequate financial and technical resources to support the GIS labs in the NCCW and other partner organisations. This could be achieved through continued funding, sustained skilled staff and equipments.

4.3.1 Exploring opportunities to strengthen PWGIS

The continuation of PWGIS greatly depends on retaining the skilled GIS personnel, the modernisation and up-gradation of computer systems and other accessories and continued inflow of data and information for keeping the wetlands information up-to-date.

Regarding the PWP GIS staff, once they are trained, would become more readily marketable as the government salaries and benefits are not equivalent to the private sector. Similarly for maintaining up-to-date hardware, software and other accessories adequate financial resources are required at regular basis which is always a limiting factor at the government side.

In such scenarios, to keep the PWGIS functional and sustainable, it should be self financing from various sources e.g. PC-1, the sale of the various GIS products and securing donations from other sources.

The NCCW authorities should prepare new PC-1 on regular basis securing continued funding to retain PWGIS employees and other operational costs etc. It is also necessary to provide continued professional trainings (in-country and abroad) to the PWGIS staff in GIS/RS applications to keep them abreast with new technological developments and its applications in NRM activities.

Likewise, PWGIS should seek internal customers/users, to which GIS products (hard copy maps, Digital Atlas of wetlands on CDs, DVDs etc) can be sold, within partners, stakeholders and in the private sectors working for the management of natural resources. These may include forestry, wildlife, fisheries, agriculture, irrigation, WAPDA, EPAs, various donor funded NRM projects and NGOs etc.

4.3.2 Continued technical support from WWF-Pakistan to NCCW's WIS Lab

There is a dire need to continue technical support to the NCCW's WIS Lab (Wetlands Information Systems Laboratory) to keep this newly established setup on track. Opportunities can be explored so that the GIS Laboratory of WWF Pakistan can continue to support data processing, generation, mapping, analysis and hands-on trainings to the new staff.

5 References

Finlayson, CM; Begg, GW; Howes, J; Davies, J; Tagi, K & Lowry, J (2002). A Manual for an Inventory of Asian Wetlands: Version 1.0. Wetlands International Global Series 10, Kuala Lumpur, Malaysia.

Harris, JH & Silveira, R (1999). Large-scale assessments of river health using and Index of Biotic Integrity with low-diversity fish communities. *Freshwater Biology* 41: 235-252.

Henricksen, B (2006). United Nations Spatial Data Infrastructure Implementation Strategy: Draft Discussion Paper, United Nations Geographic Information Working Group, United Nations.

Mitsch, WJ & Gosselink, JG (2000). *Wetlands.* John Wiley & Sons Inc., New York.

Nebert, DD (2004). Developing Spatial Data Infrastructures: The SDI Cookbook version 2.0. Global Spatial Data Infrastructure Organisation.

Phillips, B; Begg, G; Finlayson, M; Lane, B; Bezuijen, M; Butcher, R & Lukacs, G (2002). 'Pilot testing' an approach for describing the ecological character of Australia's Ramsar sites. Report prepared for Environment Australia under the National Wetlands Program of the Natural Heritage Trust.

Reid, M & Brooks, J (1998). Measuring the effectiveness of environmental water allocations: recommendations for the implementation of monitoring programs for adaptive hydrological management of floodplain wetland sin the Murray-Darling Basin.

Savage, CDW (1968). The Wildfowl and Wetland Situation in the West Pakistan. *In*: Proc. Technical Meeting on Wetland Conservation, Ankara-Bursa-Istanbul, October 1967. IUCN Publications New Series No.12: 122-128.

Scott, DA (comp) (1989). A Directory of Asian Wetlands. IUCN, Gland, Switzerland, and Cambridge, United Kingdom.

Shekar, S., Chawla, S. (2002). Spatial Databases: A Tour, New Jersey: Prentice Hall.

USA EPA (1998). Lake and reservoir bioassessment and biocriteria. Technical Guidance Document. USA Environmental Protection Agency, Office of Water, Washington D.C. EPA 841-B-98-007.

Appendix 1: Description of international wetland inventory methods

1. Mediterranean Wetlands Initiative (MedWet) Inventory:
The main objective of this inventory was the identification of wetland sites, their values and prioritizing them for conservation.

Information was reviewed in consultation with experts who had knowledge of other inventories and various Ramsar guidelines on managing wetlands. Current inventory method was reviewed considering database methods used elsewhere in Asia, United States and specially Europe. Multiple scales for river Basins, wetland sites and habitats were adopted. Standard datasheets have been established for river basins, wetland sites, habitat, flora, fauna, activities and impacts, meteorological data and references. For habitat classification at broader scale Ramsar classification was used while for detailed information United States National Wetland Inventory Classification was adopted.

Method adopted would be site selection, site identification through cartographic means or remote sensing, habitat classification, data collection and management through standard datasheets and database and map production using standard conventions. The complexity of the inventory determines the time schedule and resources required. The feasibility of programme depends on the availability of resources for the inventory. Specific format for reporting is used and standard datasheets are provided for storing information and a specific database for ease of reporting. Inventory working group reviews and evaluates and updates the information and methods as necessary.

2. United States National Wetland Inventory:
Natural resource inventory of wetlands was prepared to be used for planning, regulation, management and conservation of wetland. According to this inventory the level of wetland protection and the availability of maps would be determined by reviewing the extent of wetland survey and inventory through consultation with the state and federal agencies to determine the inventory techniques being used. Maps would be produced at a scale of 1:80,000 or 1:40,000. For habitat classification and production of maps data is collected in a standardized way. To provide uniformity in concepts and terms hierarchical classification was developed for describing ecological units. The method for wetland identification is based on interpretation of coloured infrared aerial photographs initially at 1:24,000 and more recently at 1:40,000 or 1:80,000 scale, involving both stereoscopic analysis of photographs and field checking. The mapping units vary according to the region and ease of identifying wetlands. Data are analysed using ARC INFO and the digital data along with the maps are made available online at www.nwi.fws.gov, maps are updated when required depending on the availability of funds. A statistical design was incorporated to provide valid representative figures for selected areas. National wetland trends are produced periodically, based on statistical sampling. Mapping targets have been set through legislation that are revised periodically. By regular review and output evaluation of inventory new targets and priorities are established. An extensive phase of method development was conducted before the inventory was considered operational. Classification system was extensively tested in the field.

