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WETLANDS EDUCATION AND AWARENESS MATERIALS FOR TERTIARY INSTITUTIONS

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UNIT 1:

INTRODUCTION TO WETLANDS

Introduction

Wetlands are important natural resources that many people do not realise their value. In the Nile basin region and even the world over, wetlands face serious abuse and are always referred to as wastelands. There is therefore urgent need for all of us to clearly understand the value of these useful resources and what they are. This module will therefore add to your existing knowledge about wetlands by examining the following;

- Wetland definition
- Wetland formation
- Wetland types
- Importance of wetlands
- Examples of wetlands

Learning Outcomes

By the end of this unit, the learners should have improved their ability to:

- Define and explain clearly the term wetland
- Describe the formation of wetlands
- List down and explain the different types of wetlands
- Give examples of wetlands in their respective countries
- Give and explain the various uses of wetlands

The learners should also be able to use the knowledge obtained to promote the conservation of wetlands in their respective countries by acting as agents of change, i.e the learners should take part in changing people's misconception of wetlands as wastelands.

Wetland definition:

What are wetlands?

Wetlands are complex habitats with various definitions due to their wide range of habitats and ecosystems, which support highly adapted characteristic fauna and flora. Wetlands are so variable that their appearance and boundaries fluctuate over time. These dynamic changes are what make wetlands difficult to define. However, wetlands have unique characteristics and may be defined as;

> *"Those areas that are saturated by surface or ground water at a frequency and duration sufficient to support a prevalence of vegetation typically adapted for life in saturated soil conditions".*

Wetlands may also be defined as areas of land that are wet, flooded either permanently or seasonally and where land retains water for long enough to allow the development of characteristic soils, plants and animals. According to the Ramsar Convention, wetlands are defined as "*areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters".*

In addition, the Ramsar Convention provides that; "wetlands may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six meters at low tide lying within the wetlands". As a result, coverage of the Ramsar Convention may be extended to include not only obvious freshwater resources such as rivers and lakes, but also coastal and shallow marine ecosystems, including coral reefs, artificial water bodies and underground water resources.

Wetlands - including (inter alia) rivers, lakes, marshes, estuaries, lagoons, mangroves, sea grass beds, and peatlands - are among the most precious natural resources on Earth. These highly varied ecosystems are natural areas where water accumulates for at least part of the year. Driven by the hydrological cycle, water is continuously being recycled through the land, sea and atmosphere in a process, which ensures the maintenance of ecological functions. Wetlands are an integral part of the hydrological cycle, playing a key role in the provision and maintenance of water quality and quantity as the basis of all life on earth. They are often interconnected with

other wetlands, and they frequently constitute rich and diverse transition zones between aquatic ecosystems and terrestrial ecosystems such as forests and grasslands. . Wetland ecosystems, by definition, depend on water to maintain their ecological functions.

The hydrological cycle renews the flow and quantity of water in rivers, aquifers, lakes and all other freshwater ecosystems. These are complex ecosystems, the boundaries of which are often in a state of flux. Wetlands are therefore easily affected by external events. Nutrient and sediment loads, for example, are frequently moved from one site to another and from one habitat to another. Thus, nutrients obtained in the headwaters of a stream may find their way into lakes or fens. Minerals and nutrients not absorbed by living freshwater organisms may find their way into the marine ecosystem, often thousands of kilometers from where they first entered the water. While the fluid nature of such exchanges guarantees a continued renewal of energy, it also represents a major potential hazard since many harmful agents (pesticides, fertilizers or other chemicals) can also be easily and rapidly transported to other areas where they might have an adverse impact on the environment.

Other essential aspects on wetlands

- Wetlands occur in every country - from the tundra to the tropics. The World Conservation Monitoring Centre has suggested an estimate of about 5.7 million square kilometers - roughly 6% of the Earth's land surface. The greatest proportion is made up of bogs (30%), fens (26%), swamps (20%) and floodplains (15%), with lakes accounting for just 2% of the total.
- They exist as swamps, flood plains, seasonally flooded grasslands, edges and shallow waters of rivers and lakes, estuaries and coasted mashes, mangroves, creator lakes and peat bogs.
- They have characteristic flora and fauna with specified features for adapting to variability in hydrology, chemical composition, environmental physical characteristics like temperature, soil nature, sediment composition, etc.
- They are very fragile habitats, which are easily degraded in terms of ecological functioning, social and economic services and products provision.

- Several broad wetland types can, be identified as; lacustrine (wetlands associated with lakes), riverine (wetlands along rivers and streams), palustrine (marshes, swamps and bogs), marine (coastal wetlands, including rocky shores and coral reefs), estuarine (including deltas, tidal marshes and mangroves), and artificial water bodies (fish ponds, reservoirs and artificial lakes).

Formation of Wetlands

How are wetlands formed?

Wetlands are formed where water is retained or delayed within a catchment. When water due to precipitation in form of rainfall and dew collects in a place and is retained for quite a long period e.g. in a depression or basin, along the valley, flood plain etc a wetland is formed.

A wetland will develop where water collects and the soil beneath becomes waterlogged and anaerobic. Vegetation gradually becomes established hence slowing the speed of surface water flow. Sedimentation of suspended silt and eroded soil occurs as a result of the low speed, which promotes more vegetation growth and further reduction in speed of water flow. This area expands gradually sideways and across the valley resulting into an established wetland

Unit activity 1: Group Discussion

In a group of five, examine the role of each of the following in the process of wetland formation;

- *Faulting and folding*
- *Down warping*
- *River meandering system*
- *Earth movements and slow-flow theory*

Types of Wetlands

Do you think all wetlands are the same?

Wetlands differ due to variation in soils, landscape, climate, water regime, vegetation and human disturbance. Different categories of wetlands have been discovered and perform different functions, many of which are not immediately obvious. Coastal wetlands (mangroves, estuaries, salt marshes, sea grass beds, coral reefs and mudflats) are vital spawning and nursery areas for large numbers of fish. Inland wetlands - rivers and lakes - not only provide abundant food and income for millions of people, but also serve as an essential lifeline for communications: goods have been traded along all major rivers for centuries. Due to these variations, the Ramsar convention on wetlands of international importance classifies wetlands as follows;

- Riverine wetlands. These are wetlands along rivers and streams.
- Lacustrine wetlands. These are wetlands associated with lakes, which include water edge wetlands and above shoreline wetlands.
- Palustrine wetlands (marshes, swamps and bogs)
- Marine wetlands (Coastal wetlands, including rocky shores and coral reefs)
- Estuarine wetlands (including deltas, tidal marshes and mangroves)

Wetlands may also be classified based on hydrological status, i.e

- *Permanent wetlands*; these are permanently flooded with water.
- *Seasonal wetlands*; these are wetlands that are mainly flooded during the rainy season.

An example of a seasonal wetland. (Water disappears during the dry season.)

Factors that influence the type of wetland that forms in a specific location include;

- Presence of water; permanent or seasonal
- Source of water eg rainfall, surface run-off, ground water etc
- Water depth
- Shape of the water basin
- Degree of slope of the basin
- Geological factors e.g. soil type
- Altitude
- Anthropogenic activities

Unit Activity 2

Using suitable examples, explain how the above factors influence the type of wetland formed.

Fact sheet: ***Distinguishing features of wetlands***

- Presence of water, either at the surface or within the root zone, for at least some part of the year.
- Water in permanent wetlands is shallow (less than 6 metres deep); this distinguishes wetlands from lakes or large deep rivers.
- Wetlands have unique soil conditions that differ from the adjacent dry land soils. Wetland soils are frequently waterlogged either permanently or seasonally.
- Wetland plants and animals are specifically adapted to wetland soil and water conditions.
- Dry land plants and crops are usually absent from wetlands due to soil conditions.
- In many wetlands, large quantities of dead plant material accumulate and do not decompose because of wetland conditions.

Importance of Wetlands

Wetlands provide important benefits often overlooked. They are among the most precious natural resources on earth. Wetlands are the natural storehouses of considerable levels of biological diversity and provide the life support systems for much of humanity. They play a vital role in sediment and erosion control, flood control, maintenance of water quality and abatement of pollution, maintenance of water supplies (including groundwater) and support for fisheries.

Wetlands provide immediate, short term needs for people including food, water, shelter, fish, medicine, etc and also caters for long term, indirect, general befits such as water storage, recharging and discharging, microclimate regulation, biodiversity conservation, flood control and water purification.

In many parts of Africa and elsewhere in the world there is increased pressure on wetlands and their resources due to social and economic dynamic aspects such as increased poverty, industrialization, overpopulation, climate change, human habitats development and urbanization. The Stockholm Conference (1972) which recommended natural resources use and Ramsar convention provided guidelines and principles for wise-use and proper management of wetlands.

Several countries ratified the Ramsar convention (e.g. Uganda) to show commitment to promoting sustainable management of wetlands and conserve its uses, attributes, services and ecological functions.

Wetlands are the homes of countless forms of plants and animals. Without these wetlands, many species of both plants and animals would become extinct.

In general, wetlands may serve as flood water retention areas for storing excess water, and may serve as ground water recharge areas and act to moderate flows in associated streams.

Wetlands may also act as sediment traps by filtering out various solids and other impurities and chemicals from the water before it actually reaches a lake or stream.

Wetlands sometimes serve as an effective shoreline barrier against wave action, thus acting as a buffer to protect animal life.

"For details about wetland values and functions, refer to unit 2"

Unit Activity 3

- *Try to determine the number of wetlands that have been altered or destroyed in your local area. This can be done by talking to area farmers, your parents, grand parents, businessmen and others who have been living in the area for a relatively long period of time.*

- *Then make a proposal to a concerned government department and land owners persuading them to protect wetlands, by bringing to their knowledge the various values and uses of wetlands*

Examples of wetlands

Wetlands exist in every country. According to the Ramsar convention, each member country is required to at least identify one wetland of international importance. Nile basin countries have responded to this requirement by identifying the following wetlands

COUNTRY	WETLAND	DESIGNATION DATE
UGANDA	L .George	4/March/1988
	L. Nabugabo wetland system	11/Feb/2004
	L. Bisina wetland system	15/Sept/2006
	L. Mburo-Nakivali wetland system	15/Sept/2006
	L. Nakuwa wetland system	,,
	L. Opeta wetland system	,,
	Lutembe bay wetland system	,,
	Mabamba bay wetland system	,,
	Nabajjuzi wetland system	,,
	Murchison falls-Alberta Delta wetland	,,
	Sango-bay-Musambwa island-Kagera wetland system	,,
KENYA	L. Nakuru	5/June/1990
	L. Naivasha	10/April/1995
	L. Bogaria	27/Aug/2001
	L. Boringo	10/Jan/2002
	L. Elmenteita	5/Sept/2005
TANZANIA	Malagarasi-Muyvozi wetlands	13/april/2000
	L. Natron	4/July/2001
	Rufigi-Mafia-Kulwa marine Ramsar site	29/Oct/2004
D.R. CONGO	Parc.national des virunga	18/Jan/1996
	Parc.national des mangroves	18/Jan/1996
RWANDA	Rugezi-Bulera-Ruhondo	1/Dec/2005
SUDAN	Sudd	5/June/2006
EGYPT	L.Bardawil	9/Sept/1988
	L.Burullus	9/Sept/1988

Unit summary

In this unit, we have defined wetlands as areas of land that are wet, flooded either permanently or seasonally and where land retains water for long enough to allow the development of characteristic soils, plants and animals. Wetlands are formed when water due to precipitation in form of rainfall and dew collects in a place and is retained for quite a long period. Various types of wetlands exist such as; swamps, marshes and bogs.

Wetlands are some of the most productive ecosystems in the world and indeed they are an important, and in many cases the exclusive source of natural resources upon which rural communities depend for food, medicine, building material, and dry season grazing. Other indirect uses of wetlands include; Flood control, Ground water recharge, Water filtration, Habitat for flora and fauna, Erosion control, Sediment retention, and Climate modification.

Further reading

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UNIT 2:

WETLAND VALUES AND FUNCTIONS

Introduction

Wetlands provide many benefits at very little cost. They are unique and vital ecological resources. They contribute to the national economy by producing natural resources and goods. The many different types and locations of wetlands make measuring their benefits difficult. However, regardless of where or what kind of wetland it is, there are some basic reasons that make wetlands so very important. These reasons include commercial values, recreational values, wildlife habitats, water quality management, storm buffers, erosion control, and flood control

The multiple roles of wetland ecosystems and their value to humanity have been increasingly understood and documented in recent years. This has led to massive expenditures to restore lost or degraded hydrological and biological functions of wetlands. Nevertheless, it is not enough – the race is on to improve practices on a significant global scale as the world's leaders try to cope with the accelerating water crisis and the effects of climate change. This is escalated by the fact that now the world's population is set to increase by 70 million every year for the next 20 years.

The ability of wetlands to adapt to changing conditions, and to accelerating rates of change, will be crucial to communities and wildlife everywhere as the full impact of climate change on our ecosystem lifelines is felt. Small wonder that there is worldwide focus on wetlands and their services to us.

Wetlands are hugely diverse. However, whether they are ponds, marshes, coral reefs, peatlands, lakes or mangroves, they all share one fundamental feature: the complex interaction of their basic components - soil, water, animals and plants - that fulfils many functions and provide many products that have sustained humans over the centuries. Of course, not every wetland performs all these functions - but most wetlands perform many of them.

Learner out comes:

By the end of this unit, learners should be able to;

- Outline the major wetland values and functions
- Demonstrate how wetlands can contribute to the livelihoods of the people.
- Relate wetland values and functions to poverty alleviation.

Commercial and Recreational Values

Wetlands provide opportunities for many popular recreational activities such as boating, hiking, hunting, fishing, and bird watching. Many people all over the world hunt, fish, bird watch, or photograph wildlife. These activities, which rely on wetlands, add millions of dollars to the national economy. Their economic value lies in the variety of commercial products they provide, such as food, fiber, lumber, and energy resources.

Wetlands Value as Wildlife Habitats

One reason wetlands are so important is the unique wildlife and vegetation they support. They are among the most productive natural ecosystems on the earth. They produce great quantities of plants, some of which could not live anywhere else. Some of the plants specific to wetlands are cattails, swamp rose, spider lilies, and cypress trees. Many of the wetland plants provide food, shelter, and nesting areas for the animals that also make wetlands their home. Wetlands are major breeding grounds for various resident and migratory birds. They are migratory stopovers for many species of waterfowl, wading birds, shorebirds, and songbirds. Many species of invertebrates, amphibians, reptiles, and mammals depend on wetlands for survival. Wetlands are extremely important refuges for this plentiful variety of wildlife. Wetlands are diverse and support an incredible diversity of life.

Water Supply

Wetlands act as reservoirs for the watershed. Wetlands release the water they retain (from precipitation, surface water, and ground water) into associated surface water and ground water. Ground water can be adversely affected by activities that alter wetland hydrology. Drainage of wetlands lowers the water table and reduces the hydraulic head providing the force for ground water discharge. If a recharge wetland is drained, the water resources into which ground water discharges will receive less inflow, potentially changing the hydrology of a watershed.

Wetlands Help Maintain Water Quality

Wetlands are also important in the way they interact with the environment around them. They are natural reservoirs and erosion controllers, and they function as natural sewage systems. When rain sinks into the ground, it is stored in naturally occurring underground depressions. This prevents the water from immediately flowing into streams, rivers, lakes, or the gulf or ocean. The specially adapted plants that live in the wetlands act as flood controllers and as water purifiers. The vegetation slows the water enough so that sediment and chemicals in the water can settle to the bottom. As the water is cleaned, the plants absorb the chemicals that are released. The plants then convert the chemicals to usable substances and eventually pass on these nutrients to the animals in the ecosystem. The ability of wetlands to recycle nutrients and to take suspended materials and chemicals out of the water is a critical and unique function. Generally, wetlands maintain water quality through the following processes.

- Nutrient Removal

Scientists have estimated that wetlands may remove between 70% and 90% of entering nitrogen. Riparian forests can reduce nitrogen concentrations in runoff and floodwater by up to 90% and phosphate concentrations by 50%. The estimated mean retention of phosphorus by wetlands is 45%. Wetlands with high soil concentrations of aluminum may remove up to 80% of total phosphorus.

Constructed wetlands have been used in wastewater treatment to improve water quality before discharge into natural water systems. Wetlands can be extremely useful in agricultural and industrial watersheds because they retain huge amount of nutrients hence preventing deterioration of water quality in recipient water bodies.

- Removal of Biological Oxygen Demand from Surface Water

Biological oxygen demand (BOD) is a measure of the oxygen required for the decomposition of organic matter and oxidation of inorganic matter. BOD is introduced into surface water through inputs of organic matter such as sewage effluent, surface

runoff, and natural biotic processes. If BOD is high, low dissolved oxygen levels result. Low dissolved oxygen Levels can lead to mortality of aquatic life. Wetlands remove BOD from surface water through decomposition of organic matter or oxidation of inorganic compounds. BOD removal by wetlands may approach 100% in a functional wetland.

- Removal of Suspended Solids and Associated Pollutants from Surface Water.

Suspended solids (such as sediment and organic matter) may enter wetlands in runoff, as particulate litter fall, or with inflow from associated water bodies. Sediment deposition in wetlands depends upon water velocity, flooding regimes, vegetated area of the wetland, and water retention time. Sediment deposition in wetlands prevents a source of turbidity from entering downstream ecosystems. Typically, wetland vegetation traps 80-90% of sediment from runoff. Less than 65% of the sediment eroded from uplands exits watersheds that contain wetlands.

Other pollutants that affect water quality such as nutrients, organic materials, metals and radionuclides are often adsorbed onto suspended solids. Deposition of suspended solids, to which such substances are adsorbed, removes these pollutants from the water. Thus, sediment deposition provides multiple benefits to downstream water quality.

- Removal of Metals

Certain wetlands play an important role in removing metals from other water resources, runoff, and ground water. Wetlands remove 20% - 100% of metals in the water, depending on the specific metal and the individual wetland. Forested wetlands play a critical role in removing metals downstream of urbanized areas.

- Removal of Pathogens

Fecal coliform, bacteria and protozoans, which are indicators of threats to human health, enter wetlands through sewage, urban storm water, leaking septic tanks, and agricultural runoff. Bacteria attach to suspended solids that are then trapped by wetland vegetation. These organisms die: after remaining outside their host organisms, through degradation by sunlight, from the low pH of wetlands, by protozoan consumption, and from toxins excreted from the roots of some wetland plants. In this way wetlands have an important role in removing pathogens from surface water.

Wetlands Help Control Erosion and Flooding

Wetlands help protect adjacent and downstream properties from potential flood damage.

The value of flood control by wetlands increases with:

- Wetland area
- Proximity of the wetland to flood waters
- Location of the wetland (along a river, lake, or stream)
- Amount of flooding that would occur without the presence of the wetlands, and,
- Lack of other upstream storage areas such as ponds, lakes, and reservoirs

Wetlands within and upstream of urban areas are particularly valuable for flood protection. The impervious surface in urban areas greatly increases the rate and volume of runoff, thereby increasing the risk of flood damage.

The drainage of wetlands, the diversion of Rivers from their original floodplains, and the development allowed in the floodplains are partly responsible for the billions of dollars in damage to businesses, homes, crops, and property that occur as a result of floods

- Vegetated wetlands help to hold together banks of lakes, rivers, and the beach rim that are often prone to serious erosion problems. When wetlands are converted and the vegetation is removed or damaged, soil erosion increases. Instead of serving as a sediment trap, wetlands become a sediment source.

- When water levels are high due to storms and flooding, the heavy, spongy vegetation absorbs the water and slows its flow. The combined action of storing and slowing can lower flood heights and reduce the water's erosive power. The presence of only 15% of a watershed in wetlands can reduce flooding peaks by as much as 60%. Additionally, the slowed water drops soil that builds up, forming higher, more insulated ground where terrestrial grasses and hardwoods can take root, reducing the force of erosion even more.

Maintaining wetlands near developed areas may be the least expensive insurance policy homeowners and business owners can purchase to protect their property.

Act as Storm Buffers

Coastal wetlands serve an extremely important storm surge protection function when tropical storms or hurricanes come ashore. Research has shown that for every mile of vegetative wetlands, storm surge height can be reduced by one foot. Coastal wetlands

such as brackish marshes, bottomland forest, and barrier islands absorb enormous amounts of wave energy and hold large quantities of water that would otherwise allow storms to do much more damage inland.

Wetlands are especially valued by many members of society because of their location on the landscape, the wide variety of functions they perform and uniqueness of their plant and animal communities. Individual landowners and members of the public also value many wetlands for their open space and aesthetic qualities, as sites for educational research, as locations of important historic and archaeological sites, and as locations for conveying floodwaters.

Generally, wetlands have intrinsic attributes, perform functions, and produce goods and services. Some of these are of primarily local interest, but others have regional, national or international imporntance.In summary, wetlands represent considerable ecological, social, and economic value. The box below shows wetlands values-derived from attributes, functions, goods and services classified into four categories i.e.; direct values, indirect values, option values and non-use values.

Direct Values	***Indirect values***	***Option Values***	***Non-Use Values***
These are production and consumption goods.e.g Fish Fuel Wood Building poles Sand,gravel,clay	These are ecosystem functions and services.e.g Water quality Water flow Water storage	This is premium placed on possible future uses and applications of wetlands.e.g Pharmaceutical Agricultural	This is an intrinsic significance of a wetland.e.g Cultural Aesthetic value Heritage value Bequest value

Thatch Water Wild foods Medicines Agriculture/cultivation Transport recreation	Water purification Water recharge Flood control Storm protection Nutrient retention Micro-climate regulation Shore stabilization	Industrial Leisure Water use	Existence value

- **Direct value**: these are extractable resources of the wetland, which can be used directly and often processed and traded.
- **Indirect values**: these are non -extractable services, which cannot be removed from the wetland directly, but do produce benefits to users.
- **Option values**: this is a value obtained from a wetland by retaining a claim on future use.
- **Heritage value:** this is a value placed on the ability to pass the wetland on to future generations, and let them have the choice to use it the way they want.
- **Existence value**: this is a value derived from knowing that the wetland is there.

Can you think of, and include more examples for each category in the table based on your knowledge and experience with special reference to wetlands in your country?

Activity: Wetland values assessment.

With reference to a wetland in your locality, Identify the products services and functions based on the categories described above.

Methods:

Field survey, photography, direct observation, literature review (wetland booklets, internet, journals, newspapers, posters etc).

Unit Summary

In this Unit our focus has been on the values, services and functions or wetlands
Generally, wetlands have intrinsic attributes, perform functions, and produce goods and services essential to our daily livelihood. This explains why we cannot ignore their ecological, economic and social contribution to our communities.

Wetlands values-derived from attributes, functions, goods and services are classified into four categories, i.e. the direct, indirect, option and non-use values. The multiple roles of wetland ecosystems and their value to humanity have been increasingly understood and documented in recent years.

This has led to massive expenditures to restore lost or degraded hydrological and biological functions of wetlands. Nevertheless, it is not enough – the race is on to improve practices on a significant global scale as the world's leaders try to cope with the accelerating global challenges especially climate change and degradation of natural resources including the valuable wetlands ecosystems.

Further reading

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UNIT 3

WETLAND VALUATION

Introduction

Today, most planning and development decisions are made on economic grounds, more, and more, on the basis of the forces at play in the free-market system. While this new paradigm has its own limitations and dangers, it would be unrealistic to ignore it and to base our quest for the conservation and wise use of wetlands on a completely different set of values. Hence, wetland goods and services must be given a quantitative value if their conservation is to be chosen over alternative uses of the land itself or the water, which feeds the wetlands.

The value of wetland functions, such as water quality improvement, may be calculated from the cost of building a treatment works to perform the same processes. It is much more difficult, however, to value biodiversity or the aesthetic beauty of wetlands, as the market for such "products" is much more elusive and their economic valuation much more difficult to achieve with traditional methods. Another major hurdle is that developing countries face significant problems in appropriating the global benefits of wetland conservation, such as their biological diversity.

The trend towards wetland conservation is exemplified by the many countries that have adopted the policy that there should be no further wetland loss or degradation, that wetlands must be used in a sustainable way and research should be undertaken on quantifying wetland values. International mechanisms and institutions, such as the Ramsar Convention on Wetlands, the Convention on Biological Diversity, the UN Commission on Sustainable Development, OECD, IUCN-The World Conservation Union, Wetlands International and WWF are promoting research, analysis and dissemination of information on economic valuation of natural systems, including wetlands. They advise that decision-makers should fully consider the social benefits of natural ecosystems as well as those of the development proposals being considered and

that they should make full use of the available techniques for accurately expressing resource benefits in economic terms.

Putting an economic tag on wetlands and the many functions they provide has proven very difficult, but has become increasingly necessary. TheRamsar Convention recognizes that it is "vital that all wetland economic values be identified, measured and reported upon to increase national and international awareness of the needs for and benefits of wetland conservation". Appreciation of the "real" value of wetlands is now growing, partly because of the realization of the costs involved in providing alternative services if those of wetlands are destroyed or degraded.

The economic value of wetland conservation is also being appreciated: in the United States, the value of wetlands in preventing serious flooding has been put at US$13,500 per hectare per annum. Fur trapping in North American marshes is thought to be worth from US$151-401 per acre, while reed cutting in East Dongting Lake, China, generates about US$1.25 million each year. . A study of recreational values of wetlands in England has suggested that they are worth from US$100-210 per visitor each year. Policy and decision makers are normally more attracted to economically valuated projects; this is why it is important to attach economic value to wetlands goods, services and functions for conservation interventions to be implemented.

The economy of many African countries is largely based on the natural resources of which water resources including lakes, rivers and wetlands are essential. For conservation and sustainable development to co-exist in Africa, natural resource economics is vital to create a sense of management responsibility for all stakeholders.

Learner outcomes

- Describe the rationale and techniques of wetlands products, services and functions economic valuation.
- Justify the need for wetland economic evaluation.
- Understand the relationship between wetlands conservation and poverty alleviation especially in rural communities.
- Identify challenges of wetland economic valuation and way forward

Economic valuation and its significance

Economic valuation of wetlands is carried out to compare the value of various use options and provide the answer to basic wetland management questions
Is there a need to invest?
If yes, where to invest?
How much should be invested?
Who should pay the investment and management costs?

Economic valuation is a powerful tool to aid and improve wise use and management of global wetland resources by providing a means for measuring and comparing the various benefits of wetlands. The following are some of the terms used while quantifying the wetland benefits.

- **Wetland Processes**:
  The fundamental hydrological, chemical and physical activities that occur in a wetland that are linked to its biological productivity. For example, the role of wetlands in the global carbon cycling.
- **Functions**: The results of the interaction of the wetland's ecological processes. Functions are the physical, chemical, and biological processes occurring in and making up an ecosystem. Processes include the movement of water through the

wetland into streams or the ocean; the decay of organic matter; the release of nitrogen, sulphur, and carbon into the atmosphere; the removal of nutrients, sediment and organic matter from water moving into the wetland; and the growth and development of all the organisms that require wetlands for life.

- **Benefits**: The goods and services made possible by a wetland's functions. For example, by reducing wave energy and stabilizing shorelines, the wetland reduces the chances of property damage. This reduced risk is a benefit to society.
- **Value**: The economic worth of goods or services, generally measured in terms of what individuals are willing to pay for (e.g., the wetland has value because it supports commercial fishery, building materials like sand, e.t.c.).

  The value of the benefit is determined by its price, i.e., the amount of money for which it will be exchanged. The value of a benefit is the price of that product in the open market.

Placing hard monetary values on wetland goods and services helps to ensure that wetlands are not under valued or ignored when economic decisions are made. Therefore, economic valuation provides a basis for rational decisions about the best use of a wetland, taking into account its real economic value.

The economic value of environmental goods and services/commodity is measured by the summation of many individuals' willingness-to-pay for it. In turn, this willingness-to-pay (WTP) reflects individuals' choice for the goods in question. Therefore, economic valuation in the environment context is about measuring the preferences/choices' of people for an environmental benefit or against environmental degradation. Valuation is therefore in relation to preferences held by people. Moreover, the use of economic values permits the comparison that is required between environmental' and 'developmental' values. The latter is expressed in fiscal/monetary terms, either in dollars/pounds/shillings or as economic rate of return.

Specific major reasons for economic valuation of wetlands goods and services are:

A key concept underlying the principles of the Ramsar Convention is that wetlands have great value. Conservation can only be achieved if wetlands can be shown to be of value and, in some cases, of greater value than proposed alternative uses of the wetland site itself or of the water feeding the wetland. In line with this, Contracting Parties are asked to provide physical and social values of wetlands as part of the information for designation on the List of Wetlands of International Importance. Contracting Parties are also committed to making environmental impact assessments, before initiating schemes that might affect wetlands, which should pay particular attention to maintaining the values of wetlands.

(i) The need for economic valuation of wetlands impacts and assets arises for pursuing efficient policies and investing in efficient projects and programmes. At the most general level of intergenerational concern, valuation is still required. If transfers of resources are to be made between generations -- with the current generation sacrificing for the future, or future benefits being lost for the sake of present gain -- then it is essential to know what is being sacrificed and how much it is that is being surrendered.

(ii) Macroeconomic management records, monetary flows and transactions within the economy. The national accounts are widely used to indicate well-being and rates of change, and national aggregates such as Gross Net Production (GNP) are widely construed as measures of 'development'. Whether the accounts are designed to record economic activity or measure well-being, or both, they are deficient with respect to their treatment of the wetlands. Economic activity involves the use of materials and energy, and, once transformed into products, the same resources become, sooner or later, waste products. Any measure of economic activity, which ignores these materials and energy flows, will fail to record important activities that affect the sustainability of the economic

activity. For these reasons, there is a need for widespread consensus so that the national accounts are modified and wetland 'stocks' and 'flows' are recorded. Depreciation in the stocks of natural resources requires proper valuation to ensure sustainability.

(iii) Information on the economic values and policy changes (with regard to the wetlands) can greatly assist in identifying the policy and sectoral priorities. Economic valuation incorporating environmental aspects including wetlands helps in evaluating developmental projects, programmes and policies.

Activity 1: Water use economic valuation

- Identify a wetland water source where people draw water for domestic use.
- Make a simple water requirement budget per person per day or per week based on the average cost of water per liter in your locality.
- Now calculate the minimum amount of money that must be spent on water for domestic use per person per day or week on average.
- Proceed to estimate the total population that depends on the wetland water source
- Calculate the minimum amount of money that population would need to spend on water bills with out a wetland per day, week, month or year.

Rationale, techniques and procedures for wetland valuation

In simple terms, wetland valuation means putting a monetary value on the products that are sold e.g. firewood, papyrus, fish, sand, etc. Economists and decision makers normally focus on these values. The total economic value of wetlands however extends far beyond the value of raw materials and physical products. A holistic economic valuation technique must therefore be employed.

If researchers are to value wetland uses and decision-makers are to take these into account when making policies that affect wetlands, then a framework for distinguishing

and grouping these values is required. The concept of *total economic value* (TEV) provides such a framework and there is an increasing consensus that it is the most appropriate one to use. Simply put, total economic valuation distinguishes between *use* values and *non-use* values, the latter referring to those current or potential) values associated with an environmental resource which rely merely on its continued existence and are unrelated to use. Typically, use values involve some human 'interaction' with the resource whereas non-use values do not. The total economic valuation framework, as applied to wetlands, is illustrated in the Table below.

Use Values			**Non-Use Values**
Direct Use Value	**Indirect Use Value**	**Option and Quasi-Option Value**	**Existence Value**
fish	nutrient retention	potential future (direct and indirect) uses	biodiversity
agriculture	flood control	future value of information	culture, heritage
fuel wood	storm protection	.	bequest values
recreation	groundwater recharge	.	.
transport	external ecosystem support	.	.
wildlife harvesting	micro-climatic stabilization	.	.
peat/energy	shoreline stabilization, etc.	.	.

Source: adapted from Barbier (1989b, 1993, 1994) and Scodari (1990)

Economic Value

This is determined by and in a market. In the market, the potential buyer sets a price they are willing to pay, and the seller sets the price they are willing to accept. An acceptable price for both parties is taken to be the market price hence the economic value of a given product. This applies to scarce goods according to the economic theory.

For services of wetlands not traded in the market like consumptive products, other valuation techniques are employed to determine their economic value.

Activity 3: Wetland market products value assessment.

- With reference to a local wetland, identify possible market products.
- Make a list of these products and attach a market price for each.
- Make a simple survey of the market products value of your local wetland in a specified period.

The economic value of a given wetland includes direct values, indirect values, option values, heritage values and existence values. To determine the total economic value of a wetland, the values of all the components of the wetland must be established.

Valuation techniques

- Market prices method.

This involves the use of prevailing prices for goods and services traded in domestic or international markets. Market prices reflect the private willingness to pay for wetland costs and benefits that are traded (e.g., fish, timber, fuel wood, recreation). They may be used to construct financial accounts to compare alternative wetland uses from the perspective of the individual or company concerned with private profit and losses. Price data are relatively easy to obtain.

The advantage of this method is that the Market imperfections and/or policy failures may distort market prices which will therefore fail to reflect the economic value of goods or services to society as a whole. Seasonal variations and other effects on prices need to be considered when market prices are used in economic analysis.

- Efficiency (shadow) prices method.

The efficiency prices method involves the use of market prices but adjusted for transfer payments, market imperfections and policy distortions. May also incorporate distribution weights, where equality concerns are made explicit. Shadow prices may also be calculated for non-marketed goods.

Efficiency prices reflect the true economic value or opportunity cost, to society as a whole, of goods and services that are traded in domestic or international markets (e.g., fish, fuel wood, peat). The disadvantage of this method is that the derivation of efficiency prices is complex and may require substantial data. Apparently, 'artificial' prices may not be accepted by decision-makers.

- Hedonic pricing method.

In this method, the value of an environmental amenity (such as a view) is obtained from property or labour markets. The basic assumption is that the observed property value (or wage) reflects a stream of benefits (or working conditions) and that it is possible to isolate the value of the relevant environmental amenity or attribute.

Hedonic pricing has potential for valuing certain wetland functions (e.g., storm protection, groundwater recharge) in terms of their impact on land values, assuming that the wetland functions are fully reflected in land prices.

The disadvantage of this method is that Application of hedonic pricing to the environmental functions of wetlands requires that these values are reflected in surrogate markets. The approach may be limited where markets are distorted, choices are constrained by income, information about environmental conditions is not widespread and data are scarce

- Production function approach.

This method estimates the value of a non-marketed resource or ecological function in terms of changes in economic activity by modelling the physical contribution of the resource or function to economic output.

Production function approach is widely used to estimate the impact of wetlands and reef destruction, deforestation and water pollution, etc., on productive activities such as fishing, hunting and farming.

This method however, requires explicit modelling of the 'dose-response' relationship between the resource or function being valued and some economic output. Application of the approach is most straightforward in the case of single use systems but becomes more complicated with multiple use systems. Problems may arise from multispecification of the ecological-economic relationship or double counting

- Related good method.

It involves the use of information about the relation-ship between a non-marketed good or service and a marketed product to infer value. The *barter exchange approach* relies on actual exchange of non-marketed goods. The *direct substitute approach* simply assumes that a marketed good can be substituted for a non-marketed good. The *indirect substitute approach* also relies on a substitute good, but if the latter is not exchanged in the market, its value is inferred in terms of a change in economic output (i.e., the direct substitute approach combined with the production function approach).

These approaches may provide a rough indicator of economic value, subject to data constraints and the degree of similarity or substitutability between related goods

The barter exchange approach requires information on the rate of exchange between two goods. The direct substitute approach requires information on the degree of substitution between two goods. The indirect substitute approach requires information on the degree of substitution and on the contribution of the substitute good to economic output.

- Constructed market techniques.

This involves the measure of willingness to pay by directly eliciting consumer preferences. This technique directly estimates Hicksian welfare measure - provides best theoretical measure of willingness to pay. However, practical limitations of constructed market techniques may detract from theoretical advantages, leading to poor estimates of true willingness to pay.

- Cost-based valuation.

This is based on assumption that the cost of maintaining an environmental benefit is a reasonable estimate of its value. To estimate willingness to pay:

It is easier to measure the costs of producing benefits than the benefits themselves, when goods, services and benefits are non-marketed. Approaches are less data- and resource-intensive.

The disadvantage of this technique is that these second-best approaches assume that expenditure provides positive benefits and net benefits generated by expenditure match the original level of benefits. Even when these conditions are met, costs are usually not an accurate measure of benefits.

- Travel cost approach.

The travel cost approach derives willingness to pay for environmental benefits at a specific location by using information on the amount of money and time that people spend to visit the location.

Other techniques include;

- *Damage costs avoided* (DC) approach, which relies on the assumption that damage estimates are a measure of value. It is not a cost-based approach as it relies on the use of valuation methods described above.
- *Contingent valuation method* (CVM) constructs a hypothetical market to elicit respondents' willingness to pay.
- *Contingent ranking* (CR) ranks and scores of relative preferences for amenities in qualitative rather than monetary terms.

- *Indirect opportunity cost* (IOC) method uses wages foregone by labour in production of non-marketed goods.
- *Restoration cost* (RSC) method uses costs of restoring ecosystem goods or services.

A systematic Guide to Undertaking a Valuation Study

There are seven practical steps, which must be followed to undertake an economic valuation of a wetland. These are presented and described below.

Seven steps to conducting a valuation study

1. *Choose* the appropriate assessment approach (impact analysis, partial valuation, total valuation)

2. *Define* the wetland area and specify the system boundary between this area and the surrounding region

3. *Identify* the components, functions and attributes of the wetland ecosystem and rank them in terms of importance (e.g., high, medium, low)

4. *Relate* the components, functions and attributes to the type of use value (e.g., direct use, indirect use and non-use)

5. *Identify* the information required to assess each form of use (or non-use) which is to be valued and how to obtain the data

6. ***Use*** available information to quantify economic values, where possible.

7. *Implement* the appropriate appraisal method, e.g., cost-benefit analysis (CBA).

Step 1: choosing the appropriate assessment approach

There are three approaches: impact analysis; partial valuation; and total valuation. If the problem is a specific external impact, such as effluent polluting a wetland, ***impact analysis*** will be appropriate. If the problem is the necessity of making one choice between wetland use options, including conversion of the wetland to residential land or diversion of water upstream of the wetland to intensive irrigation, then **a *partial valuation*** would be the correct approach. Sometimes the problem is more general. For example, developing a national conservation strategy may require assessment of the total net benefits of the wetland system. In this case**, a *total valuation*** should be undertaken.

- **Step 2: defining the wetland area**

The boundary of the wetland may already have been defined for political purposes, such as gazettement as a National Park or Ramsar site. No definitive methodology exists to delineate the boundary scientifically. This will be the first task for the multi-disciplinary team based on maps of flood extent, soils, agricultural use and vegetation.

- **Step 3: identifying and prioritizing components, functions and attributes**

The third step involves using various data sources, including scientific studies, consultancy reports and national resource inventories, to produce a more definitive list of components, functions and attributes present in the wetland, and then to place them in order of importance. This may be in rank order, say 1 to 10, or expressed as being of high, medium or low importance. The major components, functions and attributes are discussed in other chapters. Clearly, no single wetland will exhibit all of these, and it is important for the multidisciplinary team to work together to identify the key components, functions and attributes of the wetland being studied and to use all available ecological, hydrological and economic information to score these various characteristics.

The distinction between components, functions and attributes is directly useful from an economic perspective, but scientists from other disciplines may have some difficulty with these concepts. Regardless of whether these characteristics or others are used, it is important that all members of the team understand their meaning and work together to establish priorities for valuation amongst themselves.

- **Step 4: relating components, functions and attributes to use value**

The fourth step is to determine whether each of the components, functions and attributes is associated with a direct use, indirect use or non-use. Interviews with local communities, census data and consultancy reports are usually good sources of information on direct use. More detailed scientific investigation is usually required to uncover the indirect use values, concentrating on the physical links between wetland system functioning and the economic activities affected. Some of the intangible values – option and existence values – may be more difficult to deter-mine, and it will often be up to the multidisciplinary team to use its best judgment, keeping in mind the difficulties of quantifying these values.

- **Step 5: identifying and obtaining information required for assessment**

The fifth step involves identifying and obtaining information required for the valuation. Different physical, chemical and biological data will be required depending on the values that are to be assessed and the methodology for collecting and analyzing the data must be specified. The range of data to be collected can be extremely diverse. For example, it may include fish population status, numbers of rare species, rates of groundwater recharge, and amounts of flood storage, degree of nutrient retention or coastal protection and so forth. Information on the extent and rate of various human uses of the wetland must also be collected.

The types of data may again be diverse, including agricultural yields, fish catches, tourist use or reduction in annual damage from storms or floods. A variety of collection methods and sources may be required. Obtaining agricultural and fisheries yields, for example, may involve interviews with fishermen and farmers, collection of statistics from government offices and visits to markets. Travel agents or tour companies could provide data on tourism in general, whilst parks and protected areas will know visitor numbers. Insurance agencies may have information on flood and storm damage in the area, whilst environmental authorities may collect water quality data.

Information is required on all inputs and outputs for all economic activities that are either directly or indirectly supported or protected by wetland ecological functions. This will include the economic costs of the inputs (e.g., labour-time, materials, and physical assets) and the prices of the outputs (products). On the inputs, a distinction needs to be made between purchased inputs (e.g., tools, licenses, hired labour) and non-cash inputs (e.g., use of their own or family labour and borrowed tools). Similarly, distinction must be made between outputs which are marketed (e.g., rice sold at the local market) and those which are non-marketed (e.g., fish eaten at home).

Information is required on the producer prices, the final market prices, the transportation, and other intermediary costs of marketed products. For non-marketed products, it is necessary to know their rates of consumption, and it may be helpful to obtain information on the market price of any substitute or alternative product.

The information required to assess non-use or preservation values is extremely difficult to collect for developing countries and may require specific studies to estimate willingness to pay. If such analysis is beyond the scope of the study, assessment of such values may warrant a qualitative rather than quantitative approach. This can be approached through interviews with local people and those outside the area who have a connection with it.

More general social and economic data should also be collected on communities living within the wetlands or where they benefit from, or are affected by, wetland functions. For example, this may include population growth rates, income levels, credit facilities and rates of interest, inflation and exchange rates.

Data collection should begin with **a *literature survey*** of available statistics, existing studies, and their analysis for the region, which may yield some of the required information. Next, any site surveys of specific economic activities should be undertaken. In the first instance, **a *rapid rural appraisal*** based on brief farmer or producer interviews and group participation may be relevant to collecting basic information on human uses and economic data. More detailed ***baseline surveys*** may be required for in-depth data

collection for actual valuation purposes. In all cases, it is important to be clear in advance about the information required to avoid collecting 'data for data's sake'.

- **Step 6: quantifying economic values**

In this step, the appropriate valuation techniques should be selected and implemented. There are many sophisticated techniques, such as contingent valuation and hedonic pricing, which are being applied to value temperate wetland functions, products and attributes, and such methods are increasingly being implemented especially in tropical regions. Although alternative approaches are available, some of these may yield extremely inaccurate valuation estimates. Care must therefore be exercised in choosing a technique which is theoretically sound but which is also appropriate to the circumstances where it will be applied.

- **Step 7: implementing the appropriate appraisal method**

In the final step, the economic analysis of the wetlands should be placed in the appropriate framework as selected during the planning for the study. An example is *cost-benefit analysis* (CBA), which normally involves calculating, on an annual basis the benefits and costs of conserving the natural wetland functions, products and attributes over a selected time period. The three most common methods for comparing costs and benefits are *net present value*, *internal rate of return* and *benefit-cost ratio*. Any valuation should be subject to a sensitivity analysis, which defines the variation in results arising from different assumptions or benchmark values used in the study, such as discount rates.

However, CBA is not the only possible appraisal method available, and other frameworks, such as environmental impact assessment, multi-criteria analysis and risk assessment may also require economic valuation as part of the assessment procedure. Initial planning of the study should determine which framework for assessing costs and benefits is desirable, as the choice of framework may affect all seven steps of the analysis.

Unit Summary

In this section a general, we have appreciated the need for and significance of wetland valuation in economic terms. The public good qualities of wetland values would be unimportant if all wetland benefits could be enjoyed simultaneously, without any conflict among the various uses. Aggregating all possible use values together in such an unfettered multiple-use situation would be more likely to lead to recognition of the importance of conserving a wetland in its natural or a semi-natural state.

However, amongst many wetland uses there are inherent conflicts or tradeoffs, even when the wetland is maintained in a more-or-less natural state.

Generally, wetland resources are particularly susceptible to misallocation decisions because of the nature of the values associated with them. Wetlands are multifunctional resources *par excellence*. Not only do they supply us with a number of important resource outputs (e.g., fish, fuel wood, wildlife), but they also perform an unusually large number of ecological functions which support economic activity. Many of these latter services are not marketed; that is, they are not bought and sold because the support they provide to economic activity is indirect and therefore largely goes unrecognized.

In the case of tropical wetlands, many of the subsistence uses of wetland resources are also not marketed and are thus often ignored in development decisions. This is why economic valuation of wetlands is very important if we are to strike a balance between development and conservation or wise use.

Wetland economic valuation can be defined as the attempt to assign quantitative values to the goods and services provided by wetland resources, whether or not market prices are available to assist us. However, such a definition goes only part way. We must be more specific about what economists mean by the term *value*. The economic value of any good or service is generally measured in terms of what we are willing to pay for the commodity, less what it costs to supply it. Where a wetland resource simply exists and provides us with products and services at no cost, then it is our *willingness to pay* alone

which describes the value of the resource in providing such commodities, whether or not we actually make any payment. This is the principle basis of wetland evaluation.

The need for economic valuation of wetlands impacts and assets arises for pursuing efficient policies and investing in efficient projects and programmes. At the most general level of intergenerational concern, valuation is still required for wise use and conservation considerations.

Discussion Questions

1. With special reference to your country, describe the importance of wetlands economic valuation.
2. How does economic valuation of wetlands help the economic policy makers in making sustainable development choices?
3. Prepare a 30 minutes presentation that can effectively convince a panel of politicians in your country to reverse their decision of allocating an urban wetland to investors ready to construct a mult-million dollar flower farm with hundreds of job opportunities.

Further reading

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Unit 3:

WETLANDS AND BIODIVERSITY

Introduction

Wetlands are among the most productive life-support systems in the world and are of immense socio-economic and ecological importance to mankind. They are critical for the maintenance of biodiversity and perform a great role in the biosphere. Ironically, wetlands have been perceived as wastelands associated with disease, difficulty and danger. Emphasizing the negative impacts and ignoring their importance, these habitats were considered obstacles in the path of progress and hence drained, filled, despoiled and degraded for economic gains. The wetland loss has been responsible for bringing to the verge of extinction countless species of animals and plants. Inadequate understanding of the crucial role and utility of wetlands is a matter of serious concern. This unit will therefore try to examine the role of wetlands in the maintenance of biological diversity.

The combination of aquatic and terrestrial conditions that produce what we describe as *'wet-lands'* makes these ecosystems among the most complex in the world. Within a wetland, the environmental characteristics are determined largely by hydrologic processes which may exhibit daily, seasonal or longer-term fluctuations, in relation to

regional climate and geographic location of the site. These factors produce a great range of wetland types globally, the majority of which have extremely variable conditions in the many habitats which they contain. As a consequence, the variety of living organisms which has adapted to the different wetland habitats tends to be high, with all major groups of plants and animals present.

Specifically the following aspects on wetland biodiversity are to be examined;

- Introduction to biodiversity
- Importance of biodiversity
- Wetland flora: diversity, adaptations and uses
- Wetland fauna: diversity, adaptations and uses
- Wetland IBAs in the Nile basin region
- Benefits of wetland biodiversity
- Threats to wetland biodiversity
- Impacts on wetland biodiversity

Learning outcomes

By the end of this unit, learners should have improved their ability to;

- *Define the term biodiversity with*
- *State and explain the importance of biodiversity with special reference to wetlands.*
- *Identify examples of wetland biodiversity*
- *Identify threats to wetlands biodiversity and propose mitigation measures*
- *Give and explain the benefits of wetland biodiversity to mankind*

Introduction to biodiversity

Biodiversity is the variation of life forms within a given ecosystem, biome or for the entire Earth. It is often used as a measure of the health of biological systems including forests, wetlands lakes rivers e.t.c.