3. Uganda National Wetlands Programme:
Prior to the onset of inventory a literature review was undertaken. Basic purpose of the inventory was to survey, describe, quantify and map all wetlands to provide the decision makers and planners the information for management planning. This would support policy implementation, economic valuation and overall natural resource management planning. SPOT imagery of 1:50,000 would be used to cover the country. The bio-physical data would encompass site name, area, location, general description, seasonality, biota and management data covering land use, land tenure, conservation status, values and threats. Habitat classification would be derived from landform, water regime and vegetation.

GIS based maps would be produced using remote sensing data, ground surveys and topographic maps of scale 1:50,000. All wetlands would be coded and standard datasheets would be used. Activity would be carried out on district basis and personnel from the district would be designated to carry out the fieldwork and compile reports. Computerised database using Microsoft Access based on the standardized field datasheets would be linked to Arc View map database using wetland codes. The linkage between the two databases forms the National Wetland Information System (NWIS). Inventory is donor funded and is regularly updated. Feasibility is assessed through pilot studies. Cost effectiveness is related to the complexity of the wetland systems, extent of areas being assessed, availability of remotely sensed images and capacity. In consultation with a few external experts the inventory would be reviewed and evaluated. Pilot study would be undertaken in a few wetlands and then districts.

4. Asian Wetland Inventory:
This inventory provides a hierarchical database on coastal and inland wetlands in Asia. This inventory was reviewed in the extensive global review of the wetland inventory conducted on behalf of the Ramsar Convention and refined through the development of a manual. Analyses done at four levels, level one at 1:10,000,000 - 1:5,000,000; level two at 1:1,000,000 – 1:250,000; level three at 1:250,000 – 1:100,000; and level four at 1:50,000 - 1:25,000. Hierarchical multi-scalar data would be obtained. For each level minimum data to be obtained would be:

Level 1: broad geology, landforms, climate for river basins
Level 2: geology, landforms, climate for wetland regions
Level 3: hydrological, climate, landform, physiochemical and biological detail for wetland complexes
Level 4: Information on management issues and procedures included in addition to site description as per level 3

At level 3 and 4 ground surveys conducted would be more intensive. Minimum data on landform and water regimes possibly supplemented with information on vegetation, area size and water quality would be used for habitat classification.

GIS based map analysis using remotely sensed imagery and maps augmented with ground surveys. Prescribed datasheets and fields with agreed codes are available for each level of analysis. Computerized database engine with web, user/data interface and GIS capabilities serves as the primary data management, storage, retrieval component of the project. The system uses MS Visual Basic and Access 97 software. The website www.wetlands.org/awi serves as the main communication node for data collection, announcements and discussions. Feasibility depends on funding provided while cost effectiveness is related to the extent of areas being assessed and availability of pre-existing inventory information, maps and remote sensed images. Tight data management and reporting procedures should be adopted to make it cost effective.

Standardised datasheets would be used for storing information and individual reports produced through the devolved projects and where appropriate copies filled by Wetlands International on its web page. Pilot study was undertaken in Japan at Hokkaido and Kushiro Marsh.

5. Ecuador Wetland Inventory:
This inventory is near completion and it aims at providing information to assist in the management and conservation of globally important biodiversity in Ecuadorian wetlands through their identification, characterisation and prioritization. Literature was reviewed for the identification and status of wetlands. Inventory methods used in Canada, Venezuela, Brazil and parts of Argentina were reviewed for their limitations for application in Ecuador. Information was

collected at 1:50,000 scale. Large individual sites of wetlands are presented at different scales but information in them was held at 1:50,000 scale.

The data was collected for social, economic, zoological, botanical, limnological and ecological features using quadratical-based matrix. Two existing systems for habitat classification were used. Method for inventory preparation includes information collection using remote sensing; validation and delineation of zones using a numerical matrix; information on socio-economical and ecological aspects of wetlands derived from interviews; published information reviewed; primary information on ecological and social aspects of wetlands generated. Data was entered into GIS containing physiographic layers to permit the production of recommended land-use strategy and management proposals for the wetlands within their catchments. The total project cost is US $ 1 million over the seven years of the project with funding from Ramsar Bureau, the World Bank, the Global Environment Fund, the MacArthur Foundation and the Eucadorian Government. During the project development phase its feasibility and cost effectiveness was assessed. Pilot study was undertaken in 1996 of the lentic wetlands in the provinces of Esmeralds and Manabi.

Summary:
The basic purpose of inventory is identification of the wetland sites and selecting priority sites for conservation and to provide a tool for planning and management of the wetlands. Inventory is reviewed through consultation with an advisory group of experts or through consulting the literature available. Prior to the onset of inventory process a review of wetland inventory globally should be conducted and their limitations for application to be considered. Maps may be produced at different specified scales. Standard datasheets would have to be prepared and used for information collection for preparation of a computerized database using Microsoft Access or any other relevant software and then linked with Arc View map database or other GIS software used for mapping. Specific formats of reporting could be used which would be periodically produced. Maps and digital data may be made available online.