Biodiversity may also be referred to as the "variation of life at all levels of biological organization". It is a measure of the relative diversity among organisms present in different ecosystems. Some ecologists also describe biodiversity as the "totality of genes, species, and ecosystems of a region".

This description classifies biodiversity into three levels of identification:

- Genetic diversity - diversity of genes within a species. There is a genetic variability among the populations and the individuals of the same species.
- Species diversity - diversity among species in an ecosystem. "Biodiversity hotspots" are excellent examples of species diversity.
- Ecosystem diversity - diversity at a higher level of organization, the ecosystem.

The 1992 United Nations Earth Summit in Rio de Janeiro defined "biodiversity" as "the variability among living organisms from all sources, including, 'inter alia', terrestrial, marine, and other aquatic ecosystems, and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems".

For geneticists, *biodiversity* is the diversity of genes and organisms. They study processes such as mutations, gene exchanges, and genome dynamics that occur at the DNA level and generate evolution.

For ecologists, biodiversity is also the diversity of durable interactions among species. It not only applies to species, but also to their immediate environment (biotope) and their

larger ecoregion. In each ecosystem, living organisms are part of a whole, interacting with not only other organisms, but also with the air, water, and soil that surround them.

Importance of biodiversity

What is the importance of biodiversity?

There are no simple answers to this question. Biodiversity itself is a complex, perhaps amorphous concept, extending from genes to ecosystems and biomes, and to interactions and processes. There are a number of ways in which we value biodiversity. Our value systems range from purely economic to ecological ones. Cultural values are also prominent but rarely universal. Values of biodiversity may also exist wholly outside the human context, as is the case of inherent values of species. There are, however, ways to bring the question into focus. As in human life, sometimes how we value others comes most into focus when we are about to lose them from our lives.

A friend moves to a new city or a grandparent dies. Their passage often provokes reflection upon what they meant to us and the ways in which they were important to us. In other words, we sometimes can most easily articulate the value of something to us when we are about to lose it. Here is a subset of some categories used to examine the value of biodiversity:

- Direct Use Values - Species provide various goods or products to humans, many of which play important roles in human economies. Examples include food, medicine, timber, fiber, etc.
- Indirect Use Values - Species provide services to humans as well as to other species. These include pollination, nutrient cycling, regulation of the atmosphere and climate.

- Ecological Value - Biodiversity provides many ecosystem services that are often not readily visible. It plays a part in regulating the chemistry of our atmosphere and water supply. Biodiversity is directly involved in recycling nutrients and providing fertile soils. Experiments with controlled environments have shown that humans cannot easily build ecosystems to support human needs; for example insect pollination cannot be mimicked by human-made construction, and that

activity alone represents tens of billions of dollars in ecosystem services per annum to humankind.

- All species are supported by the interactions among other species and ecosystems, each providing an ecological value to one another. Loss of species makes ecosystems less resilient and often less productive.
- Cultural-social and Spiritual Value- The identity of human cultures around the world is attached to varying degrees to wild species. Wild species are often referred to in religious texts. Outside of formal religion, many people feel connected to species for reasons that can be hard to explain. Some may be inspired by a species' intrinsic beauty, revere it for its strength, or admire it for its cleverness. Whatever the case, cultural diversity is closely linked to wild species. Many people derive value from biodiversity through leisure activities such as enjoying a walk in the countryside, bird watching or natural history programs on television. Biodiversity has inspired musicians, painters, sculptors, writers and other artists. Many cultural groups view themselves as an integral part of the natural world and show respect for other living organisms.
- Intellectual value-Through the field of bionics, a lot of technological advancement has been done which may not have been the case without a rich biodiversity.

Unit Activity 1

Visit a nearby wetland; observe the various flora and fauna. Identify any of the plants and animals that have value to man, clearly stating the value of each.

The Biological Diversity of Wetlands

Wetland flora and fauna

Most plants and animals depend on water for life, so it is not surprising that wetlands are species-rich in both flora and fauna. However, because of the dynamic nature of wetlands, with periods of drying and inundation varying in frequency and duration over time, not all plants and animals that live in wetlands are present in them all of the time. Some plants may be hidden and lie dormant as seeds or bulbs in the soil waiting for water, while others, are more permanent and conspicuous landmarks of a wetland environment.

Wetland ecosystems are therefore cradles of biological diversity, providing the water and primary productivity upon which countless species of plants and animals depend for survival. They support high concentrations of birds (especially waterfowl), mammals, reptiles, amphibians, fish and invertebrate species.

Levels of species diversity do, however, vary considerably between different wetland ecosystems. Some lakes display high levels of diversity and endemism, whereas others support little life. Unlike terrestrial ecosystems, the richness of freshwater biodiversity is still poorly known. Identification and classification of wetland species is hampered by the fact that many species may spend part of their life cycle in both freshwater and marine ecosystems.

Wetlands are an important storehouse of plant genetic materials. Rice, a common wetland plant, is the staple diet of more than half of the world's population. West African rice (*Oryza glabberrina*), for example, was domesticated over 2000 years ago and wild rice from other wetlands continues to be an important source of new genetic materials in developing disease-resistant and higher-yield strains. A wide range of important woody species are also found in wetlands: many bear adaptations to changing hydrological conditions (changes in water regimes or increased salt levels) and may be of value in the context of global climate change and rising sea levels. Conserving the genetic variability of such plant resources is therefore essential.

Wetlands are renowned for their high levels of endemic species, especially fish and invertebrates. Nowhere is this more obvious than in the East African Rift Valley lakes (Victoria, Tanganyika, Malawi) which support exceptionally high levels of endemic fish. More than 700 endemic species of cichlids have been recorded. Some 80% of the cichlids in Lake Tanganyika are endemic. A survey conducted by the World Conservation

Monitoring Centre showed that 18 "hot spots" for biodiversity contained 737 species of amphibians alone, clearly demonstrating the importance of wetlands in maintaining biological diversity.

Biodiversity in African Wetlands

The biological diversity of wetlands in the continent is unevenly distributed, with some habitats being characterized by a richer range of species than others. In particular, wetlands in areas of high rainfall and warm climates, such as the Congo Basin, display richer species diversity than those of drier regions north and south of the 15ºN to 20ºS zone. Of course, the importance of any given wetland from a biodiversity perspective is assessed not only by the overall richness in number of species present, but on the uniqueness of the area in terms of the number of localized species, particularly the endemic species. In this regard, most African wetlands display both characteristics, richness in number of species and endemism. There are, for example, over 2,000 known species of indigenous freshwater fishes in Africa. The Zaire River Basin, probably the most diverse area in Africa for its fishes, has over 700 identified species of which 560 are endemic to the basin. There are at least 18 families of endemic freshwater fish fauna many of which are found in the great lakes of east and central Africa.

It is believed by some authorities that wetland areas of highest endemism and of international significance in Africa are the Inner Niger Delta in Mali, the seasonally inundated floodplain of northern Central African Republic and southern Chad, the Sudd region of southern Sudan, Lake Victoria and Kyoga in Uganda, the swamps of western Tanzania and various parts of Zambia, and the Okavango region of northern Botswana.

Wetland flora

Wetland flora is distinctive and varied. It typically includes several different plant forms including algae; floating plants such as the duckweed; benthic plants which are attached to the bottom but grow submerged such as sea grasses and pond weeds; emergent macrophytes such as reeds, rushes, sedges, herbs, grasses, trees and shrubs. Trees and shrubs characteristic of wetlands include paper-bark and tea-tree species.

The ready availability of water, which transports nutrients and removes waste products, and the frequent association between plant roots and microscopic organisms able to use nitrogen, allow wetland plants to grow rapidly and produce large quantities of organic matter. In tropical wetland plants, such as mangroves, this primary production can go on all year and reach levels comparable to the most intensively mechanized agricultural production, for example sugar cane crops. Plants play a critical role in the structure and productivity of coral reefs in near-shore wetland environments.

In many areas, the reefs can be described as 'cor-algal' reefs because of the close association between the corals (animals) and species of algae (plants). Other algae living in the coral tissues aid in the production of organic matter and are largely responsible, thus, for the high productivity of the reefs.

Adaptations of wetland plants to wetland conditions

Wetland plants have developed adaptations to deal with the challenges posed by wetland ecosystems, the biggest of which is probably oxygen deficiency.

For plants to take up nutrients, they have a natural pumping system in the roots. This pump requires energy and in dry land, with the ample oxygen available in the root zone, the energy is provided by oxidation of carbohydrates. If oxygen levels are low in the root zone, there are various strategies a plant can exploit; these are;

- To bring oxygen from the air to the root zone.
- To use another metabolism to generate energy.
- Some wetland plants have a porous stem and root system which allows oxygen to be picked up from the air to travel to the roots.
- Other plants have developed anaerobic respiratory processes and can diffuse the toxic by-products through a fine root system.

Wetland fauna

The species diversity and high production levels of wetland plants support even more diverse animal communities. The vegetation distribution patterns and water level fluctuations make a range of continuously changing wetland habitats available at

different times of the year to aquatic, terrestrial and arboreal animals. Wetlands support a wide variety of grazing and browsing animals, including several large mammals such as African Buffalo (*Syncerus caffer)* and Hippopotamus (*Hippopotamus amphibius)* in Africa. A number of invertebrates, particularly snails and crustaceans graze on water plants and convert these to animal biomass, in some cases impoverishing wetland vegetation.

Wetland ecosystems are therefore cradles of biological diversity, providing the water and primary productivity upon which countless species of plants and animals depend for survival. They support high concentrations of birds (especially waterfowl), mammals, reptiles, amphibians, fish and invertebrate species.

other invertebrates. Some of the native animals found in wetland areas are considered rare and threatened, e.g. the Shoebill.

Some larger mammals such as the cheetah visit wetlands for shelter and food.

Most wetlands undergo cycles of wetting and drying, and many wetland animals are adapted to this. The drying and subsequent re-flooding of a wetland may be the most important impulse for the growth and reproduction of wetland plants and animals. Wetlands that retain water in times of drought may provide valuable wildlife refuge. The

drying phase is equally important, however, for the decomposition of plants and their associated release of nutrients. Many wetland plants also set seed during this dry period.
The re-flooding of a dry wetland triggers prolific growth and breeding of insects as well as the germination of native wetland plants. These insects and plants provide food for native fish, water birds and other animals.

Apart from native fauna, wetlands are used for grazing cattle and sheep and may also support pest species such as pigs, goats, cats, deer, rabbits and foxes.
Many wetlands provide habitat for other important faunal components, serving as resting and feeding stations along migratory flyways for ducks, waders and shorebirds which benefit from the diversity of food organisms. The seasonal influx of passage migrants serves to increase the biodiversity of many wetland sites.

Adaptations of wetland animals to wetland conditions

Just as wetland vegetation is unique to wetlands, so the fauna has adapted to the special conditions of wetlands. To exploit wetland habitats, animals have evolved unique adaptations to live more competitively. These adaptations include; `
Respiration; Some insects, fish, and amphibian larvae, utilize dissolved oxygen in the water where it is available. The insects absorb oxygen through the thin cuticles; fish and amphibians use gills; mosquito larvae use tinny tubes pocking out of the water for breathing; lung fish have lung-like apparatus with which they breathe air to supplement the poor oxygen supply in the wetlands.
Mobility: wetland animals have specialized appendages enabling them to move with speed and agility within the environment. Examples include; the long hooves of the sitatunga that spread out as the animal moves, the webbed and elongated toes of many wetland birds, and the waterproof body of animals, such as the otter. Swimmers such as fish and otter also have muscular, slim and smooth bodies enabling them to cut through the water easily.

Feeding; Some wetland animals have adapted to changing water levels by having versatile feeding habits. For example; the sitatunga feeds on a variety of vegetation on wetland

margins when water levels are high. When water levels drop, it moves deep into the swamp to feed almost exclusively on papyrus shoots. Wetland birds have elaborately adapted feet and beaks for feeding at different depths in the mud or water. This avoids competition for food and enables a high number of birds to feed in the same physical space. Crustaceans are filter feeders, trapping detritus or plankton from the water.
Lung fish also aestivate during dry season to conserve energy until water levels rise.

Benefits of Wetland Biodiversity

Wetlands are some of the most productive ecosystems in the world and indeed they are an important, and in many cases the exclusive, source of natural resources upon which rural economies depend, providing food and energy, medicine, building material, dry season grazing and transportation for large human populations.

There are many examples of how local communities make use of the diversity and high productivity of wetlands. For example, in Uganda, people harvest *Cyperus papyrus* to make mats and baskets. In Rwanda, *Cyperus papyrus* is compressed into fuel briquettes with a high calorific content.

Unit Activity 2

In a group of five, visit a wetland that is nearest to your school and do the following;

- *Observe carefully the various flora and fauna of the wetland.*
- *In your record sheets, make a list of the plants and animals that you can identify.*
- *Make a descriptive summary of the identified plants and animals.*
- *Collect a few plants and animals from the wetland, and identify any physical observable features that enable them to survive in the wetland environment.*

Threats to Wetland Biodiversity

The Nile basin region has a significant number of precious wetlands, however, some wetland areas are experiencing immense pressure from human activities, the most important being drainage for agriculture and settlement, excessive exploitation by local communities and improperly planned development activities.

In spite of the noted importance of wetlands to local communities, the human pressure on wetlands is expected to increase as populations grow, unless strategic actions are put in place for the conservation of wetlands. For example the construction of dams on the Tana and Athi rivers in Kenya has blocked upstream movement of migratory fish species

Changes in wetland water quality, is also another big threat to wetland biodiversity. This is mainly due to the effects of industrial effluent and agricultural pesticides, siltation from highland catchment areas, and introduction of alien species of flora and fauna leading to colonization by single species and loss of endemic species diversity.

Perhaps one of the biggest single catastrophes has been the introduction of the Nile Perch (*Lates niloticus)* and a species of tilapia *(Oreochromis niloticus)* to Lake Victoria which has led to the extinction of a large number of the 200 or so endemic cichlids of the lake; a tragic loss of biodiversity. Similarly, the introduction to the same lake of alien plant species, the Water Hyacinth, (*Eichhornia crassipes*) and Water Lettuce (*Pistia stratiotes)*, threatens the existence of endemic flora.

The threat to wetlands has global effects on the world's biodiversity. The future of wetlands lies in a stronger political will to protect them, based on sound wetland policies and encouragement for community participation in their management. Although the goal for protected wetlands should continue to be conservation of endangered and fragile sites, greater efforts should be focused on wetlands outside protected areas, and new management strategies formulated which incorporate the stakeholders.

The Government of Uganda has recently launched such a policy for the conservation of its wetland resources. This is the first of its kind in Africa to have been formulated in

accordance with the recommendation from the Ramsar Convention. It encompasses wetlands in protected and non-protected areas and offers the best example in Africa of a strong political will to conserve wetlands and their biodiversity. It is important that other Nile basin countries put such policies in place, and other management strategies

Consequences of Wetland Biodiversity loss

It is obvious from the large number of resource organisms mentioned earlier, that loss of wetland species has economic implications. The livelihood and culture of large numbers of people, in almost every country of the world, will be endangered if wetland resources become further depleted. A major portion of fisheries production, most hunting, much forest production and a significant part of ecotourism will be lost worldwide, as well as elements of heritage and environmental quality. It is important to stress, however, that it is not sufficient just to protect the populations of plants and animals that are directly exploited: their health and survival, or sustainability, depend on maintaining the whole complex of biodiversity that characterizes wetland ecosystems.

Commercially exploitable wetland plant and animal species will be available only if the biological processes which produce them are maintained. These include primary production, nutrient cycling, pollination, flowering, fruiting, decomposition, food web interactions, grazing, predation, immigration and emigration. Hundreds of inter-related organisms take part in this gamut of processes and it is this diversity of wetland species which keeps these ecosystems in ecological equilibrium and makes them so productive. Loss of any link in the web of biodiversity will reduce the goods, functions and attributes of a wetland site.

Decline in a wetland will impact on associated systems: loss of nursery habitat could reduce coastal fishery yields or loss of a wetland on a flyway could disrupt waterfowl migrations, threatening the capacity of individual birds to reproduce and eventually the survival of populations or species.

Finally, the real biodiversity of nature lies at the level of the genotype (the hereditary or genetic make-up). The variability, geographic dispersion and biological richness of wetlands globally mean that they contain a tremendous pool of genetic resources. This genetic diversity is important for a variety of reasons: it determines the ability of individuals and populations to adapt to changing environmental conditions, such as global warming or new diseases; it is essential for the continuing evolution of various species; it provides the basis for the selection and production of new resource organisms. Finally, it is also important for maintaining the distinctiveness of plants and animals in different locations which has implications for our appreciation of nature. Loss of wetland habitats, which contain so much of the world's plant and animal biodiversity, thus endangers the genetic resources on which our future prosperity depends.

Wetland Important Bird Areas (IBAs) in the Nile Basin Region

Important Bird Areas (IBAs) are sites of international importance for bird conservation and other biodiversity. They are recognized worldwide as practical tools for bird conservation. IBAs are small enough to be practical targets for conservation management, but large enough to meet the global IBA criteria.

Important Bird Areas, provide essential habitats for one or more species of birds. They include sites for breeding, and migrating birds. IBAs may be a few acres or thousands of acres, but usually they are discrete sites that stand out from the surrounding landscape. They may include public or private lands, or both, and they may be protected or unprotected.

Criteria for selection of a site as an IBA

The selection of Important Bird Areas (IBAs) is achieved through the application of quantitative ornithological criteria, grounded in up-to-date knowledge of the sizes and trends of bird populations. The criteria ensure that the sites selected as IBAs have true

significance for the international conservation of bird populations, and provide a common currency that all IBAs adhere to, thus creating consistency among, and enabling comparability between, sites at national, continental and global levels.

A set of objective, standardized criteria has been developed for selecting Important Bird Areas (IBAs) of global significance, based on the presence of world wide conservation concern. A site may qualify as an IBA, if it meets one or more of the following criteria;

- *Species of global conservation concern*; A site qualifies to be an IBA if it is known, estimated or thought to hold on a regular basis, significant numbers of bird species categorized by the IUCN Red List as Critically Endangered, Endangered or Vulnerable. In general, the regular presence of a Critical or Endangered bird species, irrespective of population size, at a site may be sufficient for it to qualify as an IBA.
- *Presence of restricted-range species*; i.e If a site has a significant component of the restricted –range bird species whose breeding distributions define an Endemic Bird Area (EBA)
- *Presence of biome-restricted species*; i.e, if a site holds a significant number of bird species, whose distributions are largely or wholly confined to one biome.
- Presence of congregatory birds; i.e If a site is known to hold on a regular basis, a large number of congregatory water bird, sea bird or terrestrial bird species.

There is growing evidence that networks of IBAs, though identified using information on birds, are disproportionately important for other animals and plants. That is to say, IBA networks are good at capturing threatened, endemic and representative species for other terrestrial groups. The effectiveness of the IBA network has already been shown for terrestrial vertebrates in East Africa; globally threatened wildlife species in the mountains and coastal forests of Kenya and Tanzania, and butterflies, large moths, small mammals and woody plants in Ugandan forests.

Examples of IBAs in the Nile Basin Region

All Nile basin countries have at least identified sites that serve as Important Bird Areas (IBAs), majority of which are wetlands. Below is an overview of the Nile basin countries and their IBAs.

Important Bird Areas in Ethiopia

In Ethiopia, numerous wetlands are important for birds including the lakes of the Rift Valley, montane marshes and bogs and particularly in the west, lowland swamps. A remarkable 69 Important Bird Areas (IBAs) were defined by the Ethiopian Wildlife and Natural History Society in Important Bird Areas in Africa and Associated Islands (Birdlife International 2001). They cover 47,757 km^2 equivalent to at least 4.3% of the land area of the country. These IBAs in Ethiopia include the following;

01 Shire lowlands in the Tekeze valley
02 Dessa'a forest
03 Simen Mountains National Park
04 Lake Ashenge
05 Hugumburda and Grat-Kahsu forests
06 Fogera plains
07 Bahir Dar—Lake Tana
08 Lake Abe wetland system
09 Yegof forest
10 Yangudi-Rassa National
36 Jibat forest
37 Tiro Boter—Becho forest
38 Mount Zuquala
39 Koka dam and Lake Gelila
40 Baro river
41 Lake Zeway
42 Gambella National Park
43 Shek Husein
44 Mugo highlands
45 Koffe swamp

Park

11 Denkoro forest

12 Awi Zone

13 Choke mountains

14 Guassa (Menz)

15 Jemma and Jara valleys

16 Mid-Abbay (Blue Nile) river basin

17 Lakes Alemaya and Adele

18 Ankober—Debre Sina escarpment

19 Aliyu Amba—Dulecha

20 Finchaa and Chomen swamps

21 Berga flood-plain

22 Bisidimo

23 Entoto Natural Park and escarpment

24 Sululta plain

25 Gudo plain

26 Chilimo forest

27 Gefersa reservoir

28 Awash National Park

46 Metu—Gore—Tepi forests

47 Lake Langano

48 Abijatta—Shalla Lakes National Park

49 Boyo wetland

50 Bonga forest

51 Senkele Sanctuary

52 Sof Omar

53 Lake Awassa

54 Bale Mountains National Park

55 Omo National Park

56 Nechisar National Park

57 Genale river

58 Anferara forests

59 Mago National Park

60 Lower Wabi Shebelle river and Warder

61 Mankubsa—Welenso forest

62 Liben plains and Negele woodlands

63 Konso—Segen

29 Akaki—Aba—Samuel wetlands

30 Dilu Meda (Tefki)

31 Menagesha State Forest

32 Bishoftu lake

33 Chelekleka lake and swamp

34 Green Lake Oromiya

35 Babille Elephant Sanctuary

64 Yabello Sanctuary

65 Arero forest

66 Dawa—Wachile

67 Lake Chew Bahir

68 Bogol Manyo—Dolo

69 Lake Turkana and Omo delta

Important Bird Areas in Burundi

In Burundi, five (5) Important Bird Areas (IBAs) have been identified which cover 1,018 km2 or 3.7% of the total area of the country. Three of these are National Parks and two are Forest or Nature Reserves. By habitat type, two IBAs are montane forest, two are wetlands and one is a mixture of savanna woodland and wetland. These IBAs include;

1. Rwihinda Lake Managed Nature Reserve; This is located north of the town of Kirundo close to the Rwandan border. Lake Rwihinda lies a little upstream of the Akanyaru wetlands IBA in Rwanda. The area of the lake is 425 ha within a total protected area of 8,000 ha. This site held large numbers of breeding water birds in the past such as African Darter (*Anhinga rufa)*, Black Egret (*Egretta ardesiaca)* and Black-headed Heron (*Ardea melanocephala*). Other key species are Papyrus Yellow Warbler (*Chloropeta gracilirostris*) and Papyrus Gonolek (*Laniarius mufumbiri)*.

2. Kibira National Park; located in the north-west of the country and extends from the Rwandan border almost as far south as the town of Muramvya. This IBA is contiguous with the Nyungwe forest in Rwanda and together, they form a montane forest block of 130,000 ha. The forest holds many of the Albertine Rift endemics and is the most

important site in Burundi for the conservation of montane forest birds. Key species include Red-collared Babbler (*Kupeornis rufocinctus)*, Grauer's Swamp-Warbler (*Bradypterus graueri)* and Shelley's Crimsonwing (*Cryptospiza shelleyi)*.

3. Ruvubu National Park; located in north-east Burundi and extends south from the Tanzanian border along a 65 km stretch of the Ruvubu river. More than 200 bird species have been recorded in this IBA. Key species include Red-faced Barbet (*Lybius rubrifacies*), Papyrus Yellow Warbler (*Chloropeta gracilirostris)* and Papyrus Gonolek (*Laniarius mufumbiri)*.

4. Rusizi National Park; which is located north-west of the capital, Bujumbura and adjacent to the frontier with the Democratic Republic of Congo. It comprises a strip of flood-plain about 2 km wide and 35 km long beside the east bank of the Rusizi River and the Rusizi delta where it enters Lake Tanganyika.

The site supports a wide diversity of waterbirds including high counts of Glossy Ibis (*Plegadis falcinellus)*, Lesser Flamingo (*Phoeniconaias minor)* and White-faced Whistling-Duck (*Dendrocygna viduata)*. Other key species are White-winged Tern (*Chlidonias leucopterus)* and African Skimmer (*Rynchops flavirostris)*.

5. Bururi Forest Nature Reserve; situated on the extreme southern edge of the Congo-Nile divide and is a small patch of forest lying to the west of the town of Bururi in south-western Burundi. A total of 87 species have been recorded here

Important Bird Areas in the Democratic republic of Congo

DR Congo holds a high proportion of species restricted to a number of biomes. Nineteen (19) Important Bird Areas (IBAs) of which 12 are protected legally have been identified covering 130,500 km^2 or 5.5% of the country and these contain a broad spectrum of habitats. Vast areas of the country however have not been surveyed ornithologically and many important sites probably remain to be discovered and documented. Examples of the legally identified IBAs in DR Congo include;

Luki Forest Reserve; an area of lowland forest near the Atlantic coast, lying to the north of the town of Boma. No detailed information is available for this site but it might be expected to contain 136 of the 228 species of the Guinea-Congo Forests biome.

Bombo-Lumene Game Reserve; lies south of the main Kinshasa to Kenge road and is the only protected area where White-headed Robin-Chat (*Cossypha heinrichi*) occurs and the only site where Black-chinned Weaver (*Ploceus nigrimentus*) has been recorded.

Ngiri: a large remote area of swamp forest situated between the Ubangi River in the west and the Congo River in the east. Large numbers of waterbirds breed including Long-tailed Cormorant (*Phalacrocorax africanus*), African Darter (*Anhinga rufa*) and Purple Heron (*Ardea purpurea*). It is the only known site in the country for Congo Sunbird (*Cinnyris congensis*).

Salonga National Park; the largest rainforest park in the world and encompasses a significant section of the central basin of the Congo River. There is little ornithological data although Congo Peacock (*Afropavo congensis*) is known to occur.

Garamba National Park is a large area of mainly densely wooded savanna situated on the Sudan border and is the only protected area in the Sudan-Guinea Savanna biome in the country.

Virunga National Park is situated near the Uganda border and comprises a large variety of habitats. Species of interest which are known to occur include Grauer's Swamp-Warbler (*Bradypterus graueri*), Yellow-crested Helmet-Shrike (*Prionops alberti*) and Shelley's Crimsonwing (*Cryptospiza shelleyi*).

Other IBAs in DR Congo include; *Lomaka-Yekokora***,** *Lendu* plateau, *Mount Hoyo Reserve, Okapi Faunal Reserve***,** *Maiko National Park***,** *Forests west of Lake Edward, Kahuzi- Biéga National Park, Itombwe mountains, Mount Kabobo, Marungu highlands, Upemba National Park, Kundelungu National Park and Lufira valley***.**

Important Bird Areas in Egypt

Egypt has a considerable range of habitat and vegetation which support in turn a diversity of fauna. It lies at the junction of four bio-geographical regions: Sahara-Sindian which is represented in the vast deserts; Iran-Turanian which occupies a small area in the Sinai highlands; Mediterranean which occupies a small area along the Mediterranean coast; and Afrotropical.

The Nile supports most of the country's wetlands which are some of Egypt's most important habitats supporting the greatest diversity and density of bird species. The major inland wetland areas are as follows: the Bitter Lakes; Wadi El Natrun; Lake Qarun; Wadi El Rayan Lakes and Nile River and Lake Nasser.

Egypt has no endemic or restricted range species although White-eyed Gull (*Larus leucophthalmus*) is endemic to the Red Sea. There are 18 species with relatively small world distributions for which Egypt constitutes an important part of their range. Perhaps the most important is that group restricted to the Sahara-Sindian biome.

Egypt has a strategic position geographically along the migration routes of Palearctic species which winter in Africa and hence internationally important numbers migrate through Egypt. Large numbers of Palearctic migrants and especially waterbirds also winter in Egypt.

A total of 34 Important Bird Areas (IBAs) have been identified which cover an area of 35,000 km^2 or 3.5% of Egypt's territory. Wetland habitats are represented in 25 IBAs. The majority of the IBAs are to the east of the Nile which indicates the lack of suitable avian habitat in much of the western deserts. Sinai holds a disproportionately large number of the IBAs which reflects its diversity of habitats as well as its unique bio-geographical location.

The following IBAs are located in North Sinai:

Lake Bardawil; which has large wintering populations of Great Cormorant (*Phalacrocorax carbo*) and Greater Flamingo (*Phoenicopterus rubber*);

Zaranik Protected Area; an extension of Lake Bardawil on its eastern side and is important as a bottleneck for migrant waterbirds.

Gebel Maghara; has a great diversity of land forms and desert habitats and as a result, holds a unique combination of species including a large proportion of Egypt's Sahara-Sindian biome restricted species and seven breeding lark species including Greater Hoopoe-Lark (*Alaemon alaudipes*), Desert Lark (*Ammomanes deserti*), Greater Short-toed Lark (*Calandrella brachydactyla*) and Dunn's Lark (*Eremalauda dunni*);

Wadi Gerafi: This holds nearly all of Egypt's Sahara-Sindian species and is one of the few areas in Egypt for a breeding (in small numbers) and wintering subspecies of Houbara Bustard (*Chlamydotis undulata macqueenii*).

The following IBAs are located in South Sinai:

Tiran Island; at the mouth of the Gulf of Aqaba has breeding Sooty Falcon (*Falco concolor*), Osprey (*Pandion haliaetus*) and seven waterbird species including Eurasian Spoonbill (*Platalea leucorodia*) and White-eyed Gull (*Larus leucophthalmus*);

St Katherine Protectorate occupies much of the central part of South Sinai and contains Egypt's highest peaks and holds most of Egypt's Sahara-Sindian biome species and is an outpost for Verreaux's Eagle (*Aquila verreauxi*) and Fan-tailed Raven (*Corvus rhipidurus*).

Important Bird Areas in Kenya

Kenya has one of the richest avifauna in Africa with about 1,090 species recorded. Around 170 of these are Palearctic migrants and at least a further 60 are intra-Africa migrants. Some 230 species are entirely forest dependent and 110 require undisturbed

habitat. The most significant biomes in Kenya are Somali-Masai, East African Coast, Afrotropical Highlands and the small Lake Victoria Basin.

Kenya has 60 Important Bird Areas (IBAs) which cover a total of 5.7 million hectares or about 10% of the land area. Below are some of these IBAs;

Aberdare Mountains and **Mount Kenya;** which hold many species of the Afrotropical Highlands biome including Hartlaub's Turaco (*Tauraco hartlaubi)*, Cinnamon-chested Bee-eater (*Merops oreobates)* and a range of montane sunbird species.

Lake Naivasha; lies in the Rift Valley, some 80 km north of Nairobi and consists of a shallow freshwater lake and its fringing acacia woodland. It is a prime site for waterbirds such as Red-knobbed Coot (*Fulica cristata)*, African Spoonbill (*Platalea alba)* and Little Grebe (*Tachybaptus ruficollis)*. It is one of several IBAs in the Rift Valley.

Masai Mara; This is probably the most visited Game Reserve in Kenya because of the high concentration and the spectacular migration of mammals. It adjoins the Serengeti National Park along the border with Tanzania and is a part of the same ecosystem. The extensive grasslands hold important populations of Corncrake (*Crex crex)* and Jackson's Widowbird (*Euplectes Jacksoni).*

Note: *Read about other IBAs in Kenya*

Important Bird Areas in Rwanda

Seven Important Bird Areas (IBAs) have been recognized in Rwanda by Birdlife International and these are as follows:-

- Akagera National Park,
- Akanyaru wetlands
- Cyamudongo forest
- Nyabarongo wetlands
- Nyungwe forest

- Rugezi marsh
- Volcans National park

(***Make an effort to find out the bird species in these areas)***

Important Bird Areas in Sudan

In Sudan, 22 Important Bird Areas (IBAs) have been designated with a total land area of 18,040 km2. Of these, 13 are legally or partly protected on paper at least. There have been few ornithological surveys in recent years and much of the data on which the selections have been made is out of date and possibly inaccurate.

Wadi Haifa is the only IBA in the north situated close to the border with Egypt and adjacent to the Lake Nasser IBA in Egypt. It has Saharan-Sindian species such as Crowned Sandgrouse (*Pterocles coronatus*) and Pharaoh's Eagle Owl (*Bubo ascalaphus*).

Gezira; is a large flood-plain between the Blue and White Niles south of Khartoum. It is an important site for waterbirds.

Village Weaver (*Ploceus cucullatus*) nests in one of Wetland IBAs in Sudan

The rest of the IBAs are all in the southern parts of Sudan and include; Dinder; Lake Kundi; Lake AbiadRadom; Ashana; Sudd; Boma; Southern National Park; Bandingilo; Bengangai; Juba; Imatong Mountains; Kidepo and Nimule**.** These hold 33 of the 36

species of the Sudan-Guinea Savanna biome found in Sudan including Red-throated Bee-eater (*Merops bulocki*) and Black-breasted Barbet (*Lybius rolleti*).

Important Bird Areas in Tanzania

Tanzania is a very important country ornithologically. It has one of the largest species lists of any African country. Tanzania holds parts of several Endemic Bird Areas (EBAs), such as *the Tanzania Malawi Mountains***,** with 32 of its restricted range species occurring in Tanzania; *the Albertine Rift Mountains and the Serengeti plains***.**

Tanzania has 80 Important Bird Areas (IBAs) which cover a total of more than 167,000 km^2 or a18% of the country's land area. Some of the major ones include;

Mount Kilimanjaro; This holds a range of forest species including Olive Ibis (*Bostrychia olivacea*) and alpine species such as Hill Chat (*Cercomela sordida*) and Scarlet-tufted Malachite Sunbird (*Nectarinia johnstoni*).

Ruaha National Park; one of the driest protected areas in Tanzania and has a list of over 400 species. It holds important populations of two Tanzanian endemics Ashy Starling (*Lamprotornis unicolor*) and Yellow-collared Lovebird (*Agapornis personatus*).

Long-billed Tailorbird (*Orthotomus moreaui*): A critically endangered species in the East Usambara Mountains, Tanzania.

The Serengeti National Park is one of the best known National Parks in Africa lying between Lake Victoria and the Eastern Rift Valley and adjacent to Kenya's Masai-Mara Reserve and bordering the Ngorongoro Conservation Area. The Park holds three Tanzanian endemic Gre-breasted Spurfowl (*Francolinus rufopictus*), Fischer's Lovebird (*Agapornis fischeri)* and Rufous-tailed Weaver (*Histurgops ruficaudus*).

Lake Natron is a shallow soda lake on the floor of the Eastern Rift valley and extends 58 km south from the Kenyan border. It is the most important breeding site for the majority of the world population of Lesser Flamingo (*Phoeniconaias minor*).

Others include; Lake Victoria, Kitulo Plateau, National Mkomazi Game Reserve etc

Important Bird Areas in Uganda

Uganda has 30 Important Bird Areas (IBAs) covering over 7% of the total area of the country. Four are in the south-west of the country and include; *Mgahinga Gorilla National Park, Echuya Forest Reserve, Nyamuriro Swamp* ***and*** *Bwindi Impenetrable National Park.* Six are in the west near the border with the Democratic Republic of Congo. They include *Rwenzori Mountains National Park, Kibale National Park, Queen Elizabeth National Park and Lake George; Kyambura Wildlife Reserve; Semliki National Park* ***and*** *Semliki reserves.*

African Fish Eagle (*Haliaeetus vocifer)* **in Queen Elizabeth National Park**, **Uganda**

Eight are in the Lake Victoria Basin in the south-central region of the country i.e. *Lake Mburo National Park, Sango Bay area, Nabugabo Wetland, Musambwa Islands, Lutoboka Point (Ssese Islands), Mabamba Bay, Lutembe Bay* ***and*** *Mabira Forest Reserve.* Five are in the north-west i.e. *Budongo Forest Reserve, Murchison Falls National Park, Ajai Wildlife Reserve, Mount Kei Forest Reserve and Mount Otzi Forest Reserve.*

A further seven are in the east towards the Kenyan border i.e. *Doho Rice Scheme, Lake Nakuwa; Lake Bisina; Lake Opeta, Mount Elgon National Park; Mount Moroto Forest Reserve and Kidepo Valley National Park.*

Unit Activity 3

Nile basin countries have at least each an Important Bird Area (IBA). With reference to a named country in the Nile basin region;

- *Identify the sites that have been selected as IBAs*
- *How many of the identified IBAs are in wetland areas?*
- *Which type of bird species are being protected in the IBAs identified?*
- *What criteria do you think were used to select the identified IBAs?*

Unit summary

In this unit we have defined Biodiversity as variation of life at all levels of biological organization. Wetlands ecosystems are cradles of biological diversity, providing the water and primary productivity upon which countless species of plants and animals depend for survival. They support high concentrations of birds (especially waterfowl), mammals, reptiles, amphibians, fish and invertebrate species. These wetland flora and fauna are of great importance to man and other creatures. Wetland ecosystems are

therefore cradles of biological diversity, providing the water and primary productivity upon which countless species of plants and animals depend for survival. They support high concentrations of birds (especially waterfowl), mammals, reptiles, amphibians, fish and invertebrate species. Wetlands also serve as Important Bird Areas (IBAs) for the conservation of threatened and migratory bird species.

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UNIT 5:

INVENTORY, ASSESSMENT AND MONITORING OF WETLANDS

Introduction

The world has lost more than half its wetlands in the last ten decades. Although preventing further wetland destruction and restoring degraded wetlands is important, many people are also concerned with the quality of our remaining wetlands and those restored. In addition to understanding individual wetlands, there is need to have a big picture when making decisions about wetlands. Questions such as; what role do wetlands play in our watersheds and landscape for fish and wildlife habitat, flood storage and water quality protection? How can we plan for growth so that we retain the value of the wetlands left? How and where can we restore wetlands, are important.

The questions raised above concern wetland management. Inventory, assessment and monitoring are important components of effective wetland management because they provide data and information for management decisions. In addition, they provide feedback on management actions and implementation of principles and frameworks which is vital information for managers and decision makers. Therefore, Inventory, assessment and monitoring cannot be treated separately from management processes hence the need for the design and implementation of integrated management programmes. This unit discusses inventory, assessment and monitoring wetland status.

Learning Objectives

- Discuss wetland assessment techniques
- Examine wetland monitoring techniques
- Outline rationale for wetland assessment

- Critique biological monitoring
- Discuss the quality of water in the surrounding communities
- Visit wetlands in their communities and identify issues threatening their existence
- Suggest mitigation measures to the issues identified

Content

- Inventory (adopt the East African wetland inventory model)
- Assessment (Rationale and techniques for wetland assessment – GIS and remote sensing, EIA)
- Monitoring (Rationale and techniques)
- Biological monitoring
- Water pollutants and control
- Water quality and its assessment

Wetland Inventory

What is wetland inventory?

The collection and/or collation of core information for wetland management, including the provision of information base for specific assessment and monitoring activities.

A structured framework for planning and designing a wetland inventory is summarized in Table below. The steps in the Framework are applicable to the planning and implementation of any wetland inventory and should be followed during the design and planning process. The framework does not provide prescriptive guidance on particular inventory methods; rather it provides guidance to the Contracting Parties and others who are planning to undertake wetland inventory by drawing attention to different methods and wetland classifications already in use and of proven utility under different circumstances. The framework should be used as a basis for making decisions for undertaking a wetland inventory under the circumstances particular to each inventory program.

Table 1. A structured framework for planning a wetland inventory

Step	Guidance
1. State the purpose and objective	State the reason(s) for undertaking the inventory and why the information is required, as the basis for choosing a spatial scale and minimum data set.
2. Review existing knowledge and information	Review the published and unpublished literature and determine the extent of knowledge and information available for wetlands in the region being considered.
3. Review existing inventory methods	Review available methods and seek expert technical advice to: a) choose the methods that can supply the required information; and b) ensure that suitable data management processes are established.
4. Determine the scale and resolution	Determine the scale and resolution required to achieve the purpose and objective defined in Step 1.
5. Establish a core or minimum data set	Identify the core, or minimum, data set sufficient to describe the location and size of the wetland(s) and any special features. This can be complemented by additional information on factors affecting the ecological character of the wetland(s) and other management issues, if required.
6. Establish a habitat classification	Choose a habitat classification that suits the purpose of the inventory, since there is no single classification that has been globally accepted.
7. Choose an appropriate method	Choose a method that is appropriate for a specific inventory based on an assessment of the advantages and disadvantages, and costs and benefits, of the alternatives.
8. Establish a data management system	Establish clear protocols for collecting, recording and storing data, including archiving in electronic or hardcopy formats. This should enable future users to determine the source of the data, and its accuracy and reliability. At this stage it is also necessary to identify suitable data analysis methods. All data analysis should be done by rigorous and tested methods and all information documented. The data management system should support, rather than constrain, the data analysis. A meta-database should be used to: a) record information about the inventory datasets; and b) outline details of data custodianship and access by other users.
9. Establish a time schedule and the level of resources that are required	Establish a time schedule for: a) planning the inventory; b) collecting, processing and interpreting the data collected; c) reporting the results; and d) regular review of the program. Establish the extent and reliability of the resources available for the inventory. If necessary make contingency plans to ensure that data is not lost due to insufficiency of resources.
10. Assess the feasibility & cost effectiveness	Assess whether or not the program, including reporting of the results, can be undertaken within under the current institutional, financial and staff situation. Determine if the costs of data acquisition and analysis are within budget and that a budget is available for the program to be completed.
11. Establish a reporting procedure	Establish a procedure for interpreting and reporting all results in a timely and cost effective manner. The report should be succinct and concise, indicate whether or not the objective has been achieved, and contain recommendations for management action, including whether further data or information is required.
12. Establish a review and evaluation process	Establish a formal and open review process to ensure the effectiveness of all procedures, including reporting and, when required, supply information to adjust or even terminate the program.

13. Plan a pilot study	Test and adjust the method and specialist equipment being used, assess the training needs for staff involved, and confirm the means of collating, collecting, entering, analyzing and interpreting the data. In particular, ensure that any remote sensing can be supported by appropriate "ground-truth" survey.

Wetland Assessment

What is wetland assessment?

This is the gathering and analysis of information needed for wetland decision making. Wetland information required by decision makers eg regulators, planners, public land use managers is not limited to only functions and values of wetlands but includes a broad range of information such as; delineation of wetland boundaries, evaluation of natural hazards eg floods, determination of land ownership, and evaluation of existing wetland uses.

Rationale for wetland assessment

For proper wetland management, we have to understand their hydrological, ecological and social economic environment. We need to know where they are, what is in them, how they are being used and the actual and possible changes that might take place because of the changes in the surrounding area.

We also need to know where, how and at what rate the wetland status is changing. This helps us to know the management interventions/options required and how effective they should be.

We need to make estimates about resources (especially finances and human resource) required to properly manage and monitor essential wetlands at the local, national and regional level

There are four levels of wetland assessment, and these include;

- The overall assessment of the wetland value and stock
- The detailed assessment of wetland functions and use
- The permanent monitoring of wetland trends and ecological status

- The topical assessment of a cross-section of wetlands that have a common service, function or use of interest.

Assessment criteria and procedures are critical because the outcome of wetland protection or destruction is determined by the information available to decision makers. Assessment procedures determine whether activities in wetlands are permitted and the impact reduction and compensation measures (restoration, creation or enhancement).

Techniques

Approaches used in wetland assessment include;

- Wetland mapping based on satellite imagery based on multi-objective landscape level analysis of land and water throughout a geographical area including wetlands. In the process of producing land and water use plans, wetland zones are indicated. Originally, this analysis was done manually and of recent by Geographic Information Systems (GIS) and remote-sensing.

- This activity is carried out by GIS experts. It is highly technical and requires specialized people with the ability to interpret satellite images according to colours to produce land use/land cover maps. This approach cannot however give some essential information such as wetland type, ecological features, present land use, threats, values and functions of the wetland.
- Local district/province/regional wetland descriptions based on physical observation of the wetlands in a given division/province/region. In this approach regional / district/province wetlands officers make physical observations in the field. Sections of a wetland are observed and general characteristics including vegetation, soils, land use, other human activities and water quality are recorded using a wetland characteristics observation sheet. This information is essential for monitoring interventions and cannot be generated by the satellite imagery approach.

- Wetlands inventory report based on analysis of the wetland descriptions showing the sate of wetlands in a given area. Each wetland is given a unique code, indicating its relative position in the drainage basin and to other wetlands. This inventory data base can easily be updated with additional data, maps, changes in wetland characteristics, human activities/land use, etc

There is a wide range of wetland assessment techniques that have been developed over the past few decades.

1. GIS and remote-sensing in inventory, assessment and monitoring

Remote sensing and Geographic Information Systems (GIS) technologies are increasingly being used as integral components of environmental management, assessment and monitoring activities world wide. A GIS is a system for management, analysis, and display of geographic knowledge which is represented using a series of information sets. The information sets include geographic datasets (file bases and data bases of geographic information feature, networks, topologies, terrains, surveys, and attributes); collections of geo-processing procedures for automating and repeating numerous tasks and for analysis and metadata.

The conservation, restoration and management of wetlands requires knowledge of wetland relationships and key components o soil, elevation, hydrology and hydrophytic plants as well as influencing functions such as climate, wildlife and human interventions. A GIS can spatially represent all these components, compile and store data, analyse, retrieve information, update, query, filter, sort, display, and be used to determine patterns and relationships by theme overlays.

Increasing recognition of the importance of wetland ecosystems to the economic and environmental health of society has stimulated renewed interest in identifying the distribution, characteristics and extent of wetlands. Significantly, the Ramsar Convention on Wetlands advocated for development of wetland inventories. In response, the contracting parties to this Convention developed wetland inventories in their respective countries. However, Global review of wetland resources and priorities

for wetland inventory (GroWI), revealed shortage in knowledge of wetland distribution and the manner in which the information for wetland inventories was collected/collated was inadequate. To improve accuracy of quantifying and describing the global wetland resource and provide basic information needed for management, it was recommended that inventory should focus on location and extent of wetlands. In order to achieve this, standardised methods for data collection and storage including use of GIS and remote-sensing was considered essential.

Remote sensing and GIS technology can be used for wetland assessment efficiently. Although remote sensing and GIS can be employed at any stage, they are particularly useful for identifying the extent of the problem and the extent of the risk. GIS and remote sensing together can help to monitor effectiveness of the risk management and reduction techniques. Specifically, the ability to integrate and overlay multiple layers of data over an area of interest which can be modelled, queried and analysed in order to determine the impact and extent of a particular risk is useful to managers doing wetland assessment.

The integration of remote sensing and GIS provides managers with a set of tolls for monitoring and surveillance of wetland resources. This is enhanced by the fact that new remotely sensed images with spatial, spectral and temporal resolutions are increasingly available. As with GIS data, many remotely sensed data sets can be downloaded through internet. The remotely sensed data available makes it possible to apply hierarchical approach to monitoring. Once the wetland extent or condition has been mapped or classified using remote sensing technology, these can be stored in a GIS. Once in the GIS, it is possible to monitor changes to the environment in the area of interest and relate to other feature datasets eg infrastructure, climate and hydrology held in the GIS. Integrating GIS and remote sensing has an added advantage in that ancillary datasets held in the GIS eg soil water logging characteristics, can be used to classify wetland features in the remote sensed image. Furthermore, integrating remote sensing and GIS enables many questions related to wetland monitoring and surveillance to be answered. Such questions include;

1. Where are wetlands being lost or reduced?
2. How quickly are wetlands being destroyed?
3. Where are the remaining wetlands located?
4. Which wetland areas remain flooded all year round?
5. Which sites are priorities for restoration?

The issue of scale

Most GIS databases are created for particular uses. The dataset could be for representation of rivers, vegetation communities, lakes or areas subject to flooding. It is important to understand that these datasets are intended to be used within specified scale ranges. The scale at which the dataset has been created reflects that intended use. For example if drainage features have been complied on a scale of 1:1000,000, such features are intended for broad scale use and should not be used at local or site scale. The accuracy and usefulness of key features of the dataset such as their position, area and shape will be degraded is applied at an inappropriate scale and will give an erroneous or inaccurate interpretation of the features. Likewise, a dataset at local scale of say <1:50,000-250,000, would be inappropriate for broad scale application as level of detail is too much to be represented clearly. Therefore, consideration has to given to determining the appropriate scale. The key factor to consider is the intended use of application of the data set (local, regional or broad scale application).