After site selection, the sites would have to be identified using remote sensing along with field surveys and usage of topographic maps. Habitat would be classified using some set way of so as to produce uniformity in concepts and terms. After gathering of information by using standard datasheets and preparing database, maps would be produces using standard conventions. Preparation of a simple or detailed inventory is greatly dependant on the availability of resources, funds and time. Feasibility can be assessed through conducting pilot studies. Cost effectiveness is related to the complexicity of the wetland systems, extent of areas being assessed, availability of remotely sensed images, extent of pre-existing inventory information and maps. Reports would be published periodically after reviewing and evaluating the project.

Appendix 2: Questionnaire for SWOT analysis of partners and stakeholders to assess their GIS/RS capabilities/resources

1. Respondent Information

1.1 Name and designation:----------

1.2 Organisation/Institute:----------

1.3 Academic qualification and professional experience: ----------

1.4 Mailing address:----------

1.5 Contact no: Tel: ----------Fax: ----------

1.6 Email:----------

1.7 Website: ----------

2. Existing GIS/Mapping staff, their qualification and requirement assessment

Staff	Nos.	Designation	Qualification	Experience	Job Nature
GIS Staff					
RS Staff					
IT* Staff					
Professional** Staff					
Support*** Staff					

* Staff who deals with computer related issues
** Professional/management staff who is involved with GIS/RS issues either directly or as supervisor
*** Staff who deals data capturing in the field or in the GIS Lab.

3. What type of GIS data management software and hard ware facilities are currently available in your organisation?

GIS/RS Software	No. of licences	Hardware	Model	No./Size
ArcInfo ver.		Desktops / Laptops		
ArcGIS ver.		Digitizing Tablets / Scanners		
ArcView ver.		Printers/plotters		
Erdas Imagine ver.		Scanners		
Others		GPS		

4. IT Resources

Do you have Internet connectivity	Yes ❑ No ❑
If yes, please specify the type of connection (i) Dial-up ❑ (ii) Cable Net ❑ (iii) DSL ❑ (iv) Other ❑	
Do you have Local Area Networking to link computers	Yes ❑ No ❑
If yes, please specify the LAN speed (i) 10 Mbps ❑ (ii) 100 Mbps ❑ (iii) Gigabit ❑ (iv) Fibre optics ❑	
Do you have dedicated server to connect computers	Yes ❑ No ❑
If yes, please specify the Operating System used (i) Windows ❑ (ii) Novel ❑ (iii) Linux ❑ (iv) Unix ❑	
Do you have external data storage devices	Yes ❑ No ❑
If yes, please specify the type of devices (i) CD ❑ (ii) DVD ❑ (iii) USB HD ❑ (iv) Tape ❑	

5. What type of GIS/Remote Sensing data already available with your organisation?

GIS Data

Data Layers	Extent	Source	Scale	Purpose / Project	Person Incharge

Remote Sensing Data

Satellites	Extent / No	Resolution	Date	Purpose / Project	Person Incharge

Maps

Types	Extent / No	Source	Scale	Purpose / Project	Person Incharge

Aerial Photographs

Type*	Extent / No	Scale	Date	Purpose / Project	Person Incharge

* Digital or Analogue

6. What type of Non-GIS data already available with your organisation?

Species Distribution/Survey/Census Data/Reports

Species	Survey Year	Data Collection Method*	Data Type**	Development Purpose / Project

* Data encoding forms, GPS points, transects or other (please specify)

** Reports, Publications, Field books

Vegetation/Habitat Survey Data/Reports

Vegetation Type	Survey Year	Data Collection Method*	Data Type	Development Purpose / Project

* Sampling, questionnaire or other (please specify)

Socio-economic/other Survey Data/Reports

Target Area	Survey Year	Data Collection Method*	Data Type	Development Purpose / Project

* Sampling, questionnaire or other (please specify)

7. Beneficiaries of your data and your policy of resource sharing

#	Beneficiaries	Please mark the relevant beneficiaries with ✓
1	Government Department	
2	Education Institutes	
3	Non-governmental Institutions	
4	Research Institutes	
5	Public Sector	
6	Others (Please specify)	
7	**Spatial / Non-spatial Data Sharing Policy**	

	Do you share data with other agencies? Yes ❑ No ❑ If yes, how can they access your dataset? Email ❑ CD ❑ Hard copy ❑ Others (pls. specify) ❑ What are the major problems and constraints in data sharing? 1. ---------- 2. ---------- 3. ---------- 4. ---------- 5. ----------
8	**Hardware/Software/IT/Human Sharing Policy**
	Do you share your computing and human resources with other agencies? Yes ❑ No ❑ If yes, please specify the resources you share? Software ❑ Hardware ❑ IT Infrastructure ❑ Human Resource ❑ What is the nature/mechanism of your resource sharing? 1. ---------- 2. ---------- 3. ---------- 4. ---------- 5. ----------
9	**Partnership/Linkages with Local/International Organisations**
	Do you have collaboration with other GIS related institutes/agencies? Yes ❑ No ❑ If yes, with which agencies you have collaborations? NGOs❑ Governmental ❑ Academic/Research ❑ Corporate ❑ What are the advantageous and limitations of your collaboration? 1. ---------- 2. ---------- 3. ---------- 4. ---------- 5. ----------

8. What type of data would you expect from PWGIS?

#	Type of Data	Please mark the relevant data with ✓
1	Birds	
2	Mammals	
3	Forest	
4	Fisheries	
5	Socio-economic	
6	Wetlands	
7	Hazards	
8	Others (please specify)	
9		
10		
11		

9. In which format would you expect data from PWGIS?

#	Type of Data Formats	Please mark the relevant data formats with ✓
1	Documents	
2	Softcopy Maps	
3	Vector Data files	
4	Satellite Data	
5	Hardcopies Map	
6	Others (please specify)	
7		
8		
9		
10		

10. What are the major strengths and weaknesses of your organisation in terms of GIS infrastructure?

Major Strengths

1. ----------
2. ----------
3. ----------
4. ----------
5. ----------

Major Weaknesses

1. ----------
2. ----------

3. ----------

4. ----------

5. ----------

11. In which areas you can collaborate & how?

#	Broader Areas of Collaboration	Please mark ✓	Please explain how
1	Field surveys		
2	Map sharing		
3	Data collection / sharing		
4	Satellite data sharing		
5	GIS Trainings		
6	Report sharing		
7	Others (please specify)		

12. Do you need additional GIS/RS trainings/refresher courses?

Yes ❑ No ❑

If yes, then what type of trainings?