2. **Wetland rapid assessment approaches** to assess abroad range of wetland functions and values. There several methods used for above purpose. E.g.
    - Wetland Evaluation Techniques (WET), uses matrices to rate welands as high, medium or low in regard to some wetland functions and values.
    - Hydrogeomorphic Wetland assessment Method (HGM), analysis wetland processes and compares such information with reference wetland.

- Indices of Biological Integrity (IBI). Involves identification of plants and animals which characterise wetland conditions across gradient from natural to highly degraded.

Actors involved in assessment

Government

Community

Scientists/ Researchers

Wetland Managers

Activity 1: **Discuss the role played by the different actors named above in wetland assessment.**

Activity 2: Rapid assessment of land use activities **Visit a nearby wetland and use the sheet below to make a rapid land use assessment.**

Land use	**Potential effects on wetland**	**Estimated % of wetland catchment/watershed**
Industrial/Commercial/Residential Development		
Agricultural cropland		
Agricultural grazing		

Grassed recreation arrears/parks		
Highway or roads		
Others (Specify)		

Monitoring

What is wetland monitoring?

The collection of specific information for management purposes in response to hypotheses derived from assessment activities, and the use of these monitoring results for implementing management. The collection of time-series information that is not hypothesis-driven from wetland assessment is surveillance rather than monitoring.

Rationale and techniques

Wetlands are aquatic ecosystems. However, many wetlands have been lost due to development, agriculture and forestry activities. The remaining wetlands are threatened by habitat loss, toxic chemicals, polluted runoff, hydrologic changes and invasive species, especially in rapidly urbanizing areas. In addition to efforts to track and report wetland quantity, for example, the number of acres filled compared to acres restored, information on the ecological health of wetlands is vital. With ever-increasing pressure from development and other human activities, there is a compelling need for improved scientific information about the current conditions of wetlands, sources and causes of degradation, and long-term trends in wetland health. To make sound decisions in wetland management, planning and regulation, it is essential to understand the relative risks to wetlands from various human activities. Therefore, the desire to measure and quantify

wetland degradation as well as the effectiveness of (restoration and mitigation) management and investment are amongst the main driving forces.

Finlayson (1996) provides a general framework for designing a monitoring programme, which is based on the identification of a problem and the resultant steps to gather data and information guided by a hypothesis that will lead to management action that redresses the situation. Monitoring within this context is a goal-oriented data gathering and analysis exercise and distinctly different from surveillance; the latter is the mere collection of data through time series to ascertain value ranges and variability.

Water quality assessment in wetlands

Wetlands are essential systems that effectively purify water to the purest natural state possible. This is why assessment of water quality is one of the most important aspect of wetland status monitoring as described in this section.

The quality of water entirely depends on the intended use, drinking, cooking, washing, laboratory work etc. different uses demand a certain level of quality levels beyond or below which the water is regarded pure or impure. Take an example of distilled water required for laboratory experiments. This water is normally de-ionized i.e. without ions such as Mg^{2+}, Ca^{2+}, Na^{+} Cl^{-}, etc ions like Ca^{2+} are important nutrients for born and teeth development. Distilled water is therefore not good for drinking but a minimum standard for laboratory experiments. Some of the ions we need in our drinking water interfere with laboratory chemical experimental results; this means that water for laboratory use is simply ***not good*** for human consumption! At the same time, pure water for human consumption is ***impure*** for laboratory experiments. Fish can jubilate, celebrate and party in highly nutritious green-water loaded with algae, this kind of water can affect human health if used for drinking!

Water quality parameters

The quality of water for any intended use is determined by both physical and chemical parameters (characteristics). The physical parameters or characteristics that determine water quality include colour, temperature, smell and turbidity (determined by the number of suspended particles) or TSS (total suspended solids).

Some of the essential chemical parameters include; the pH, conductivity, alkalinity ,dissolved oxygen(DO) and percentage oxygen saturation, Biological oxygen demand (BOD),Chemical oxygen demand (COD), Total nitrogen including; Nitrates, Nitrites ,and Ammonium ions, Total phosphorus and Total hardness etc.

Selected commonly used water quality parameters in wetlands assessment and monitoring are discussed below:

Temperature

Temperature of water is a very important factor for aquatic life. It controls the rate of metabolic and reproductive activities, and determines which organisms or particular species can survive in a given part of an aquatic system like a wetland. Temperature also affects the concentration of dissolved oxygen and can influence the activity of bacteria and toxic chemicals in water. Temperature is measured using a thermometer, and is recorded in either degrees Celsius (□ C) or degrees Fahrenheit (□ F).

PH

PH represents the effective concentration (activity) of hydrogen ions (H^+) in water. This concentration could be expressed in the same kind of units as other dissolved species, but H^+ concentrations are much smaller than other species in most waters. The activity of hydrogen ions can be expressed most conveniently in logarithmic units. pH is defined as the negative logarithm of the activity of H^+ ions:

$pH = -\log [H^+]$ Where $[H^+]$ is the concentration of H^+ ions in moles per liter (a mole is a unit of measurement, equal to 6.022×10^{23} atoms). Because H^+ ions associate with water molecules to form hydronium (H_3O^+) ions, pH is often expressed in terms of the concentration of hydronium ions.

In pure water at 22 0C (72 0F), H_3O^+ and hydroxyl (OH^-) ions exist in equal quantities; the concentration of each is 1.0 x 10^{-7} moles per liter (mol/L). Therefore, pH of pure water = -log (1.0 x 10^{-7}) = -(-7.00) = 7.00. Because pH is defined as –log $[H^+]$, pH decreases as $[H^+]$ increases (which will happen if acid is added to the water). Since pH is a log scale based on 10, the pH changes by 1 for every power of 10 change in $[H^+]$. A solution of pH 3 has an H^+ concentration 10 times that of a solution of pH 4. The pH scale ranges from 0 to 14. However, pH values less than 0 and greater than 14 have been observed in very rare concentrated solutions.

The pH of water can be measured with a pH meter, which is an electronic device with a probe. The probe contains an acidic aqueous solution enclosed by a glass membrane that allows migration of H^+ ions. The electrical potential of the glass electrode depends on the difference in $[H^+]$ between the reference solution and the solution into which the electrode is dipped. pH can also be measured with pH paper or by adding a reagent (universal indicator solution) to the water sample and recording the colour change.

Carbon dioxide (CO_2) enters a water body from a variety of sources, including the atmosphere, runoff from land, release from bacteria in the water, and respiration by aquatic organisms. This dissolved CO_2 forms a weak acid. Natural, unpolluted rainwater can be as acidic as pH 5.6, because it absorbs CO_2 as it falls through the air. Because plants take in CO_2 during the day and release it during the night, pH levels in water can change from daytime to night. For an example of how pH typically varies over a daily cycle. Other factors that affect pH of water in a wetland include; *Geology* and *Soils* of the watershed, increasing alkalinity of the water which raises the pH, drainage water from forests and marshes is often slightly acidic, due to the presence of organic acids produced by decaying vegetation, gaseous pollutants (e.g. nitrogen oxides (NO_2, NO_3) and sulfur dioxide (SO_2)) which can react in the atmosphere to form nitric acid (HNO_3) and sulfuric acid (H_2SO_4). These acids can affect the pH of streams and wetlands by combining with moisture in the air and falling to the wetland ecosystem as acid rain.Sewage, agricultural and industrial discharge into the wetland e.t.c

DISSOLVED OXYGEN (DO)

Dissolved Oxygen (DO) is found in microscopic bubbles of oxygen that are mixed in the water and occur between water molecules. DO is a very important indicator of a water body's ability to support aquatic life. Oxygen enters the water by absorption directly from the atmosphere or by aquatic plant and algae photosynthesis. Oxygen is removed from the water by respiration and decomposition of organic matter.

Dissolved Oxygen can be measured with an electrode and meter or with field test kits. The electronic meter does not measure oxygen directly; rather, it uses electrodes to measure the partial pressure of oxygen in the water, which is converted to oxygen mass weight concentration. The field test kits (such as a drop bottle, a microburet, or a digital titrator) involve adding a solution of known strength to a treated sample of water from the stream. The amount of solution required to change the color of the sample reflects the concentration of DO in the sample. The amount of oxygen dissolved in water is expressed as a concentration, in milligrams per liter (mg/l) of water.

Dissolved oxygen levels are also often reported in percent saturation. Temperature affects DO concentrations, and calculating the percent saturation will factor out the effect of temperature. The "saturation level" is the maximum concentration of dissolved oxygen that would be present in water at a specific temperature, in the absence of other factors.

Factors that affect DO include; ***velocity and volume of water*** flowing into the wetland water stream(In fast-moving streams, rushing water is aerated by bubbles as it churns over rocks and falls down hundreds of tiny waterfalls), ***Climate/Season,(***During dry seasons, water levels decrease and the flow rate of a river/steam slows down. As the water moves slower, it mixes less with the air, and the DO concentration decreases. During rainy seasons, oxygen concentrations tend to be higher because the rain interacts with oxygen in the air as it falls), the ***type and number of organisms in the water*** body (During photosynthesis, plants release oxygen into the water. During respiration, plants remove oxygen from the water. Bacteria and fungi use oxygen as they decompose dead organic matter in the stream), ***Dissolved* or *suspended solids*** *(*Oxygen is more easily dissolved into water with low levels of dissolved or suspended solids), ***Amount of***

nutrients in the water (Nutrients are food for algae, and water with high amounts of nutrients can produce algae in large quantities. When these algae die, bacteria decompose them, and use up oxygen, this process is called **eutrophication**), ***Organic Wastes*** *(*Organic waste is decomposed by bacteria; these bacteria remove dissolved oxygen from the water when they breathe), ***Vegetation cover,*** e.t.c

Alkalinity

Alkalinity is a measure of the buffering capacity of water, or the capacity of bases to neutralize acids. Measuring alkalinity is important in determining a wetland's/stream's ability to neutralize acidic pollution from rainfall or wastewater. Alkalinity does not refer to pH, but instead refers to the ability of water to resist change in pH. The presence of buffering materials help neutralize acids as they are added to the water. These buffering materials are primarily the bases bicarbonate (HCO_3^-), and carbonate (CO_3^{2-}), and occasionally hydroxide (OH^-), borates, silicates, phosphates, ammonium, sulfides, and organic ligands.

Waters with low alkalinity are very susceptible to changes in pH. Waters with high alkalinity are able to resist major shifts in pH. As increasing amounts of acid are added to a water body, the pH of the water decreases, and the buffering capacity of the water is consumed. If natural buffering materials are present, pH will drop slowly to around 6; then a rapid pH drop occurs as the bicarbonate buffering capacity (CO_3^{2-} and HCO_3^-) is used up. At pH 5.5, only very weak buffering ability remains, and the pH drops further with additional acid. A solution having a pH below 4.5 contains no alkalinity, because there are no CO_3^{2-} or HCO_3^- ions left.

Alkalinity not only helps regulate the pH of a water body, but also the metal content. Bicarbonate and carbonate ions in water can remove toxic metals (such as lead, arsenic, and cadmium) by precipitating the metals out of solution.

Alkalinity is measured by titration. An acid of known strength (the titrant) is added to a volume of a treated sample of water. The volume of acid required to bring the sample to a

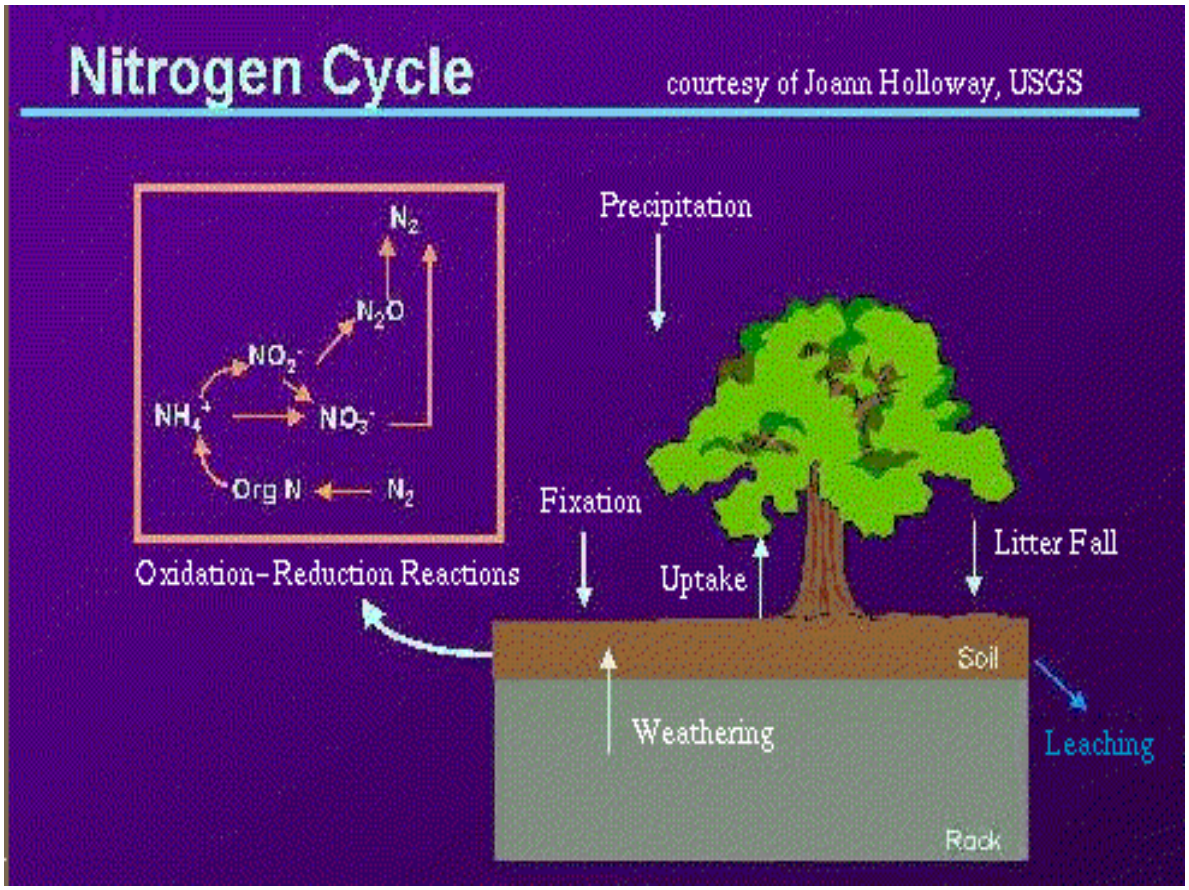
specific pH level reflects the alkalinity of the sample. The pH end point is indicated by a colour change. Alkalinity is expressed in units of milligrams per liter (mg/l) of $CaCO_3$ (calcium carbonate).

Nitrogen

Nitrogen is required by all organisms for the basic processes of life to make proteins, to grow, and to reproduce. Nitrogen is very common and found in many forms in the environment including wetlands. Inorganic forms include nitrate (NO_3), nitrite (NO_2), ammonia (NH_3), and nitrogen gas (N_2). Organic nitrogen is found in the cells of all living things and is a component of proteins, peptides, and amino acids. Nitrogen is most abundant in Earth's environment as N_2 gas, which makes up about 78 percent of the air we breathe.

<u>The Nitrogen Cycle</u>

Nitrogen is recycled continually by plants and animals. This recycling of nitrogen through the environment is called the "nitrogen cycle.



Activity:

Describe the various processes by which nitrogen is converted into the various inorganic and organic forms in the nitrogen cycle.

Most organisms (including humans) can't use nitrogen in the gaseous form N_2 for their nutrition, so they are dependent on other organisms to convert nitrogen gas to nitrate, ammonia, or amino acids. "Fixation" is the conversion of gaseous nitrogen to ammonia or nitrate. The most common kind of fixation is "biological fixation" which is carried out by a variety of organisms, including blue-green algae, the soil bacteria *Azobacter*, and the association of legume plants and the bacteria *Rhizobium*. Additionally, nitrogen can be fixed by some inorganic processes. For example, "high-energy fixation" occurs in the atmosphere as a result of lightning, cosmic radiation, and meteorite trails. Atmospheric nitrogen and oxygen combine to form nitrous oxides (NO_x), which fall to the earth as nitrate.

When plants and animals die, proteins (which contain organic nitrogen) are broken down by bacteria to form ammonia (NH_3). This process is called "ammonification." Ammonia is then broken down by other bacteria (*Nitrosomonas*) to form nitrite (NO_2), which is then broken down by another type of bacteria (*Nitrobacter*) to form nitrate (NO_3). This conversion of ammonia to nitrate and nitrite is called "nitrification." Nitrates can then be used by plants in order to grow.

Completing the nitrogen cycle, nitrates are reduced to gaseous nitrogen by the process of "denitrification." This process is performed by organisms such as fungi and the bacteria *Pseudomonas*. These organisms break down nitrates to obtain oxygen.

Common Forms of Nitrogen in Water

- *Nitrate and Nitrite*

- Nitrate (NO_3) is highly soluble (dissolves easily) in water and is stable over a wide range of environmental conditions. It is easily transported in streams and groundwater. Nitrates feed plankton (microscopic plants and animals that live in water), aquatic plants, and algae, which are then eaten by fish. Nitrite (NO_2) is relatively short-lived in water because it is quickly converted to nitrate by bacteria. Excessive concentrations of nitrate and/or nitrite can be harmful to humans and wildlife.
- Nitrate is of most concern for humans. Nitrate is broken down in our intestines to become nitrite. Nitrite reacts with hemoglobin in human blood to produce methemoglobin, which limits the ability of red blood cells to carry oxygen.

  This condition is called methemoglobinemia or "blue baby" syndrome (because the nose and tips of ears can appear blue from lack of oxygen).

- Nitrite enters the bloodstream through the gills and turns the blood a chocolate-brown color. As in humans, nitrite reacts with hemoglobin to form methemoglobin. Brown blood cannot carry sufficient amounts of oxygen, and affected fish can suffocate despite adequate oxygen concentration in the water. If excessive amounts of phosphorus and nitrates are added to the water, algae and aquatic plants can be produced in large quantities. When these algae die, bacteria decompose them, and use up oxygen. This process is called eutrophication. Dissolved oxygen concentrations can drop too low for fish to breathe, leading to fish kills.

➢ *Ammonia*

- Ammonia, another inorganic form of nitrogen, is the least stable form of nitrogen in water. Ammonia is easily transformed to nitrate in waters that contain oxygen and can be transformed to

nitrogen gas in waters that are low in oxygen. Ammonia is found in water in two forms - the ammonium ion (NH_4^+), and dissolved, unionized (no electrical charge) ammonia gas (NH_3). Total ammonia is the sum of ammonium and unionized ammonia. The dominant form depends on the pH and temperature of the water.

Unionized ammonia (NH_3) is much more toxic to aquatic organisms than the ammonium ion (NH_4^+).

- Toxic concentrations of ammonia in humans may cause loss of equilibrium, convulsions, coma, and death. Ammonia concentrations can affect hatching and growth rates of fish; changes in tissues of gills, liver, and kidneys may occur during structural development.

Measurement of Nitrogen Forms

- Total nitrogen can be determined by adding chemicals to convert all of the nitrogen forms in a sample to nitrate, and then measuring nitrate concentration. Nitrate and nitrite can be measured together or separately. Nitrate and nitrite are most often measured using a **colorimetric method**, which means the color of treated sample reflects the concentration of the parameter. A chemical is added to the water sample and the darker the color of the sample, the more nitrate and/or nitrite present. This test can be done visually, comparing the treated sample to a set of reference colors. However, it is more accurate to use an **electronic colorimeter**, which uses a light source and a **photo detector** to find the concentration based on how much light is absorbed by the sample

- Total ammonia (ammonium ion (NH_4^+) plus unionized ammonia gas (NH_3)) is often measured in a laboratory by **titration.** Ammonia and organic nitrogen compounds are separated by distillation, and then an acid

(the titrant) is added to a volume of the ammonia portion. The volume of acid required to change the color of the sample reflects the ammonia concentration of the sample.

Factors Affecting Nitrate Nitrite Concentrations

- *Wastewater and Septic System Effluent*

Human waste is significant contributor of nitrogen to water. Ammonia, nitrite, and nitrate are decomposition products from urea and protein, which are in human waste. Ammonia is an ingredient in many household cleaning products and is sometimes used to remove carbonate from hard water. Therefore, these nitrogen species go down the drains in our houses and businesses, and can enter streams from wastewater treatment plant (WWTPs) effluent, illegal sanitary sewer connections, and poorly functioning septic systems.

- *Fertilizer Runoff*

Fertilizer is a major influence on nitrogen concentrations in the environment. Commercial nitrogen fertilizers are applied either as ammonia or nitrate, but ammonia is rapidly converted to nitrate in the soil. Animal manure is also used as a nitrogen fertilizer in some areas. Organic nitrogen and urea in the manure are converted to ammonia and, ultimately, to nitrate in the soil. Nitrate that is not used by plants washes from farmlands and residential and commercial lawns into storm drains and nearby streams, or seeps into groundwater.

- *Animal Waste*

A significant amount of nitrogen is released in the wastes produced by animals. This can be a serious problem in waters near cattle feedlots, hog farms, dairies, and barnyards.

- *Industrial Discharge*

Many industries use nitrogen during processing. Nitrite is sometimes used as a corrosion inhibitor in industrial process water. Ammonia is used in the production of nitric acid, urea and other nitrogen compounds, and in the production of ice and in refrigerating plants. Ammonia is also used in cleaning supplies and to remove carbonate from hard water. Water from industries is usually discharged to a wastewater treatment plant

(WWTP), and may end up in a downstream wetland or water body if not completely removed in the WWTP.

Phosphorus

Phosphorus is a nutrient required by all organisms for the basic processes of life. Phosphorus is a natural element found in rocks, soils and organic material. Phosphorus clings tightly to soil particles and is used by plants, so its concentrations in clean waters is generally very low. However, phosphorus is used extensively in fertilizer and other chemicals, so it can be found in higher concentrations in areas of human activity. Many seemingly harmless activities added together can cause phosphorus overloads.

Phosphorus exists in water in either a particulate phase or a dissolved phase. Particulate matter includes living and dead plankton, precipitates of phosphorus, phosphorus adsorbed to particulates, and amorphous phosphorus. The dissolved phase includes inorganic phosphorus and organic phosphorus. Phosphorus in natural waters is usually found in the form of phosphates (PO_4^{-3}). Phosphates can be in inorganic form (including orthophosphates and polyphosphates), or organic form (organically-bound phosphates).
If excessive amounts of phosphorus and nitrogen are added to the water, algae and aquatic plants can be produced in large quantities. When these algae die, bacteria decompose them, and use up oxygen. This process is called eutrophication. Dissolved oxygen concentrations can drop too low for fish to breathe, leading to fish kills. The loss of oxygen in the bottom waters can free phosphorus previously trapped in the sediments, further increasing the available phosphorus.

There are several forms of phosphorus which can be measured. Total phosphorus (TP) is a measure of all the forms of phosphorus, dissolved or particulate, that are found in a sample. Soluble reactive phosphorus (SRP) is a measure of orthophosphate, the filterable (soluble, inorganic) fraction of phosphorus, the form directly taken up by plant cells.

Both phosphorus and orthophosphate are often measured using **a colorimetric method,** which means the color of treated sample reflects the concentration of the parameter.

If total phosphorus is being measured, all forms of phosphorus are converted to dissolved orthophosphate with acid, persulfate, and heat. A chemical is then added to the water sample. The darker the color of the sample becomes, the more phosphorus present. This test can be done visually, comparing the treated sample to a set of reference colors. However, it is more accurate to use an **electronic colorimeter**, which uses a light source and a **photo detector** to find the concentration based on how much light is absorbed by the sample.