#	Type of Training	Please mark ✓	Please specify topics, if any
1	Basic Level	❑	
2	Mid Level	❑	
3	Advance Level	❑	

13. Please suggest, how these trainings will help to improve/sustain your GIS capacity?

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14. General recommendations, if any

Appendix 3: Description of 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 2: 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 3: 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 4: 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 4: Description of 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 5: Erosional status of coastal landforms and wetland complexes

Erosional status	Definition / example
Eroding	Areas where the action of the sea is eroding the land substrate, e.g. cliffs, dunes, or beaches

Erosional status	Definition / example
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 6: 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 7: **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 (see Appendix 10) 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 8: 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 9: 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 10: 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 (Appendix 7).

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

Appendix 5: Description of 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 (Appendix 10) 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.

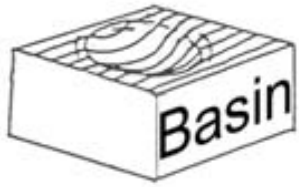
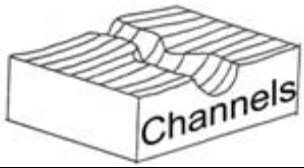
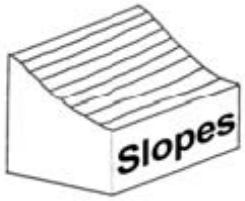
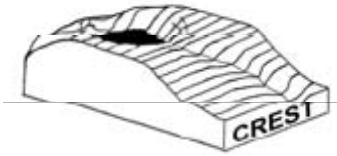
Those responsible for entering data must specify the type of projected coordinate system used e.g. WGS 1984 LCC projection, including the coordinate map grid in which the habitat is situated.

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.

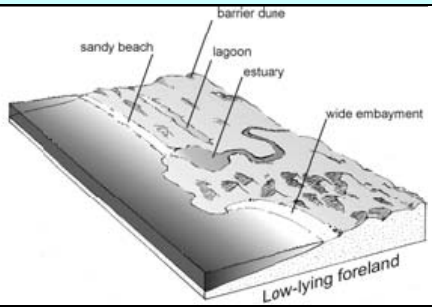
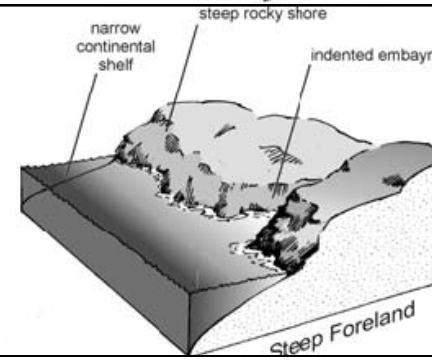
Ecological character
i) Physical features
Geomorphic setting
Describe the landform (or cross-sectional geometry) of the habitat using the terms supplied in Table 11. Generally there are at least 5 basic landform types that determine the occurrence of wetlands and, whilst each are intergradational, it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

Table 11: 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 12: 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 13: 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 14:**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 15: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 16: Categories of thermal characteristics based on different types of mixing (adapted from Bayly and Williams 1981)

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

Salinity
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 17: Salinity classification

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

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 18: Acidity / alkalinity classification based on pH units

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

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

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

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 20: 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 21: 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 22: 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 23. 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).

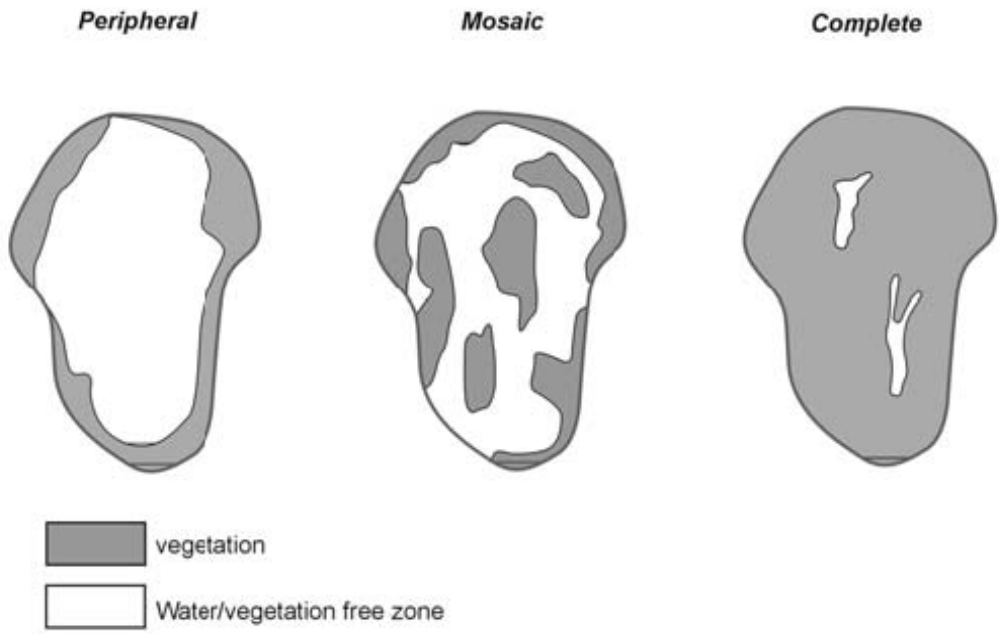


Figure 6: Categories of vegetation cover (after Semeniuk *et al*., 1990).