Eutrophication is a process that results from accumulation of nutrients in lakes or other water bodies. Eutrophication is a natural process, but can be greatly accelerated by human activities that increase the rate at which nutrients enter the water. Algae growth is limited by the available supply of phosphorus or nitrogen, so if excessive amounts of these nutrients are added to the water, algae and aquatic plants can grow in large quantities. When these algae die, they are decomposed by bacteria, which use dissolved oxygen. This process is called "eutrophication."

Activity: Discuss the role of wetlands in prevention of <u>Eutrophication</u> of large water bodies in Africa like Lake Victoria

Water hardness

Hardness is measure of polyvalent cations (ions with a charge greater than +1) in water. Hardness generally represents the concentration of calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions, because these are the most common polyvalent cations. Other ions, such as iron (Fe^{2+}) and manganese (Mn^{2+}), may also contribute to the hardness of water, but are generally present in much lower concentrations. Waters with high hardness values are referred to as "hard," while those with low hardness values are "soft".

Hardness affects the amount of soap that is needed to produce foam or lather. Hard water requires more soap, because the calcium and magnesium ions form complexes with soap, preventing the soap from sudsing. Hard water can also leave a film on hair, fabrics, and glassware.

Hardness is generally measured by titration. A buffer and a color indicator are added to a volume of water. An acid (the titrant) is then added to the water, and it reacts with the Ca^{2+} and Mg^{2+} in the water. The volume of acid required to change the color of the sample reflects the Ca^{2+} and Mg^{2+} concentration of the sample. The more acid needed, the more Ca^{2+} and Mg^{2+} in the sample. Hardness is generally expressed in units of milligrams per liter (mg/l) or parts per million (ppm) of $CaCO_3$ (calcium carbonate).

SPECIFIC CONDUCTANCE (SC)

Specific Conductance (SC) is a measure of how well water can conduct an electrical current. Conductivity increases with increasing amount and mobility of ions. These ions, which come from the breakdown of compounds, conduct electricity because they are negatively or positively charged when dissolved in water. Therefore, SC is an indirect measure of the presence of dissolved solids such as chloride, nitrate, sulfate, phosphate, sodium, magnesium, calcium, and iron, and can be used as an indicator of water pollution.

Specific Conductance measures how well water can conduct an electrical current for a unit length and unit cross-section at a certain temperature. More specifically, it is defined as the "reciprocal (opposite) of the resistance in ohms measured between opposite faces of a centimeter cube of an aqueous solution at a specified temperature" (Hem, 1985). That is,

Conductance = 1 / resistance

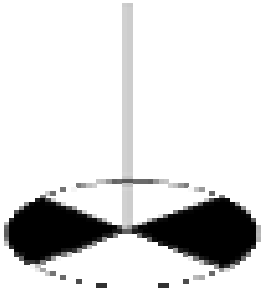
Specific conductance is measured using a sensor which measures resistance.

TURBIDITY

Turbidity is a measure of the cloudiness of water- the cloudier the water, the greater the turbidity. Turbidity in water is caused by suspended matter such as clay, silt, and organic matter and by plankton and other microscopic organisms that interfere with the passage of light through the water. Turbidity is closely related to total suspended solids (TSS), but also includes plankton and other organisms.

Turbidity itself is not a major health concern, but high turbidity can interfere with disinfection and provide a medium for microbial growth. It also may indicate the presence of microbes.

Turbidity is a measure of how much of the light traveling through water is scattered by suspended particles. The scattering of light increases with increasing suspended solid and plankton content. Turbidity in slow moving, deep waters can be measured using a device called a Secchi disk. A Secchi disk is a black and white, 20-cm diameter disk.



The disk is lowered into the water until it just disappears from sight. The depth at which the disk disappears is called the Secchi depth, and is recorded in meters.

A Secchi disk does not work in shallow, fast-moving streams. In these waters, a turbidimeter (sometimes called a nephelometer) is used. A turbidimeter measures the scattering of light, and provides a relative measure of turbidity in Nephelometric Turbidity Units (NTUs). A less expensive method of measuring turbidity is to evaluate the fuzziness of a mark at the bottom of a clear tube when a water sample is poured in the

tube. Units are reported in Jackson Turbidity Units (JTUs). This method can only be used in highly turbid waters.

TOTAL SUSPENDED SOLIDS (TSS)

Total Suspended Solids (TSS) are solids in water that can be trapped by a filter. TSS can include a wide variety of material, such as silt, decaying plant and animal matter, industrial wastes, and sewage. High concentrations of suspended solids can cause many problems for stream health and aquatic life.

High TSS can block light from reaching submerged vegetation. As the amount of light passing through the water is reduced, photosynthesis slows down. Reduced rates of photosynthesis causes less dissolved oxygen to be released into the water by plants. If light is completely blocked from bottom dwelling plants, the plants will stop producing oxygen and will die. As the plants are decomposed, bacteria will use up even more oxygen from the water.. High TSS can also cause an increase in surface water temperature, because the suspended particles absorb heat from sunlight. This can cause dissolved oxygen levels to fall even further (because warmer waters can hold less DO), and can harm aquatic life in many other ways.

To measure TSS, the water sample is filtered through a pre-weighed filter. The residue retained on the filter is dried in an oven at 103 to 105□ C until the weight of the filter no longer changes. The increase in weight of the filter represents the total suspended solids.TSS can also be measured by analyzing for total solids and subtracting total dissolved solids.

TOTAL AND FECAL COLIFORM BACTERIA

The coliform bacteria group consists of several genera of bacteria belonging to the family *enterobacteriaceae*. These mostly harmless bacteria live in soil, water, and the digestive system of animals. Fecal coliform bacteria, which belong to this group, are present in large numbers in the feces and intestinal tracts of humans and other warm-blooded animals, and can enter water bodies from human and animal waste. If a large number of fecal coliform bacteria (over 200 colonies/100 milliliters (ml) of water sample) are found

in water, it is possible that pathogenic (disease- or illness-causing) organisms are also present in the water. Fecal coliform by themselves are usually not pathogenic; they are indicator organisms, which means they may indicate the presence of other pathogenic bacteria. Pathogens are typically present in such small amounts it is impractical monitor them directly.

Swimming, drinking or bathing in waters with high levels of fecal coliform bacteria increases the chance of developing illness (fever, nausea or stomach cramps) from pathogens entering the body through the mouth, nose, ears, or cuts in the skin. Diseases and illnesses that can be contracted in water with high fecal coliform counts include typhoid fever, hepatitis, gastroenteritis, dysentery and ear infections. Fecal coliform, like other bacteria, can usually be killed by boiling water or by treating it with chlorine. Washing thoroughly with soap after contact with contaminated water can also help prevent infections.

Measurement of Fecal Coliform

Bacteria are single-celled organisms that can only be seen with the aid of a very powerful microscope. However, coliform bacteria form colonies as they multiply, which may grow large enough to be seen. By growing and counting colonies of coliform bacteria from a sample of water, it is possible to determine approximately how many bacteria were originally present.

There are several ways coliform bacteria are grown and measured. Methods commonly used include the **most probable number** (MPN) method and the **membrane filter** (MF) method.

- In the MPN method, a "presumptive test" is performed first. A series of fermentation tubes that contain lauryl tryptose broth are inoculated with the water sample and incubated for 24 hours at 35 °C. Fermentation tubes are arranged in 3 or more rows, with 5 or 10 tubes per row, with varying dilutions of the samples in the tubes. The fermentation tube contains an inverted tube to trap gases that are produced by the coliform bacteria. After 24 hours,

the fermentation tube is examined for gas production. If there is no gas production, the samples are incubated for another 24 hours and reexamined. If gas production is observed by the end of 48 hours, the presumptive test is positive; coliform bacteria are present in the sample. A "confirmed test" is then performed to determine if fecal coliform bacteria are present. For the confirmed test, some of the content of the fermentation tube is transferred with a sterile loop to a fermentation tube containing another broth. The sample is incubated in a water bath at 44.5 □C for 24 hours. Gas production in the fermentation tube after 24 hours is considered a positive reaction, indicating fecal coliform. Based on which dilutions showed positive for coliform and/or fecal coliform, a table of most probable numbers is used to estimate the coliform content of the sample. The results are reported as most probable number (MPN) of coliform per 100 ml (American Public Health Association, 1998).

- The MF method is more rapid than the MPN method, but the results are not as reliable for samples that contain many non-coliform bacteria, high turbidity, and/or toxic substances such as metals or phenols. The water sample is filtered through a sterile membrane filter. The filter is transferred to a sterile Petri dish and placed on a nutrient pad saturated with broth. The plates are inverted, placed in watertight plastic bags, and incubated in a water bath at 44.5 degrees C for 24 hours. Colonies produced by fecal coliform bacteria are blue, and are counted using a microscope or magnifying lens. The fecal coliform density is recorded as the number of organisms per 100 ml.

Activity: Field study

- Make a checklist of wetland degradation activities within the catchment area to be surveyed and outline their potential impacts on quantity, quality of water entering the wetland
- Proceed to the wetland site and outline on-site activities that degrade the wetland
- With the guidance of your teacher try to reach to the people that live or interact with in or around the wetland in a friendly manner. Find out if they
    - Benefit from the wetland and how
    - Are aware of the impacts of the various activities that you have found in the wetland.
- Make recommendations with your teacher that can be of importance to wetland conservation.

Questions

1. Discuss the importance of water quality assessment in wetland monitoring.
2. Write a simple news paper article to create awareness of your local community about the importance of wetland assessment, monitoring and conservation.
3. How is wetland assessment and monitoring important in the development of your Country?

Unit Summary

In this Unit, you have been able to

- Define the terms wetlands inventorying, assessment and monitoring
- Give the rationale for assessing wetland status
- Describe the various techniques that can be used to assess wetlands
- Apply the various techniques learnt to assess water quality

Further reading

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UNIT 6:

WETLAND CONSERVATION AND MANAGEMENT

Introduction

Over the years, it has been recognized that wetlands and people are interdependent. Nonetheless, wetlands have been lost and degradation is continuing through agricultural, industrial encroachment and conversion to other uses, reducing the capacity of wetlands to provide ecological, social and economic services to humanity. Wetland conservation and management is aimed at sustaining the bio-physical and socio-economic values of wetlands for present and future generations. Frameworks that enhance the capacity of the national, district and local structures to implement the National Wetlands policy are central to their conservation and management. This unit discusses the concept of conservation and management of wetlands.

Objectives

- Examine the conservation wetlands
- Discuss the relationship between wetlands and sustainable development
- Identify and examine stakeholders in wetland management
- Identify and analyze linkages between wetlands and sustainable development
- Solve problems related to conservation of wetlands and make responsible decisions using critical and creative thinking
- Attend a local meeting in the surrounding communities on wetland conservation

Content

- Wetland conservation-wise use concept
- Why conserve wetlands?
- Wetlands and sustainable development
- Conservation strategies/approaches
- Wetland management planning
- Stakeholder involvement in wetland conservation
- Guidelines for proper conservation of wetlands
- Management of trans-boundary wetlands

- International, regional and national institutions overseeing wetland management

What is wise use concept?

The concept of wise use refers to use of wetlands on sustainable basis. Sustainable uses are uses that do not harm the natural properties and functions of wetlands in the short or long term. This means that wise use is aimed at protecting and conserving wetlands for the benefit of nature and people, therefore wise use concept is synonymous to conservation. Natural properties of wetlands are defined as the physical, biological or chemical components, such as soil, water, plants, animals and nutrients, and the interactions between them. The wise use concept applies to all wetlands and their support systems within the territory of a Contracting Party, both those wetlands designated as Ramsar wetlands and all other wetlands. The concept of wise use seeks both the formulation and implementation of general wetland policies, and wise use of specific wetlands. These activities are integral parts of sustainable development. It is desirable in the long term that all Contracting Parties should have comprehensive national wetland policies that are appropriate to their national institutions.

In an effort to address further degradation and loss of wetlands, and in response to Article 3.1 of the Ramsar Convention, the signatories have elaborated the `Wise Use' concept and accompanying guidelines to provide a basis by which the sustainable use of wetlands can be attained.

This wise-use concept is particularly relevant due to its recognition of wetland values to local communities for meeting their needs. The wise use concept is on the basis of recognition of the fact that wetlands are useful for meeting many of human direct and indirect needs. People use the wetlands for dry seasonal grazing, and extract reeds to weave our sleeping mats and baskets. Wetlands provide fuelwood and timber for building houses, source of drinking water and food. Rivers and lakes are also recreation areas. Wetlands are therefore vital to our lives and we must continue to use them in such a way as to ensure their continued existence and reliability to meet the needs of our grandchildren and great grandchildren.

The principal measure in the Wise Use concept is the formulation and implementation of comprehensive national wetland policies and integration of these policies into the national planning processes. Furthermore, the guidelines to the wise use principle outline measures that member states ought to take in the process of formulating National Wetland Policies. These include actions to address legislation and government policies (such as a review and harmonization of existing legislation), to increase knowledge and awareness of wetlands and their values; to review the status of wetlands and priorities for wetlands and to address problems at particular wetland sites. A few countries, including Australia, Canada and Uganda, already have such policies in place, while several others are in the process of formulating policies or have incorporated wetland conservation concerns in National Biodiversity Strategies or into National Environmental Action Plans etc., as measures to protect wetlands from degradation and/or loss.

It is important that any land use planning exercise which aims to allocate uses of various wetland types be viewed in the context of a wetland policy, whether it is in place or not, and it should also takes into consideration the multiple functions and benefits of wetlands in the national, regional and global context. Furthermore, it is imperative that land use planning in wetlands involves careful consideration of an integrated approach to wetland use, recognizing that more often than not, wetlands transcend different ecological zones and often undergo impacts whose source is often far removed from them.

Why conserve wetlands?

Although developing countries are faced with political, social and economic instability, the key development challenge is to promote economic growth and equitable income distribution without degrading its wetland resources. Inspite of difficult economic conditions, developing countries should strive to make wetland issues a priority. Efforts to reduce poverty at local, regional and national level should be done while conserving wetlands. Development should be aimed at promoting sharing of wetland resources, securing rights of access especially for poor communities, diversifying livelihoods, improving the income earning potential of stakeholders and creating incentives for

wetland conservation. Initiatives for development of capacity in wetland conservation skills of institutions and community-based organisations are important. Therefore, conservation of wetlands should focus on actions that either increase or sustain functions and values of wetlands such as hydrology, nutrients and biodiversity.

Until recently, wetlands were viewed as undesirable, unappealing infestations harboring snakes, insects and rodents. In agricultural areas, wetlands were drained, cleared and put into crop production. In expanding urban areas, wetlands were filled to provide land for more houses, office buildings, industrial facilities and sanitary landfills. However, wetlands have values and functions that either directly or indirectly benefit society.

Wetlands Protect and Improve Water Quality

Healthy wetlands remove and retain excessive nutrients, such as nitrogen and phosphorus, from the water. Wetlands remove phosphorous and nitrogen from water, which act as water contaminants and may result in unhealthy algae blooms. Wetlands also can minimize sediment loads and absorb chemical and organic pollutants before they can enter lakes, rivers, streams or oceans.

Wetlands Help Control Flooding and Erosion

Wetlands often have been referred to as natural sponges that absorb flooding waters.
By temporarily storing floodwaters, wetlands help protect adjacent and downstream property owners from flood damage. Wetlands in urban areas are especially valuable for flood protection, since urban development increases the rate and volume of surface water runoff, thereby increasing the risk of flood damage. Wetlands are often located between rivers and high ground and, therefore, are in a good position to buffer the land against erosion. Wetland plants can reduce erosion by binding soil with their roots.

Wetlands Provide Habitat for Terrestrial and Aquatic Wildlife

Wetlands provide vital habitat for fish, shellfish, waterfowl, wading birds and mammals.
Commercially important fish and shellfish depend on estuarine wetlands as their home. Freshwater wetlands also provide valuable fish habitat and support a variety of birdlife,

including ducks, geese and many songbird species. Mammals that are commonly found in wetlands include sitatunga. Wetlands foster the production of many species including fish and waterfowl and plants such as wild rice. Forested wetlands supply valuable timber products.

Recreation in Wetland Areas

Waterfowl hunting, fishing, and crabbing are popular activities in these areas, but wetlands also provide rich opportunities for bird-watching, swimming, boating and nature photography.

Activity 1

Identify wetlands in communities surrounding your institution.

Learn about habitat values of the wetlands and types of plants and animals that inhabit or frequent the area. Have the vegetated zones around the wetlands been maintained?

Does the land use planning in the area promote wetland conservation?

Activity 2

Simple conservation activities can improve the health of a wetland. Before you think of activities to improve the heath of the wetland, you need to be aware of which factors contributed to the degradation of a wetland in order to help correct them. Start by identifying which activities have contributed to degradation of the wetland you have visited. **List these activities in order of their magnitude**.

Classify activities into;

Protect the wetland (tourism eg bird watching, canoeing, and hiking).

Conserve the wetland (water fetching, fishing).

Convert the wetland (fish ponds, cultivation).

Destroy/lead to loss of wetland (channelling water, clay/sand, infilling).

Some important conservation and management activities include;

Buffer zone

Does the wetland you are observing have a buffer zone?

Before human activities altered the landscape, a continual expanse of uninterrupted vegetation linked uplands and wetlands. Historically, land use practices have tended to alter or develop upland areas, creating abrupt boundaries between upland and wetland at the wetland edge. By establishing a buffer zone, you can recreate the vegetation continuum and minimize the abrupt boundary between cultivated or grazed lands and wetlands. A buffer area can protect wetlands from siltation, excess nutrients, and pollution from chemicals such as pesticides and herbicides applied to neighbouring agricultural fields. **What kind of vegetation is around the wetland you have visited? How big is the area (in meters) where this vegetation is?**

Vegetation of Edges of Lakes or Streams.

Does the lake/stream have any vegetation around it? What kind of vegetation is it?

The vegetated wetland edge of a lake or stream is important habitat for fish, reptiles, amphibians, songbirds, waterfowl, and mammals. The shoreline of all water bodies should not be disturbed or mowed. Native plants along the shoreline will buffer wave action and help cool shallow water, while their roots bind the soil to resist erosion. This unmowed shoreline edge also protects water quality by filtering and slowing runoff from the upland areas.

Livestock

Do cattle or sheep or goats graze in this wetland? Or are these animals watered in this wetland? What kinds of plants can see around areas where cattle, sheep or goats are grazing? Are these native wetland plants? If not how did they get there? What can be done to protect the wetland from cattle, sheep or goats?

Cattle trampling can destroy sensitive wetland plants and break wetland sod, providing an opportunity for invasive species to become established. Additionally, invasive plant seeds can hitchhike into the area by clinging to the hooves of livestock. Some species of wetland grasses and wildflowers are favorite food items of grazing livestock and quickly disappear under grazing pressure. Manure can quickly become a source of excess nutrients and unwanted seeds. Undesirable plants, like reed canary grass, often establish themselves in grazed wetlands and along their edges.

Wetlands and sustainable development

What is sustainable development?

Sustainable development is development that meets the needs of the present without compromising the ability of the future regenerations to meet their own needs.

Wetlands and sustainable development

Wetland resources are important for our existence. Our health and well-being are closely linked to the quality of our water, air, soil and biological diversity. Their landscape and wildlife is inseparable from our culture and our economy and industrial sectors directly or indirectly reliant on functioning of wetland ecosystems. Therefore, role of wetlands in sustainable development can be summarised under wetland services and human well – being.

Wetlands services and human well-being

Fisheries

Wetland ecosystems including rivers, lakes, marshes, and coastal areas provide many services that contribute to well being and poverty alleviation. Some people particularly those living near wetlands are highly dependent those services. Fish and water supply are among the important wetland services that affect human well-being. Fisheries are important in developing countries because are primary source of protein which rural communities have access. Wetland related fisheries make important contribution to local and national income.

Water supply

Physical and economic water scarcity and limited or reduced access to water is major challenges facing society and are key factors limiting development of many countries. However, the principle supply of fresh water for human use comes from wetlands including lakes, rivers, swamps and groundwater acquifers. Groundwater often recharges through wetlands, plays an important role in water supply with estimated 1.5-3 billion depending on it as source of drinking water.

Other services of wetlands related to human well-being include;

Wastewater purification and detoxification

Wetlands play a major role in treating and detoxifying waste products. Some wetlands have been found to reduce concentrations of nitrate by more than 80%.

Climate regulation

One of the important roles of wetlands is regulation of global climate change through sequestering and releasing of fixed carbon in the atmosphere. For example, peat lands are estimated to hold more carbon than is present in terrestrial vegetation.

Mitigation of climate change

Sea level rise and increase in storms associated with climate change will result in erosion of shores and habitats, increased salinity of estuaries and bays and increased coastal flooding. Wetlands can play a critical role in physical buffering of climate impacts.

Cultural services

Wetlands provide aesthetic, educational, cultural and spiritual benefits as well as a variety of opportunities for recreation and tourism. Recreational activities generate income at local and national level.

Activity

Conservation strategies/approaches

Strategies/approaches

Wetland Conservation strategies provide for the use and management of wetlands so that they can continue to provide a broad range of functions on a sustainable basis. Strategies/approaches are set to ensure wetlands conservation and public awareness actions both nationally and internationally which are deemed critical to the implementation of the wetland Policy by governments.

Ecosystem approach

The ecosystem approach to wetland conservation is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use of wetlands in an equitable way. This is because wetland ecosystems are

interconnected communities of living things, including humans, and the physical environment within which they interact. Healthy and well-functioning wetland ecosystems are vital to the protection of biodiversity and to sustaining our economies and communities that rely on their products. Ecosystem approach recognizes the interrelationship between the natural environment and healthy, sustainable economies, and emphasizes the integration of planning for the protection and preservation of both. The ecosystem approach is characterized as a method for sustaining or restoring natural wetland ecosystems and their functions and values. It is goal driven, and is based on a collaboratively developed vision of desired future conditions that integrates ecological, economic, and social factors. It is applied within a geographic framework defined primarily by ecological boundaries. Ecosystem approach is the primary framework for action under the Convention on Biological Diversity (CBD).

Community approach

Community approach to wetland conservation involves a local community taking the lead, initiating major actions, and achieving results for the long-term conservation and wise use of wetlands. It is an approach aimed at demonstrating how to implement two major objectives of the Ramsar Convention: conservation and wise use of wetlands for the well-being of local populations, by building consensus on major issues to be addressed, and increasing commitment on the steps to be taken by various stakeholders the community inclusive.

Resource user approach

This approach aims to management of specific wetland resources by involving members of the community with who use that resource. Members of the community who have a stake in a particular resource are deemed to have interest in it and hence are motivated to conserve the resource. Other approaches to wetland conservation include;

Developing Public Awareness

The Government should

- promote public awareness and understanding of the wetland resource in the country and actively encourage participation of the public, including
  -landowners,
  -non-government organizations,
  - Institutions,
  -and the private sector in wetland conservation.
- Design and deliver a national public awareness program on wetlands in cooperation with other governments, non-government organizations and the private sector.
- Inform citizens of the health of the wetland resources on a regular basis through State of the Environment Reporting. Ensure that results of wetland research are available in formats suitable for public use and education.
- Provide information and expertise concerning sustainable land use management and conservation practices, particularly as they affect soil, water and wetland conservation and management.
- Provide suitable opportunities for public review and evaluation of the Government's performance relative to its wetland conservation goals.
- Promote development of targeted wetland education and outreach materials.

Promoting Wetland Conservation in Protected Areas

The Government should

- Manage the use of National Parks, National Wildlife Areas, Migratory Bird Sanctuaries, and other areas established for ecosystem conservation purposes so as to sustain their wetland functions and natural processes.
- Require the creation of management plans which adequately reflect the special role of the wetland resource on lands secured for ecosystem conservation purposes, and the periodic review and update of these plans. Management of such wetlands should only support those activities which are compatible with sustaining wetland functions.

- The goal of no net loss of wetland functions in all areas secured for conservation purposes should be promoted.
- Protect these wetlands from impacts resulting from land or water use and environmental quality changes, both internal and external to the boundaries, by applying the Environmental Assessment and Review Process, enforcing compliance with regulations, by working cooperatively with other levels of government, non-government organizations and the private sector and, if required, by intervening in legal or decision-making processes.
- Encourage recreational, scientific, and educational uses of wetlands as long as these uses are not detrimental to wetland functions and do not conflict with the purposes of the area.
- Develop and amend, where necessary, new and existing policies and legislation so as to enhance wetland conservation within areas established for ecosystem conservation purposes.