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 24: 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 25: 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 (Appendix 10) 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 26: Example format for listing of key faunal taxa associated with each major habitat together with an indication of the available information for each

Habitat type	Key fauna taxa	Available information
Open water	Invertebrates Amphibia Waterbirds	September 1992; December 1996 Very limited Numerous surveys (50+) have been conducted over the period 1965 – present
Fringing 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 27: Summary of the criteria for listing a wetland as internationally important under the Ramsar Convention

Criterion	Description
1	a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate 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 28: 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 (Appendix 7 & 8).
Date sheet completed / updated: The date the datasheet was completed should be stated (e.g. 02 October 2001).

References:

Ramsar Convention (http://www.ramsar.org/key_criteria.htm)

Waterfowl Population Estimates' (http://www.wetlands.org/IWC/WPE2toc.htm)

Appendix 6: Ramsar classification of wetland types

(Source: Ramsar Convention Bureau : (http://www.ramsar.org/key_ris_types.htm)

Marine/Coastal Wetlands

A -- **Permanent shallow marine waters** in most cases less than six metres deep at low tide; includes sea bays and straits.
B -- **Marine subtidal aquatic beds**; includes kelp beds, sea-grass beds, tropical marine meadows.
C -- **Coral reefs**.
D -- **Rocky marine shores**; includes rocky offshore islands, sea cliffs.
E -- **Sand, shingle or pebble shores**; includes sand bars, spits and sandy islets; includes dune systems and humid dune slacks.
F -- **Estuarine waters**; permanent water of estuaries and estuarine systems of deltas.
G -- **Intertidal mud, sand or salt flats**.
H -- **Intertidal marshes**; includes salt marshes, salt meadows, saltings, raised salt marshes; includes tidal brackish and freshwater marshes.
I -- **Intertidal forested wetlands**; includes mangrove swamps, nipah swamps and tidal freshwater swamp forests.
J -- **Coastal brackish/saline lagoons**; brackish to saline lagoons with at least one relatively narrow connection to the sea.
K -- **Coastal freshwater lagoons**; includes freshwater delta lagoons.
Zk(a) – **Karst and other subterranean hydrological systems**, marine/coastal

Inland Wetlands

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

Human-made wetlands

1 -- **Aquaculture** (e.g., fish/shrimp) **ponds**
2 -- **Ponds**; includes farm ponds, stock ponds, small tanks; (generally below 8 ha).
3 -- **Irrigated land**; includes irrigation channels and rice fields.

4 -- **Seasonally flooded agricultural land** (including intensively managed or grazed wet meadow or pasture).
5 -- **Salt exploitation sites**; salt pans, salines, etc.
6 -- **Water storage areas**; reservoirs/barrages/dams/impoundments (generally over 8 ha).
7 -- **Excavations**; gravel/brick/clay pits; borrow pits, mining pools.
8 -- **Wastewater treatment areas**; sewage farms, settling ponds, oxidation basins, etc.
9 -- **Canals and drainage channels, ditches**.
Zk(c) – **Karst and other subterranean hydrological systems**, human-made

Appendix 7: Summarised results of SWOT assessment

Based on the initial survey, results synthesised from the received responses regarding the various issues are presented collectively below.

Existing GIS/Mapping human resources and their training requirements:

Survey results show that 42% of the respondent organisations have GIS staff whereas only 14% have remote sensing staff. However, 64% of the organisations have information technology (IT) related staff who's skills in GIS/RS techniques could be improved to deal with geo-information and data.

Initial findings show that qualification and skill levels of partner organisations vary a lot. Most of the professional staff of the partner organisations working as GIS professional has either masters or bachelor degrees. Most of them, engaged in GIS/RS applications, have graduated in disciplines other than GIS/RS. Very few people have received proper education and possess skills of GIS and Remote Sensing techniques. Most of the staff has received local level training and field experience in GIS/RS applications.

Most of the organisations informed that beyond technical skills, managers and other professionals dealing with GIS activities need training and greater understanding of the subject matter so that more human resources are produced in this sector. Findings show that 64% of the stakeholder organisations are interested in the basic and mid level GIS/RS training for their staff whereas 36% have asked for advanced level training in the subject matter. For further details see Table 29 and Table30.

Available GIS/RS data with stakeholders and data sharing mechanisms:

Overall findings of consultations relating to geo-information and data are summarised in Table 31. According to the survey 36% stakeholder organisations have vector data layers at various scales for their project areas, whereas same number of organisations have satellite remote sensing data from low to medium resolutions for various applications in their project sites.

Regarding data sharing mechanisms, survey data reveals that there is no established mechanism of data sharing among the data custodians. Seventy nine percent of the respondents are in view of data sharing, however, lack of coordination among stakeholders, no proper data sharing policy, sensitivity of data, lack of sufficient funds and misuse of data are the major concerns in this regard. Most of the respondents have shown interest in sharing human and hardware resources.

Technical infrastructure for GIS data management (hardware and software):

Survey has revealed that most of the respondent organisations have hardware facilities but very limited number of them has GIS/RS facility. Results show that 42% of the respondents have GIS/RS licences of different versions. There are total 18 licences of different GIS softwares and 9 licences of RS software (ERDAS Imagine). Requirement analysis shows there is still lack of such softwares in the government and private sector without which development of spatial datasets is quite impossible (See Table 32).