Enhancing Cooperation

The Government should;

- Create joint regional wetland inventory, evaluation, and monitoring programs in support of: the identification of geographic areas within which the continuing loss or degradation of wetlands has reached critical levels; the identification of significant wetlands requiring protection; and the identification of management strategies for the sustainable use of wetland resources.
- Encourage and support regional policies that promote wetland conservation, and promote the development of other related strategies. Encourage recognition of wetlands in the development and implementation of regional conservation strategies.
- Encourage consultation with interested regions and other parties whereby senior levels of government ensure that their wetland conservation policies and programs are supportive of each other.
- Enhance and, where necessary, develop new mechanisms for the resolution of interjurisdictional wetland problems.

Conserving Wetlands of Significance to Citizens

The government should

- Participate in and promote the establishment of a systematic and coordinated national network of wetlands to be achieved in cooperation with regional governments and other stakeholders. Such an approach will lead to a comprehensive network of secured sites or complexes of exemplary and strategically important wetlands of significance to nations together representing the full range of wetland functions and types.
- Develop national and regional criteria for identification and promote listing of wetlands of significance to nations in the regions using a standardized approach primarily on the basis of existing information.
- Promote use of a national network of secured wetlands as benchmark sites for environmental monitoring, scientific research, education, and public awareness.

Ensuring a Sound Scientific Basis for Policy

The government should

- support and promote the development of expertise for a sound technical and scientific basis for wetland conservation, ensuring that the information necessary for making decisions regarding wetlands is accessible to planners, managers, regulators, and other decision-makers at all levels.
- Encourage research that is directed towards advancing wetland conservation and sustainable use of wetland resources and ensure that the results of such research are effectively integrated into decision-making.
- Encourage the establishment of wetland centres of research and expertise in the country and foreign educational institutions.
- Undertake, support and promote the development of guidelines and standards aimed at establishing regional target levels for the quantity and quality of wetlands required to safeguard the range of wetland functions across the country. Such standards must refer to the level at which wetland loss or degradation threatens the health of regional ecosystems and species survival.

- Support research and demonstration projects on mitigating the impacts of inappropriate development on wetlands, and on the restoration and rehabilitation of degraded wetlands.
- Encourage the development of techniques for the integration of wetland functions into natural resource allocation decisions, reflecting the full range of wetland functions and values in such techniques, and demonstrate the appropriate roles of wetland conservation in solving land use problems.
- Promote research to better define the role of wetlands in the hydrologic cycle (groundwater recharge, water purification, flood control, and the maintenance of flow regimes), and the effects on wetlands of global atmospheric cycles, shoreline erosion, renewable resource production, management of exotic species such as purple loosestrife, and the provision of fish and wildlife habitat.

Promoting International Actions

The government should

- Promote conservation and sustainable use of wetlands internationally, and encourage the involvement of other nations and international organizations in wetland conservation efforts.
- Provide technical and advisory assistance to wetland conservation efforts in other countries, particularly for those wetlands used by wildlife populations shared with country
- Strengthen country's role in international wetland conservation, by requiring regular review of the country's progress on international conventions with relevance to wetlands, and by identification of gaps or weaknesses in honouring international commitments and responsibilities.
- Promote wetland conservation through continued strong commitments to the Ramsar Convention on Wetlands of International Importance, the World Heritage Convention and international agreements and treaties.
- Create and support the implementation of bilateral and multilateral agreements and similar arrangements that promote conservation and sustainable use of wetlands such as the International Biosphere Reserves Program, and new or

existing agreements on marine and estuarine environmental quality, and emerging issues such as biodiversity and climate change.

- Ensure that the countries representatives on international inquiries and commissions have an adequate understanding of wetland issues so as to promote wetland conservation in their consideration of the implications of transboundary management issues and opportunities for the sustainable use of wetland resources.

Wetland management planning

A wetland management plan outlines the direction and actions which are required to ensure wetlands remain health. Therefore a management plan helps in achievement of objectives, while protecting the benefits that wetlands bring. Wetlands function as integral parts of the general landscape. Understanding how wetlands work is essential to the process of developing a wetland management plan. Most actions taken to protect wetlands involve both the wetland and adjacent wetland areas. Management of the adjacent areas reduces negative effects of land use practices on wetlands.

There are four basic steps involved in preparing a wetland plan

- Inventory and assessment of wetland resources
- Define values, goals and objectives
- Implement a course of action that will protect wetlands and meet objectives
- Monitor the effectiveness of your actions

Wetland inventory

Wetland management planning involves taking decisions about the wetlands in consideration. Descriptions and documentation of the wetland characteristics is important. This inventory should include both the extent and type of wetland, its condition/health and also the condition/health of the surrounding areas. Information on aspects such as; number of wetlands in the area, total area of the wetlands, how many of these are temporary, seasonal or permanent, are these wetlands part of a main water body or isolated; is important.

The condition/health of the wetland

This refers to ability of the wetland to perform its functions. The assessment of the condition/health can be based on physical, hydrological and vegetative factors. The vegetative factor (types of species of plants) provides the greatest insight into the condition of wetlands. The wetland condition can be assessed by looking at either a representative area of the wetland or a critical area.

Examples of indicators used assessing wetland condition

How much ground is covered by vegetation? If less than 85% determine why?

How much of the shoreline is protected by vegetation with deep binding root mass? Plant species in the category of woody vegetation, bulrushes and sedges have good root systems. If 85% of the shoreline is covered by these species, it is a good indication.

How much soil in the wetland is exposed due to human disturbance or land use practices? More than 5% is problematic.

Are there any invasive species or noxious weed?

Are undesirable plants dominant in the vegetation?

Is there a diversity of sizes and species of trees and shrubs? The roots of trees and shrubs hold soil together and prevent erosion. It is also important to note the presence of young plants as they replace older ones.

Is the woody vegetation heavily browsed? If there is high browsing, regeneration of shrubs may be impaired.

It is equally important to look at the surrounding areas of the wetland. Information to answer questions such; are the surrounding areas cultivated or grazed? What is the size of the individual fields, Are wetlands used for grazing? Has drainage affected wetland water supply?

Incase the surrounding areas are cultivated; how close does cultivation come to the wetland? If grazed, are the pastures native or artificial? Is grazing pressure uniformly distributed? Do stocking rates much foraging ability?

Wildlife habitat

What kind of birds and animals are commonly present?

Checklist for the wetland condition

Attribute	Score (%)
Plant cover of wetland attribute	
Shoreline with deep binding root mass	
Exposed soil the wetland margin	
Invasive species	
Undesirable species	
Diversity of shrubs/trees	
Browse on woody vegetation	
Dead or decadent woody vegetation	
Artificial control of water	

Defining values or goals

Clearly stating what you value the wetland for and what your objectives are is vital to the development of a wetland management plan. Values and objectives are useful in setting realistic management goals. The goals relate to information from assessment of the wetland and the surrounding areas. The goals provide a sense of direction, guide the actions needed and are a basis for measuring success. There are varying reasons for conserving and protecting wetlands. The common ones include; livestock forage, wildlife habitat, erosion control, recreation opportunities and water source among others. However, due to limited time and resources, priorities need to be set so that so values and objectives are split into short and long term.

Implement a course of action that will protect the wetland

A majority of wetlands exist as agricultural landscapes and most management plans tend to reflect this. The information collected during inventory and set objectives helps in deciding upon the best set of land use management practices for a given wetland. Management considerations for land use activities include grazing and wetlands, cultivation and wetlands and wetland drainage. Managing wetlands for grazing requires that the wetland plant communities are grazed in a controlled manner. These include considerations such as timing, intensity, and frequency of grazing. Also important is the stocking rate, fallow period and rotation among others.

Monitor the effectiveness of your actions

This is a continuous process after the management plan has been implemented so as to assess the effectiveness. It is necessary to revisit the assessment of the wetland to check for change in condition of the wetland or any evidence that change is taking place. This can give an indication of the effectiveness or success of the plan. Continued periodic evaluation ensures that actions have desired effects and wetlands remain healthy.

Stakeholder involvement in wetland conservation

The principle of wise use integrates the conservation of wetlands with sustainable use for the health and well-being of people through an integrated management approach. This is achieved through facilitation of equitable and effective participation of all stakeholders (government, local communities, NGOS, private sector and academicians) in decision making about how resources of wetlands can be managed.

Roles of stakeholders

Central government

Policy formulation and implementation, financing and monitoring

Local government

The national laws passes by parliament are implemented by bye-laws formulated in by local governments. Management plans are made by local governments. In addition, local government finance activities related to wetland conservation.

Community

Make bye-laws and act as monitoring agencies by reporting to relevant authorities illegal activities in wetlands.

Activity

Facilitate a brainstorming session through which students list specific local environmental problems or issues and then identify one for discussion (if possible, choose a real issue being debated). Example: **Should the proposed development of a business park on a significant wetland go ahead?**

Divide the class into groups, each group representing a stakeholder. Each group researches and develops a case for its particular interest, which it will later present during the round table. Provide stakeholder role cards (in form of activity sheet) or if adequate local research material is available, (newspaper articles, television broadcasts, etc.), allow the students to compose the role cards themselves. (Note: the stakeholder cards included only work with the issue stated above. For other issues, new stakeholder cards need to be created).

Following the research and the development of the stakeholder case, invite one student per group to sit in a round table discussion and represent his or her group's point of view. Once all the cases have been put forward, guide the discussion so the round table can consider the pros and cons of each side.

Ask students to re-examine their cases in light of the pros and cons of the other stakeholders. Allow them to regroup, brainstorming what they believe will be the best sustainable solution.

Reconvene the round table discussion and ask students to present their revised plans.
From revised plans, facilitate debate, bargaining and negotiating between stakeholders and if consensus is achieved, have them draw up an Action plan outlining proposed solutions.

Explain to students they should not feel discouraged if they do not arrive at consensus within the time available for the activity. In complex issues with many competing interests, few decisions please everybody. Whether consensus is achieved or not, the round table simulation can provide valuable insights into the real world of economic-environmental decision-making.

Stakeholder cards

Central Government	**National Investment authority**	**Investors**
The municipality has little industrial development and wants to expand its	Its purpose is to attract new business and industry to the area and help maintain the	They want development to continue and are interested in creating an

industrial base. The local municipal council is firmly behind the development. There is an economic recession taking place, so the municipality needs to attract new development. Local mayors in the regional municipality are opposed to the establishment of a greenbelt around the area since this would limit development in their jurisdictions.	economic health of the region. It has already attracted several new businesses to develop at the proposed business park. They have put lots of work and economic resources into planning this project and don't want to start from square one again. They consider the land swap proposed by the region to be a poor solution since it will set the project back too far to replan on another site. They claim the business park can still be built while preserving part of the wetland and it will also create green space in the form of recreational areas around the new office buildings.	environmentally attractive community but are not especially concerned with the ecological level of preserving habitats and species and creating a green buffer zone. They support the business park development but are not adamant about maintaining it on the current proposed site.

Regional Government	**Local Environmental Organization**
Regional government is interested in 'greening' the region and designating special ecological areas for protection, such as a greenbelt in the official regional plan. They have instituted a planning process to identify these special areas, but the process is not completed. Sympathetic to protecting the wetland, the region is offering a 'solution' in the form of a land swap of some of its own less ecologically sensitive land in the affected municipality.	Interested in saving green spaces and special natural areas. They are opposed to the business park development and want the entire wetland to be protected within a greenbelt around the region. They also want an immediate moratorium on development generally. The group is involved at the regional level and has good experience and expertise in this process. The organization is supported by 1 000 which includes several ecological scientists and environmental experts.

Local Conservation Authority	**Local Community Groups**
Its mandate is to improve and maintain the environmental health of watersheds. They want to see the whole wetland protected with a buffer zone around it. REDCO and the municipality want the Conservation Authority to de-list this wetland from their proposed protected list. The Conservation Authority is not prepared to de-list it but might be persuaded to protect less of it. They have an “open mind”.	Their concerns are basic — controlling pollution in the water and air, having good and well-maintained infrastructures and keeping taxes down. Their environmental concerns are at the level of recycling programmes and water filtration and sewage treatment. The members have different concerns. This community organization has been involved in many similar issues and is an old hand at regional politics and the planning process. They are very confident.

Guidelines for proper conservation of wetlands

The wise-use principles of the Convention on Wetlands (Ramsar 1971 encourages wetland use that does not endanger the vital wetland functions and the overall integrity of

the wetland ecosystem. The guidelines for proper conservation of wetlands are based on four basic principles aimed at maintaining or enhancing wetland functions.

The hydrological and ecological integrity of the wetland ecosystem must be maintained.

Sustainable use of wetlands means using selected portions of wetlands for a variety of multi-purpose activities. Original conditions of the wetland will be expected to change, the extent of change depends on the kind of use the wetland is subjected. However, not the main hydrological and ecological processes must be maintained.

Wetland conservation guided by larger ecosystem management objectives

Wise use of wetlands has to be considered also in the context of sustainable use of the ecosystem as a whole. Proposed wetland management options must, therefore, support wider ecosystem management objectives and options should be guided by information from EIA.

Wetland conservation options must be supportive of the socio-economic objectives and aspirations of the people

Wetland conservation is expected to contribute to local livelihoods and poverty alleviation by acting as a stimulus foe economic development through continued or expanded sustainable wetland. Wetland conservation is also expected to create new opportunities from consumptive and non-consumptive wetland uses.

Management of trans-boundary wetlands

Trans-boundary areas could be politically fragmented or transitional wetland areas. These wetlands do not have more moral pressure in their management than strict obligations. It calls for harmonisation of legal frame works (eg ownership), access to information, encouraging coordinated management and positive cooperation.

Many natural wetlands are trans-boundary, the establishment of cross border cooperation on wetland management required. While management of wetlands on a national scale has challenges, the management of trans-boundary wetlands is more complex because of wetland connectivity across the borders which call for shared responsibility. Trans-

boundary wetland management needs to take into consideration the role wetlands play at restoring the natural discharge and recharge patterns of the water system of the overall catchment. In addition, trans-boundary wetland management needs to acknowledge the role wetlands play to purify water and to trap sediments.
Creating awareness, fostering a sense of shared responsibility, cooperation, and opening common and a broader view on management is vital for the survival of trans-boundary wetlands.

Trans-boundary cooperation

Many challenges have to be surmounted before being able to successfully establish trans-boundary co-operation. These challenges are due to a number of factors such as;

- Differences in legislation
- Differences in policy goals
- Political differences
- Differences in governing structures
- Lack of knowledge of each others language
- Lack of financial resources
- Social and cultural differences
- Lack of structural agreements on the implementation of trans-boundary co-operation

In most cases, cooperation begins informally, with private contacts between wetland managers on both sides of the border, based on a common interest in the sustainable management and/or protection of the area concerned.

However, to formalize a trans-boundary cooperation agreement, governmental level support is required. Due to the difficulties mentioned above, this can be a time consuming and sometimes frustrating process, which may include set backs in what has been achieved. Managers, scientists and planners concerned with trans-boundary wetlands must be encouraged to cooperate directly with their colleagues across the border as a bottom-up approach appears to be the best guarantee for successful trans-boundary

cooperation. International workshops, exchange programmes, conferences and training courses provide excellent opportunities for initiating cooperation.

Financing trans-boundary wetland management

Trans-boundary cooperation is not only important because of the protection of biodiversity values, but is also required to establish political stability. However, financial mechanisms support projects aiming to enhance trans-boundary wetland management may be a challenge.

Cooperation on the development and implementation of joint projects on integrated trans-boundary wetland management, including the establishment of a trans-boundary wetland monitoring network would be a good gesture.

International, regional and national institutions involved in wetland management

Worldwide, environmental institutions exist. However, a majority of these institutions are relatively young. For the case of Uganda, institutions and legal structures involved in wetland management include;

Local and national institutions

- Universities
- Ministry of Agriculture
- Ministry of Water, Lands and Environment
- Ministry of Energy
- Ministry of Tourism

Regionally

- East African Community
- Lake Victoria Fisheries Organization
- Global Environment Facility
- IGAD
- Nile Basin Initiative

- Nile Basin Society

Internationally

- The World Conservation Union
- Conventions on wetlands eg. Ramsar sites, UNESCO
- Birdlife International

Challenges

Since many institutions have a stake in wetland conservation, often conflicts resulting from their mandates exist. In Uganda, the Ministry of Water, Lands and Environment is the lead agency of water. However, the Ministry of Agriculture is mandated to provide water for production. The Fisheries Department has the authority over fish. Some lakes are located in protected areas, the mandate of the Wildlife Authority. This multi-sectoral management of wetlands is a big challenge.

Unit Summary

In this Unit, you have been able to:

- Define the term conservation or wise use
- Give the rationale for conserving and managing wetlands properly
- Identify the actors in the management of wetlands
- Explain why it is important to have policies that govern wetlands management and give examples of such policies in your country
- Critically examine ways of strengthening wetlands management in your country as well as the trans-boundary wetlands
- Relate what has been achieved by individuals on wetlands management elsewhere in the world to our own situation in the Nile basin region.

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UNIT 7

WETLAND INSTITUTIONS, POLICIES AND LAWS

Introduction

Wetlands are among the world's most productive environments. They are cradles of biological diversity, providing the water and primary productivity upon which large numbers of plant and animal species depend for survival. They are also important locations of plant genetic diversity and support large numbers of bird, mammal, reptile, amphibian, fish and invertebrate species. Unfortunately, they are also among the world's most threatened ecosystems, owing mainly to continued drainage, pollution, over-exploitation or other unsustainable uses of their resources.

The wetland loss has been responsible for bringing to the verge of extinction countless species of animals and plants. Inadequate understanding of the crucial role and utility of wetlands is a matter of serious concern.

Recognizing the importance of wetland resources, the Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar, 1971) has been instrumental in worldwide action at the governmental level for conservation and wise use of wetlands. The Ramsar Convention has played an important role in promoting awareness of wetlands and providing technical support to governments for conservation and management of these ecosystems on a sound ecological basis.

In this unit, we shall explore the various national and international policies and laws put in place to ensure the conservation and wise use of wetlands. We shall also have a look at International agreements and conventions such as the Ramsar convention on wetlands of international importance. Greater emphasis will be on countries of the Nile basin region.

Learning Outcomes

By the end of this unit, the learners will have improved your ability to:

- *Explain the Ramsar convention*
- *State aims and objectives of the Ramsar convention*
- *Describe the extent of implementation of Ramsar obligations*
- *Give international and national policies and laws that govern wetland conservation*
- *Give examples of national policies on wetland conservation*
- *Fully explain the African Eurasia Waterbird Agreement (AEWA)*

The learners should be able to use the knowledge obtained on wetland laws and policies to enhance wetland conservation in their local areas and in the region at large.

Ramsar and wetlands of international importance

The Ramsar Convention

The *Convention on Wetlands of International Importance, especially as Waterfowl Habitat,* was adopted in 1971 in the Iranian city of Ramsar, hence the name *Ramsar Convention and came into force in 1975.* It is an intergovernmental treaty, which provides the framework for national action and international cooperation for the conservation of and wise use of wetlands and their resources. It was the first global instrument to address the conservation of a particular habitat. It reflected new international legal efforts aimed at conservation by protecting a habitat rather than a

species. The convention's origin was mainly the research activities conducted by a non-governmental organization, the *International Waterfowl Research Bureau*.

The official name of this convention reflects its emphasis on the conservation and wise use of wetlands primarily to provide habitat for water birds. It is to be noted, however, that, over the years, the convention has expanded in scope to cover all aspects of wetland conservation and wise use. In this regard, wetlands are recognized as ecosystems that are highly important for biodiversity conservation and for the well-being of human communities.

The mission of the Ramsar Wetlands Convention is the conservation and wise use of wetlands through local, regional and national actions and international co-operation, as the means for achieving sustainable development throughout the world.

The convention recognizes the fundamental ecological functions of wetlands, including biological, productivity and their economic, cultural, recreational and scientific values (including biodiversity conservation). This convention directly addresses the conservation of biological diversity. It seeks to secure the maintenance of the ecological integrity of wetlands, and to promote resource development.

7.2.2 Aims and Objectives of the convention

The Convention aims to ensure the conservation and wise use of wetlands. For this purpose, it contains four major commitments that Contracting Parties have agreed to by joining the treaty which include;

- The first obligation under the Convention is to designate at least one wetland for inclusion in the *List of Wetlands of International Importance* (the "Ramsar List") and to promote its conservation, including, where appropriate, its wise use. Selection for the Ramsar List should be based on the wetland's significance in terms of ecology, botany, zoology, limnology, or hydrology. The Contracting Parties have adopted specific

criteria and guidelines for identifying sites that qualify for inclusion in the List of Wetlands of International Importance. As of August 2005, Contracting Parties have designated 1,462 Ramsar sites, with a total surface area of more than 125 million hectares.

- Under the Convention, there is a general obligation for the Contracting Parties to include wetland conservation considerations in their national land-use planning. They have undertaken to formulate and implement this planning to promote, as far as possible, "the wise use of wetlands in their territory". The Conference of the Contracting Parties (COP) has approved guidelines and additional guidance on how to achieve *"wise use"*, which has been interpreted as being synonymous with "sustainable use".
- Contracting Parties have also undertaken to establish *nature reserves in wetlands,* whether or not they are included in the Ramsar List, and they are also expected to promote training in the fields of wetland research and management.
- Contracting Parties have also agreed to *consult with other Contracting Parties* about implementation of the Convention, especially about transfrontier wetlands, shared water systems, and shared species.

Institutional structure of the Ramsar convention

- *Conference of the Contracting Parties (COP)*:

Every three years, government representatives of the Contracting Parties meet as the Conference of the Contracting Parties, the policy-making organ of the Convention, which reviews the general trends in the implementation of the Convention as reflected in the National Reports and adopts decisions to improve the way in which the Convention works. The programme of each meeting of the COP also includes a series of technical sessions, which analyze issues of importance in the field of wetland conservation and wise use, including further interpretation and development of the key Convention concepts. Ramsar COPs have gained the reputation of being highly

effective events, allowing an active involvement and participation of the non-governmental and academic community.

- *Standing Committee:*

The Standing Committee meets annually to carry out interim activities between each COP on matters previously approved by the Conference; prepare documentation for consideration at the next COP; supervise implementation of policy by the Ramsar Bureau (see below) and execution of the Bureau's budget; and decide upon applications for project support from the Ramsar Small Grants Fund (see below). The Standing Committee consists of 13 Contracting Parties elected on a proportional basis from the six Ramsar regions – Africa, Asia, Europe, Neotropics, North America, and Oceania – as well as the host countries of the most recent meeting and the next meeting of the COP. The Contracting Parties that host the Ramsar Bureau and Wetlands International, are invited to participate as permanent observers, and the International Organization Partners (see below) are invited to participate in an advisory capacity.

- *Scientific and Technical Review Panel (STRP):*

The Scientific and Technical Review Panel provides scientific and technical advice to the Conference of the Contracting Parties. The STRP is composed of 13 individual members with appropriate scientific and technical knowledge, selected from the six Ramsar regions, and representatives of the four International Organization Partners (see below). Other relevant organizations also contribute to the work of the STRP as observers

- *Ramsar Bureau:*

The Ramsar Convention Bureau is the permanent secretariat for the Convention and carries out the day-to-day coordination of the Convention's activities. The Bureau is headed by a Secretary General, who supervises the work of a small number of

technical, communications and administrative staff, as well as interns and outposted members of the MedWet Coordination Unit in Athens, Greece.

- *International Organization Partners (IOPs)*:

The Conference of the Parties may confer the status of International Organization Partner to international organizations, both intergovernmental and non-governmental, that "contribute on a regular basis and to the best of their abilities to the further development of the policies and technical and scientific tools of the Convention and to their application". So far, four international non-government organisations that have been associated with the Convention since its inception have been recognized as IOPs. They are Birdlife International, IUCN–The World Conservation Union, Wetlands International, and the World Wide Fund for Nature (WWF).