Table 29: GIS/RS related existing staff of the stakeholder organisations of PWP

Sr.No	Name of Organisation	Existing GIS/RS/IT Staff	Total no. of staff	Designation	Qualification	Experience (yrs)	Job Nature
1	IWASRI, WAPDA, Lahore	GIS Staff	3	Senior Engineer,Junior Engineer	Bsc, Msc	6 (GIS)	Application of GIS and RS in Water Resource Management
		RS Staff	1	Senior Engineer	Msc	6 (GIS)	Application of GIS and RS in Water Resource Management
		IT Staff	1	Dy Director	Msc	18	Computer Programming
		Professional Staff	1	Director	Bsc (Agri Eng)	3	Supervision
		Support Staff	2	Tracer & K.D.O	D.C.S	10	Digitization of Map Data Punching
2	Northern Areas Development Project, Gilgit	GIS Staff	1	GIS Specialist	Msc GIS	5	Managing GIS for the Projects of NADP
3	Forest Deptt:Gilgit	IT Staff	5	Computer Operator	BA	3	
4	KNP, Gilgit	IT Staff	1	En Resend Officer	Msc	1 Year	Env.related research&Mgt of KNP
5	Zoological Survey Deptt.Karachi	IT Staff	2	Stenographer, U.DC	BA,BA	30 , 20	Office Work
		Support Staff	3	Research Officers	Msc		Research Work
6	Sind Coastal Development Authority, Karachi	IT Staff	1	Computer Operator			Typing
7	Department of Geography, Univ.of Karachi	GIS Staff	7	Faculty	Msc,Mphil,Phd	4 to20	Depends upon Project
		RS Staff	3	Faculty	Msc,Phd	2 to 20	Depends upon Project
		IT Staff	3	Lab Incharge,Lab Assistant		8	Maintance of Hardware and Software
		Professional Staff	12	Faculty and Research St	Msc,Mphil,Phd	2 to 20	Depends upon Project
		Support Staff	5	Research Asst/Student	Msc(Min)	5 to 10	Depends upon Project
8	Sind Forest Deptt.Karachi	IT Staff	12	Computer Operator	Graduate + Diploma in Computer Science	10	Computer Operator
9	Sustainable Use Specialist Group-Central Asia; Habitat & Species Conservation Project.	IT Staff	2	Admin 7 Finance Ast Secretary/Record Keepers	MBS,BA	2	Administration
		Professional Staff	3	National Project Manager Monitoring & Evaluation Officer Conser Officer	Msc Forestry,Rural Development, Msc Rural Development Zoology,Botony	NPM 15 M & E Officer 08 Conservation Officers 6 to 7	Policy Guidance, Management, Monitoring and Evaluation Field Office incharge
10	Federal Envi.Mgt Unit,National Drainage Programme, Lahore	GIS Staff	1	Asst Programmer	Msc (GIS)		Water Sector
		Professional Staff	1,3	Director , Dy Director	Phd,Msc		Environmental Uses
		Support Staff	1	Computer Operator			Official Assignment
11	Planning&Monitoring circle, Forest Deptt.NWFP	GIS Staff	7	GIS Specialist,GIS Analyst,Digitizing apparatus	M.Sc.	7,7,1	
		Professional Staff	2				
		Support Staff	5				
12	Forest Deptt: AJK	IT Staff	1	Computer Operator	BA	5	Computer related
13	SLMP, Islamabad	GIS Staff	1	GIS Analyst	M.Sc.	20	GIS analysis for Land use

Table 30 Training requirements of GIS/RS related existing staff of the stakeholder organisations of PWP

Sr.No.	Training required	Type of Training	Yes/ No	Topic
1	Yes	Basic Level	Yes	Remote Sensing, New Softwares
		Mid Level	Yes	GIS Application in other Fields, Remote Sensing in Water Resources
		Advance Laevel	Yes	
2	Yes	Basic Level		
		Mid Level		
		Advance Laevel	Yes	GIS Programming, Gmai Coding, ArcIMS, ArcSDE, Image Classification
3	Yes	Basic Level	Yes	Forest Management, Landuse Mapping, Use of Softwares
		Mid Level		
		Advance Laevel		
4	Yes	Basic Level	Yes	Introduction to GPS, GIS and RS and its uses for the Forest Management
		Mid Level		
		Advance Laevel		
5	Yes	Basic Level	Yes	
		Mid Level	Yes	
		Advance Laevel		
6	Yes	Basic Level	Yes	
		Mid Level	Yes	
		Advance Laevel		
7	Yes	Basic Level	Yes	
		Mid Level		
		Advance Laevel		
8	Yes	Basic Level	Yes	Introductory Courses
		Mid Level	Yes	Overseas trainings (Short term and Long Term)
		Advance Laevel		
9	Yes	Basic Level	Yes	
		Mid Level	Yes	
		Advance Laevel		
10	Yes	Basic Level	Yes	GIS mapping of Environmental Issues
		Mid Level	Yes	
		Advance Laevel		
11	Yes	Basic Level		
		Mid Level	Yes	
		Advance Laevel	Yes	
12	Yes	Basic Level	Yes	GIS, Software operation, data collection, mapping
		Mid Level		
		Advance Laevel		
13	Yes	Basic Level		
		Mid Level		
		Advance Laevel	Yes	Digital image processing with LP suit

Table 31 Existing geospatial data with stakeholder organisations

Sr. No	Type of Data (GIS/RS)	Data Layers	Satellites	Extent	Resolution	Source	Date	Scale	Purpose / Project	Person Incharge
1	GIS Data	Surface Salinity Depth to Water Table Water Quality Land use Soil Texture Irrigation		Indus Basin		SMO, WAPDA		1:50000	Salinity Assesment	Director WM-GIS
	RS Data		SPOT Images	Indus Basin	20m		2003		Salinity Assesment	Director WM-GIS
2	GIS Data	Rivers Roads Pony Tral Project Area Boundary Demarcation							NADP	Javed Iqbal
	RS Data		Landsat 7							Javed Iqbal
3	GIS Data	KNP Layers				WWF			KWP Project	Muhammad Shah
	RS Data									
4	GIS Data	Raster		Pak		NASA		30,15m	Teaching & Project	Jamil Kazmi
		Raster		Karachi		SPOT		10,2.5m	Teaching & Project	Jamil Kazmi
		Vector		Pak		census org		1:100000	Teaching & Project	Jamil Kazmi
		Vector		Karachi		UGA		1:50000	Teaching & Project	Jamil Kazmi
	RS Data		Landsat 7				90,92,98,2000		Multiple	Jamil Kazmi
			SPOT Images				86		Multiple	Jamil Kazmi
			KVR				1999		Multiple	Jamil Kazmi
5	GIS Data	Province, District & Frontier Division Boundaries		Whole Province		Topographic Sheets		1:50000		GIS Specialist
	RS Data		TM Image of 1999	8 scenes	30*30m	Purchased in FSP	1999			
6	GIS Data									
	RS Data		Aster	Project site	15m		2006		SLM project sites	Imtiaz Ahmad

Table 32: GIS/RS software available with the stakeholder organisations

Sr. No	GIS/RS Software	No. of licenses	Sr.No	GIS/RS Software	No. of licenses
1	ArcInfo ver (3.5) ArcGIS ver (8.5) ArcView ver. (3.1) Erdas Imagine ver. (8.5) Others (surfer 32)	1 1 1 1 1	7	ArcInfo ver ArcGIS ver (8.1,8.3&9.0) ArcView ver. (3.1&3.2) Multiple Erdas Imagine ver. (8.3,8.6) Others (PC1 Geomatica)Map Info	1each 3 1,2
2	ArcInfo ver ArcGIS ver ArcView ver.	1 1	8 9 10	ArcInfo ver Others ArcInfo ver	

Sr. No	GIS/RS Software	No. of licenses	Sr.No	GIS/RS Software	No. of licenses
	Erdas Imagine ver. Others	1		ArcGIS ver (9.0) ArcView ver.	1
3	ArcGIS ver ArcView ver.		11	Others ArcInfo ver	6
4	ArcInfo ver ArcView ver. (3.2) Others			ArcGIS ver ArcView ver. Erdas Imagine	4 3
5	Others			Others	
6	ArcInfo ver ArcView ver. Erdas Imagine ver.		12	ArcInfo ver ArcGIS ver ArcView ver.	

Table 33: Hardware resources and their specifications

Sr. No	Hardware	Model	No./Size	Sr.No	Hardware	Model	No./Size
1	Desktops / Laptops Digitizing Tablets / Scanners Printers/plotters Scanners GPS	P-IV, P-III Summa Grid HP 500, HP 250L HP 7400	7 1 3 1 3	7	Desktops / Laptops Digitizing Tablets / Scanners Printers/plotters Scanners GPS	P-IV, P-III HP HP(Laser Desk Jet) HP Magellin	 A3 Size A3/A4 A3 2
2	Desktops / Laptops Digitizing Tablets / Scanners Printers/plotters Scanners GPS	1 HP Design Jet 500 ps with 6 heads and 6 cartridges canon T*40 contex 176c (Garmin III)	1 1 1 1 3	8 9 10	Desktops / Laptops GPS Desktops / Laptops Digitizing Tablets / Scanners Printers/plotters GPS	P-IV GARMIN e Trex Vista P-IV HO Color Laser-5550 Magellin 500	15 4 2/3.2GHz intel 1/A3 4
3	Digitizing Tablets / Scanners Printers/plotters	Geni ous HP 1200s		11	Desktops / Laptops Digitizing Tablets / Scanners Printers/plotters Scanners	P-IV, P-III 2 1 1	13 A0 Size Vector A0 Size
4	Desktops / Laptops Printers/plotters GPS	Asus P-IV HP 1200 Garmin III					
5	GPS	Garmin etrex	1/ 4.4"H * 2"W * 1.2"D	12	GPS	Garmin	4
6	Desktops / Laptops Printers/plotters Scanners	Desktops,Laptops	5,1 3 1		Desktops / Laptops Digitizing Tablets / Scanners Printers/plotters	P-IV Scanner HP 800	5 36+ 1
				13	Desktops / Laptops Digitizing Tablets / Scanners Printers/plotters Scanners	P-IV HP-1286 HP	21" 1/A-3

Table 34: Fauna information available with stakeholder organisations

Sr. No	Species	Survey Year	Data Collection Method	Data Type	Development Purpose / Project
1		2001 2005	GPS GPS	Reports Field Book	NADP
2	Marine Mammals	2005	Line transect (GPS Points)	Publication	Development Purpose
	Coastal Birds	2004-2005	Line transect	Report	
	NRDA Study	2003-2004	Line transect, Direct census, Neeropsy, PAHs	Report	Project
	Vert Mangrove Fauna (Sind)	1984-1989	Direct Census	Report	
	Vert Mangrove Fauna (Sind)	1992-1996	Direct Census	Report	
	Birds, Mammals, Reptiles, Fishes, Invertebrates	1969-2005		Publications, Record, Zoological Survey of Pak Vol 1-16	Development Purpose
	Field Guide to the Ducks			Book	Development Purpose
	Edible Fish of Pak			Book	Development Purpose
	Wild Ungulates of Pak			Book	Development Purpose
	Wild Carnivores of Pak			Book	Development Purpose
	Cranes of Pak			Book	Development Purpose
	A Booklet on Marine turtles of Pak			Book	Development Purpose
	Raptors of Pak			Book	Development Purpose
3	Straight Horn Markhor	1997,98,2000 and 2006	Data Encoding forms, GPS points	Reports, Publication	Know the population dynamics for better Management
	Afghan Urial	1997,98,2000 and 2006	Data Encoding forms, GPS points	Reports, Publication	Know the population dynamics for better Management

Table 35: Vegetation data available with stakeholder organisations

Sr. No	Vegetation Type	Survey Year	Data Collection Method	Data Type	Development Purpose / Project
1	Tamarix, Afedra, Suburth	2005-06	Sampling	Field Book	Dev Project
2	Habitat Survey Torghar	2006	Sampling	Vegetation inventory,Reports	Management Purposes
	Floral Inventory	2001	Sampling	Vegetation inventory,Reports	Management Purposes
3	Landuse Category	1995-96	Visual Interpretation of TM Satellite Image	Landuse Map	GTZ prepare report for Fort Development
4	All Vegetation Specie of KNP Area	2006	GPS Points	Field Books	Dev Purpose
5	Plants	1980-2004	Field Survey		Studyv Project
6	MIS system is under process thereafter village will be linked with GIS				
	Landuse Category	1995-96	Visual Interpretation of TM Satellite Image	Landuse Map	GTZ prepare report for Fort Development

Table 36: Stakeholder organisations having socio-economic data

Sr. No	Target Area	Survey Year	Data Collection Method	Data Type	Development Purpose / Project
1	Diamer Diamer	2001 2005	Sampling Questionnaire	Field Book Field Book	NADP NADP
2	Ibrahim Hyder/Rehri Goth (Sindh)	1992	Questionnaire	Socio-Economic	Thesis
3	Thatta and Badin Districts	2005-06	Survey	Report	Project
4	Malir Gudap	1988-2000 1982-2004			
5	Torghar	2004-05	Questionnaire	Case Study	For Management Purpose

Table 37: List of respondents of SWOT analysis

No.	Respondent organization
1	International Water logging and Salinity Research Institute (IWASRI), Water and Power Development Authority (WAPDA). Near Muhammad Pura Village, P.O. Thokar Niaz Baig, Lahore Ph. 042-5303390, Fax. 042-5303050, 5303393 Contact Person: Mr. Nazir Ahmad, Director Email: iwasri@brain.net.pk
2	Northern Areas Development Project, Near P & D Department, Secretariat, Gilgit Ph. 05811-50141, Fax. 05811-50215 Contact Person: Javed Iqbal, GIS Analyst Email: javed08039@itc.nl
3	Conservator of Forest, Baber Road, Near AKRSP office, Gilgit Ph. 05811-50274, Fax. 05811-52944. Contact Person: Mr. Maqsood Ahmad, Email: maqsood_ahmad_kashroti@hotmail.com
4	Director Khunjarab National Park, Near Imamia Eidga, NLI colony, Gilgit Ph. 05811-50237, Fax. 05811-50146 Contact Person: Mr. Khisam Hussain, Email: hope4best2002@yahoo.com
5	Zoological Survey Department, Block 67, Pakistan Secretariat, Shah Rah-e-Iraq, Karachi-74200. Ph: 021-9203334, Fax: 021-9203334 Contact Person: Mr. Abrarul Hasan, Email: habibee786@hotmail.com. Website: www. zsd.gov.pk
6	Sind Coastal Development Authority, Karachi, P.I.D.C Building, First Floor, M.T.I Road, Karachi Ph: 021-9204660, Contact Person: Mr. Shamsul Haq Memon, Email: zameer_ujjan2000@yahoo.com
7	Director, Centre of Excellenece in Marine Biology, University of Karachi, Karachi-75270 Ph: 021-9243230, 4969185, Fax: 021-9243677 Contact Person: Prof.Dr. Javed Mustaquim Email: jmst@cyber.net.pk, jmst48@hotmail.com

No.	Respondent organization
8	Department of Geography, University of Karachi, Karachi 75270 Ph: 021-9261300-06, Ext:2292, Fax: 021-9243206 Contact Person: Dr. Syed Jamil Hasan Kazmi, Email: jkazmi@usa.net, Website: www.uok.edu.pk
9	Sind Forest Department, Karachi, c/o Chief Conservator of Forest, Shahbaz Building, Block-A, Hyderabad Ph: 022-9200227, Fax: 022-9200202 & 10 Contact Person: Amjid Ali Shah, DFO, Email: amjadalishah@hotmail.com, Website: www.sindforests.gov.pk
10	Sustainable Use Specialist Group-Central Asia; Habitat & Species Conservation Project. BRSP House, 5-A Sariyab Road, Gulshan-e-Janan, Quetta, Ph: 081-2451551, Fax: 081-2446287 Contact Person: Mr. Tahir Rasheed Email: tahir_rasheed20@yahoo.com, rasheedtahir@hotmail.com
11	Federal Environment Management Unit, National Drainage Programme, Office of the PRO/Director FEMU, Sunny View estate, Empress road, Lahore Ph: 042-9202775-6, 9202667, Fax: 042-9202574 Contact Person: Dr. Muhammad Ashrif Bodla, Director/PRO, Email: femu@lhr.paknet.com.pk
12	Planning & Monitoring Circle, NWFP, Forest Department, FP & M Circle, Palosi Road, Amanabad, NWFP Ph: 091-9216248 Contact Person: Mr. Kifayat Ullah Baloch, GIS Specialist, Email: balochitc@gmail.com
13	Forest Department, c/o Chief Conservator of Forests, Bank Road, Muzaffarabad, AJK Ph: 058810-43806, Fax: 058810-44298 Contact Person: Mr. Raja Khizar Hayat Khan, CCF AJK, Email: kiani1888@yahoo.com
14	Sustainable Land Managemnt Project, 40, Bazar Road, G-6/4, Islamabad Ph: 051-2831027, Fax: 051-2831028 Contact Person: Mr. Imtiaz Ahmad, GIS Analyst, Email: imtiaz@slmp.org.pk Website: www.slmp.org.pk