- *Ramsar Small Grants Fund (SGF)*:

The Small Grants Fund for Wetland Conservation and Wise Use was established by the 1990 Conference of the Contracting Parties (at that time under the name "Wetland Conservation Fund"). The SGF provides financial assistance in the form of small grants (maximum Swiss Francs 40,000 per project) for projects in developing countries and countries with economies in transition. At present, funding is provided for activities related to the implementation of the Convention's Strategic Plan 2003-2008 (see below), including requests for emergency assistance. So far, some 166 projects have been funded in about 80 countries, for a total amount of about Swiss Francs 5,475,000. The Fund relies entirely upon voluntary contributions for its operations.

Ramsar Convention Strategic Plan

The Conference of the Contracting Parties adopted a first Strategic Plan, for the period 1997-2000, at its sixth meeting in 1996. This was seen as a success, and encouraged the

eight meeting of the COP, in 2002, to adopt the *Strategic Plan 2003-2008.* In this second Strategic Plan, containing five general and 21 operational objectives, Contracting Parties seek to deliver their commitments to wetland conservation and wise use through three pillars of action. These are:

- Working towards the *wise use of wetlands.* This can be done through a wide range of actions and processes that contribute to human well-being, through sustainable wetlands, water allocation, and river basin management, including establishing national wetland policies and plans; reviewing and harmonizing the framework of laws and financial instruments affecting wetlands; undertaking inventory and assessment; integrating wetlands into the sustainable development process; ensuring public participation in wetland management and the maintenance of cultural values by local communities and indigenous people; promoting communication, education and public awareness; increasing private sector involvement; and harmonizing implementation of the Convention with other multilateral environmental agreements.
- Devoting particular attention to the further identification, designation and management of a coherent and comprehensive suite of sites for the *List of Wetlands of International Importance* as a contribution to the establishment of a global ecological network, and to ensure the effective monitoring and management of those sites included in the List;
- *Cooperating internationally* in their delivery of wetland conservation and wise use, through the management of transboundary water resources and wetlands and shared wetland species, collaboration with other conventions and international organizations, sharing of information and expertise, and increasing the flow of financial resources and relevant technologies to developing countries and countries in transition.

. Implementation of Ramsar Obligation

The prospects for the achievement of Ramsar's aims lie in achieving a successful blend and balance between action at the national and international levels. An interesting

illustration of this approach may be found in the process of enhancing awareness of wetland values and functions. This has been confirmed as a key objective of the Ramsar system and is pursued through its Outreach Programme, embracing activity at a variety of levels.

This includes the development at the national level of educational programmes concerning wetlands, both through formal academic instruction and, more generally, through provision of information to the public at zoos, museums, and dedicated wetland centres; the organization at the regional level of conferences and workshops devoted to wetland issues; and, globally, the dissemination of information by the Ramsar Bureau itself. The development of an impressive website, together with the preparation of a regular newsletter and numerous specialist publications, demonstrate that the bureau has been particularly active in this regard. Nevertheless, when it comes to the implementation of substantive commitments to sustainable development, experience of conservation treaties generally suggests that the practical limitations of international institutions in terms of powers, finance, and resources, reinforced by the still strong attachment to the concept of national sovereignty, tend to result in the primary emphasis being placed upon national activities and agencies.

The role of international agencies lies principally in the realms of monitoring. An effective system of reporting by states upon national measures adopted in implementation of their obligations provides the necessary link between these two aspects.

Implementation of the Ramsar convention at the National Level

Site Designation

An important first step in this regard is the designation of sites for the List of Wetlands of International Importance. The current Strategic Framework and Guidelines for the Future Development of the List, adopted at COP 7 in 1999, sets an ambitious target of 2000 sites to be designated by 2005, which represented an increase of over 100 per cent on the number of sites listed at that time. The COP has continually encouraged parties to go beyond the minimum obligation of listing one site, and several have added repeatedly to

their original list of designations, with Australia, Italy, and the UK especially prominent in that regard.

The review of national laws and institutions in order to ensure their compatibility with the Ramsar obligations of conservation and wise use is also an important priority. It is still unclear, however, to what precise extent these reviews had been effective in promoting Ramsar objectives.

The relatively 'soft' nature of most Ramsar obligations suggests that this strategy of coaxing governments towards the progressive adoption of appropriate mechanisms and policies for wetland conservation is generally sound and sensible, though there is a risk that the emphasis upon simple quantitative indicators may operate to the detriment of qualitative aspects. The record reveals that the Ramsar institutions are alive to this risk, though measurement of the *actual effectiveness* of wetland policies is, of course, a much more complex and problematic business than simply the head-counting processes referred to above.

Site Management

One obvious indicator of the extent to which contracting parties have successfully implemented their Ramsar obligations, concerns the ongoing ecological condition of sites on the list, the preservation of which represents one of the principal objectives of the Ramsar system. The achievement of this goal clearly depends upon effective management at site level, and the identification and implementation of conservation and management priorities for each site consequently constitutes an important aspect of the wise-use concept..

Where effective management is lacking, there is an obvious risk that environmental quality will deteriorate, and it is in these circumstances that the duty to report adverse changes may come into play.

Overview of the implementation of the Convention in Africa

The achievements and major challenges towards the implementation of the convention in the Nile basin region and Africa at large are as follows;

Achievements

The major achievements of the convention include the following;

- Increased membership
- Increased Ramsar site designations, confirmed or in the process
- Development of national wetland policies and strategies, finalized or in the process
- Development and implementation of management plans, already in place or being prepared
- Establishment of coordination mechanisms at national level, including National Ramsar/Wetlands Committees
- Progress in capacity building in some countries
- Most countries have designated more than one Ramsar Site since the last COP.
- Most countries are in the processes of developing or reviewing wetland policies and legislation. For example, South Africa is preparing specific legislation to enable full Ramsar implementation, including designation of Ramsar sites that are not protected areas.
- Most countries have National Ramsar/Wetlands Committees and others are in the process of having one, for example, Kenya is considering establishing a broader Kenya Wetlands Forum.
- Most countries have developed or are in the process of developing management plans for their Ramsar sites.
- For those countries with environmental legislation, Environmental Impact Assessment (EIA) has been incorporated in the legislation.

- Previous efforts in designation of Ramsar Sites have been directed at designating protected areas, as observed in Kenya, South Africa and Zambia. However, a focus to designating unprotected wetlands as Ramsar sites is gaining momentum.
- Most countries are in the process of or are planning to undertake inventories.
- Most countries are involving local communities at the lowest appropriate level and other sectors in wetlands conservation and management through formation of management committees.

Challenges

The main challenges still prevailing include:

- Accession to the Convention of the remaining countries in the sub-region
- Need for further policy development and implementation
- Adoption of legislative frameworks to allow full implementation of the Convention
- Communication within the region
- Conflicting sectoral policies
- Better knowledge of wetland values
- Further increasing the profile of the Convention to ensure more political support for wetland conservation and wise use.
- The need to mainstream wetland issues.
- To put policies into practice.
- How to effectively enforce environmental legislation.
- Cross-sectoral cooperation in implementing the wise use principle.
- How to balance development activities and wise use.
- How to enhance local communities' livelihoods as an incentive to wetlands management.

Way forward

- There is a need to have an overall legislation for management of wetlands in the region.
- There is a need to emphasize stakeholder's involvement in wetland management, in particular the local communities and the private sector, including using incentives to do so.
- There is a need to build capacity in terms of training and funding for wetland management.
- There is a need to reinforce education and public awareness in wetland management.
- The need to harmonize existing policies and legislations
- The huge costs of combating alien invasive species in wetlands constitute a high priority to address.
- Legal status of the Convention and Ramsar Sites in Contracting Parties: need for specific enabling legislation for the implementation of the Ramsar Convention.

Unit Activity 1

- *Briefly give an overview of the Ramsar convention, stating clearly its mission and objectives.*
- *With reference to any country in the Nile basin region, find out the extent to which the Ramsar convention has been implemented.*
- *Which countries in the Nile basin region have not ratified the convention and what reasons do they give for not doing so.*

Wetlands of international importance

The Ramsar convention requires contracting parties to designate at least one wetland of international importance. Some criteria have been put in place for identifying these wetlands.

Article 2.2 of the convention provides that;

"*Wetlands should be selected for the List on account of their international significance in terms of ecology, botany, zoology, limnology or hydrology" and indicates that "in the first instance, wetlands of international importance to waterfowl at any season should be included".* (See Appendix I)

The process of adopting specific criteria for the identification of internationally important wetlands began in 1974, but the first official Criteria were agreed at COP1 in 1980. In 1987 and 1990, the Conference of the Parties revised the Criteria further, and at COP6 in 1996, the Parties added new Criteria based on fish and fisheries. The Criteria were reorganized into two groups – based upon representativeness/uniqueness and upon biodiversity – by the *Strategic Framework and guidelines for the future development of the List* and at COP9 (2005) a ninth Criterion was added to cover wetland-dependent non-avian animal species.

Recognizing that cases may arise where a Ramsar site was designated for the List prior to the adoption of the latest version of Criteria and may no longer meet any of those current Criteria, or where a Ramsar site has subsequently lost the ecological values for which it was originally designated, the practice has been that the Secretariat, in consultation with the Contracting Party concerned, evaluates what measures might be necessary to extend, enhance or restore the wetland's functions and values to the degree that it would qualify for inclusion in the List.

Where there is no possibility of extension or enhancement/restoration of its functions or values, the Contracting Party concerned instructs the Secretariat to remove the site from

the List, and the Party then applies the provisions for compensation, as provided in Article 4.2 of the Convention. This has only occurred in a very few cases.

The designation of a wetland in this respect is governed by eight specific criteria. A wetland should be considered internationally important if it:

- Contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.
- Supports vulnerable, endangered, or critically endangered species or threatened ecological communities;
- Supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographical region.
- Supports plant and/or animal species at a critical state in their life cycles, or provides refuge during adverse conditions;
- Regularly supports 20,000 or more water birds.
- Regularly supports one percent (1%) of the individuals in a population of one species or sub-species of water bird;
- Supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity;
- Either is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, within the wetland or elsewhere, depend.
- Regularly supports one percent (1%) of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species.

Basing on the above criteria, member countries of the Nile basin region have designated the following sites as wetlands of international importance.

COUNTRY	**WETLAND**	**DESIGNATION DATE**
	L .George	4/March/1988

	L. Nabugabo wetland system	11/Feb/2004
	L. Bisina wetland system	15/Sept/2006
	L. Mburo-Nakivali wetland system	15/Sept/2006
	L. Nakuwa wetland system	,,
	L. Opeta wetland system	,,
	Lutembe bay wetland system	,,
	Mabamba bay wetland system	,,
	Nabajjuzi wetland system	,,
	Murchison falls-Alberta Delta wetland	,,
	Sango-bay-Musambwa island-Kagera wetland system	,,
KENYA	L. Nakuru	5/June/1990
	L. Naivasha	10/April/1995
	L. Bogaria	27/Aug/2001
	L. Boringo	10/Jan/2002
	L. Elmenteita	5/Sept/2005
TANZANIA	Malagarasi-Muyvozi wetlands	13/april/2000
	L. Natron	4/July/2001
	Rufigi-Mafia-Kulwa marine Ramsar site	29/Oct/2004
D.R. CONGO	Parc.national des virunga	18/Jan/1996
	Parc.national des mangroves	18/Jan/1996
RWANDA	Rugezi-Bulera-Ruhondo	1/Dec/2005
SUDAN	Sudd	5/June/2006
EGYPT	L.Bardawil	9/Sept/1988
	L.Burullus	9/Sept/1988

Source: http://www.ramsar.org/.

Unit Activity 2

- *With reference to any country in the Nile basin region, identify the wetlands that have been designated as Ramsar sites (wetlands of international importance)*
- *With specific reference to each wetland, what criteria have been considered for identifying them?*
- *Using the knowledge obtained, which other wetlands in the country of your choice do you think can qualify as Ramsar sites.*

International and regional policies on wetlands

Little has been done in formulating regional policies, but internationally various conventions related to conservation of biological diversity have helped in providing policy guidelines for wetland conservation.

International agreements and conventions related to wetlands

Six international conventions that focus on biodiversity issues including wetland conservation have been put in place. They include;

Convention on Biological Diversity (CBD)
Convention on Conservation of Migratory Species (CMS)
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)
International Treaty on Plant Genetic Resources for Food and Agriculture
Ramsar Convention on Wetlands
World Heritage Convention (WHC)

Each of the above conventions and agreements works to implement actions at the national, regional and international level in order to reach shared goals of conservation and sustainable use. In meeting their objectives, the conventions have developed a

number of complementary approaches (site, species, genetic resources and/or ecosystem-based) and operational tools (e.g., programmes of work, trade permits and certificates, multilateral system for access and benefit-sharing, regional agreements, site listings and funds).

CBD

The objectives of the Convention on Biological Diversity (CBD) are the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising from commercial and other utilization of genetic resources. The agreement covers all ecosystems, species, and genetic resources including wetland resources.

CITES

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) aims to ensure that international trade in specimens of wild animals and plants does not threaten their survival. Through its three appendices, the Convention accords varying degrees of protection to more than 30,000 plant and animal species, including those that inhabit wetlands.

CMS

The Convention on the Conservation of Migratory Species of Wild Animals (CMS, or the Bonn Convention) aims to conserve terrestrial, marine and avian migratory species throughout their range. Parties to the CMS work together to conserve migratory species and their habitats by providing strict protection for the most endangered migratory species, by concluding regional multilateral agreements for the conservation and management of specific species or categories of species, and by undertaking co-operative research and conservation activities.

International Treaty on Plant Genetic Resources for Food and Agriculture

The objectives of the Treaty are the conservation and sustainable use of plant genetic resources for food and agriculture and the fair and equitable sharing of the benefits arising out of their use, in harmony with the Convention on Biological Diversity, for

sustainable agriculture and food security. The Treaty covers all plant genetic resources for food and agriculture, while its Multilateral System of Access and Benefit-sharing covers a specific list of 64 crops and forages. The Treaty also includes provisions on Farmers' Rights.

Ramsar

The Convention on Wetlands (popularly known as the Ramsar Convention) provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. The convention covers all aspects of wetland conservation and wise use, recognizing wetlands as ecosystems that are extremely important for biodiversity conservation in general and for the well-being of human communities.

WHC

The primary mission of the World Heritage Convention (WHC) is to identify and conserve the world's cultural and natural heritage, by drawing up a list of sites whose outstanding values should be preserved for all humanity and to ensure their protection through a closer co-operation among nations. Wetlands are also regarded as heritage and cultural sites.

While each convention stands on its own and with specific objectives and commitments, inter-linkages between the issues each addresses, and potential complementarities in their monitoring and implementation processes, provide a basis for cooperation.

Wetland institutional arrangements and the Ramsar convention

It has become apparent in recent years that, the prospects of success of any treaty, which has the protection of the environment as its principal objective, will depend to a considerable extent upon the effectiveness of the institutional mechanisms, which it incorporates. While the drafters of the Ramsar Convention are to be congratulated on being amongst the first to perceive this need, it soon became clear that if their creation

were to have any chance of fulfilling its potential, arrangements would be required of a far more elaborate kind than anything they could reasonably have envisaged.

The Convention itself actually made provision for the creation of only one new institution - *the Conference of the Contracting Parties*. To be strictly accurate, Article 6(1) merely provided that:

'The Contracting Parties shall, as the necessity arises, convene Conferences on the Conservation of Wetlands and Waterfowl.'

It is to be noticed that these events were not in fact labelled Conferences of the Contracting Parties as such. The first Wetlands Conference following the Convention's entry into force was duly held at Cagliari, Italy, in November 1980. The second meeting, held at Groningen in the Netherlands in May 1984, was referred to as a Conference of the Contracting Parties and all the later meetings have been similarly titled.

The 1987 amendments to Article 6(1) do in fact expressly now refer to these meetings as Conferences of the Contracting Parties, as well as regularizing their occurrence by providing that ordinary meetings shall no longer be convened 'as the necessity arises', but rather 'at intervals of not more than three years, unless the Conference decides otherwise'. Such meetings have been duly held in accordance with this timetable ever since Groningen. The functions of ordinary meetings of the Conference have already been described in the context of implementation mechanisms. Provision is also made in the amended Article 6 for the holding of extraordinary meetings at the written request of at least one third of the Contracting Parties.

The principal reason for convening an extraordinary meeting would be for the adoption of amendments to the Convention in accordance with Article 10 but there would seem to be no reason why such meetings could not be convened for other purposes also.

The only reference in the text of the Convention to the question of participation in meetings of the Conference is to be found in Article 7(1), which states that:

'*The representatives of the Contracting Parties at such Conferences should include persons who are experts on wetlands or waterfowl by reason of knowledge and experience gained in scientific, administrative or other appropriate capacities.'*

It is apparent that this provision expressly neither authorizes nor excludes the presence of other participants, but, given the substantial role of NGOs in the Convention's formative stages, it would have been surprising had they been denied participation in the implementation phase. Given, furthermore, that the original text spoke only of Conferences on the Conservation of Wetlands and Waterfowl, there was no obvious reason to exclude them.

Conservation of wetlands and of their flora and fauna, whether national or international, governmental or non-governmental, is also to be admitted unless the Parties decide otherwise, though national non-governmental agencies must first secure the approval of their government for this purpose. Once admitted, observers are entitled to participate but not to vote. They may even submit proposals for deliberation if they secure the sponsorship of a delegation, and there appear to be some examples of this having occurred.

The only other form of institutional arrangement to which express reference is made in the text of the Convention concerns the performance of Bureau duties, such as the convening and organization of Conferences, the maintenance of the List and the receipt of information concerning changes in the ecological character of designated sites, and the transmission to the parties of such details, together with any recommendations of the Conference adopted in response.

It has been pointed out that these functions are relatively limited, certainly when judged by the standards of later environmental treaties, and it is significant that no new entity was initially to be created for this purpose

'The International Union for the Conservation of Nature and Natural Resources shall perform the continuing bureau duties under this Convention until such time as another

organization or government is appointed by a majority of two-thirds of all Contracting Parties.'

National Wetland Policies and Institutions

A significant proportion of the activities undertaken within the Ramsar system has been directed towards the establishment of a clear policy framework for the conservation and wise use of wetlands, and a crucial indicator of the success achieved by the Convention concerns the extent to which such principles have been embraced at the national level.

The adoption and implementation of a national wetland policy has emerged as one of the highest Ramsar priorities, and recently approved guidelines are intended to assist in that regard. While in 1993 only two parties (Canada and Uganda) had formally adopted such policies, by 1999 the number had expanded to 22. A further 31 indicated that such policies were currently under development, while 24 others advised that such instruments were planned for the near future.

Uganda is the only country in the Nile basin region known to have made a national wetlands policy. Other countries such as Kenya are in the process of making one.

Examples of National Wetland Policies include**;**

- **Canada:** The Canadian Federal Government Policy on Wetland Conservation**, 1991**
- **Australia:** The Wetlands Policy of the Commonwealth Government of Australia**, 1997**
- **Ghana:** A National Wetlands Conservation Strategy**, 1999**
- **Greece:** National Strategy for Wetland Resources**, 1999**
- **New Zealand:** New Zealand Wetlands Management Policy**, 1986**
- **Trinidad and Tobago:** National Policy and Programs for Wetlands**, 2002**
- **Turkey:** 2003-2008 National Wetlands Strategy for Turkey**, 2002**
- **Uganda:** National Policy for the Conservation and Management of Wetland Resources, Uganda**, 1995**

Unit Activity 3:

Before you read further, identify any national, regional or local policies that your country has put in place in response to the Ramsar convention

African Eurasian Waterbird Agreement (AEWA)

The Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA) is the largest of its kind developed so far under CMS. It was concluded on 16 June 1995 in Hague, Netherlands and entered into force on 1 November 1999 after the required number of at least fourteen Range States, comprising seven from Africa and seven from Eurasia had ratified.

The African Eurasian Waterbird Agreement works on the protection of the migratory birds in the region. Most countries along this route signed the agreement. Wetlands International is actively involved in the meetings of this agreement in order to induce the right decisions. The countries that signed the African Eurasian Waterbird Agreement (AEWA) meet regular to discuss the state and to take decisions about the protection of the migratory birds following the route from West and North Asia, Europe to Africa. Wetlands International plays a very active role in providing the data about waterbirds and to propose the right measures to protect the birds and their sites.

Objectives and approach

Parties to the Agreement are called upon to engage in a wide range of conservation actions that are described in a comprehensive Action Plan (2003-2005). This detailed plan addresses such key issues as species and habitat conservation, management of human activities, research and monitoring, education and information, and implementation.

Work areas: The Agreement has an ambitious programme of work. With the productive outcome of 20 adopted resolutions, the Third Meeting of the Parties to AEWA (23 – 27 October 2005 in Dakar, Senegal) paved the way for a host of activities to be implemented within the next three years. An important issue was the adoption of the Communication Strategy, which is expected to bring major improvements in internal and external communication, capacity building and public awareness.

Parties to AEWA (Africa)

A number of countries in the Nile basin region are parties to the African Eurasian Waterbird agreement (AEWA), including Egypt, Kenya, Sudan, Tanzania and Uganda.

The full list of African countries that are a party to the AEWA are as follows;

i. Benin
ii. Congo
iii. Djibouti
iv. Egypt
v. Equatorial Guinea
vi. Gambia
vii. Ghana
viii. Guinea
ix. Kenya
x. Libya
xi. Mali
xii. Mauritius
xiii. Niger
xiv. Nigeria
xv. Senegal
xvi. South Africa
xvii. Sudan
xviii. Tanzania,
xix. Togo
xx. Tunisia
xxi. Uganda

Unit summary

In this unit, we have examined the Ramsar convention and wetlands of international importance. The Ramsar convention adopted in1971, is an intergovernmental treaty that aims at ensuring conservation and wise use of wetlands. Several countries have

responded to the convention by becoming parties to it and at least designating one site as a wetland of international importance.

International laws and policies are also in place and at national level; some countries have already formulated wetland policies while others are yet to do so. Several international agreements and conventions related to wetlands such as CBD, CMS, WHC, CITES and AEWA are in place. We have also examined several examples of national wetland laws and policies with Uganda in the Nile basin region the only country with a wetland policy.

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Unit 8

WETLANDS AND GLOBAL CLIMATE CHANGE

Introduction

Wetlands have the ability to trap and lock away huge quantities of carbon dioxide. Plants assimilate carbon dioxide from the atmosphere, but hold onto that carbon after they have died because decomposition is extremely slow in wetlands. The result is an accumulation of the partially decayed plant material that called peat. The process of accumulating plant carbon is often described as carbon sequestration and has resulted in our peatlands becoming a major global carbon sink. Warmer conditions speed reactions - including decomposition reactions - and so this could release carbon that was previously stored away. In addition, global climate change may impact on drivers of wetland degradation. For example, decreased precipitation as a result of climate change will increase problems associated with the demand for water. This unit gives an overview of the nature of climate change issues related to wetlands. It is intended to examine these issues and to explore ways of incorporating them into wetlands conservation efforts.

Objectives

By the end of the unit the learners should be able to

- Define climate change
- Examine impact of climate change on wetlands
- Discuss role of wetlands in climate change
- Examine existing policies (national, international) in relation to climate change and wetlands

Content

- Global climate change
- Importance of wetlands in global climate change
- Impact of global climate change on wetlands

- Impact of global change on economy and society resulting from wetland changes
- Policies (national and international) in relation to wetlands and climate change

What is global climate change?

Climate average patterns of weather over long periods of time. Global climate change therefore refers to the variation in the earth's global climate or in regional climates over time scales ranging from decades to millions of years. These changes cab be caused by processes internal to earth, external (variation in sunlight intensity) and human activities.

The single human activity that is most likely to have a large impact on the climate is the burning of "fossil fuels" such as coal, oil and gas. These fuels contain carbon. Burning them makes carbon dioxide gas. Carbon dioxide gas traps solar heat in the atmosphere, partly in the same way as glass traps solar heat in a sunroom or a greenhouse. For this reason, carbon dioxide is sometimes called a "greenhouse gas." As more carbon dioxide is added to the atmosphere, more solar heat cannot get out of the atmosphere leading to increase in temperature of the atmosphere.

What is the role of wetlands in mitigating climate change?

Wetland ecosystems provide a range of functions such as climate regulation, carbon recycling, flood control, purifying water, breeding grounds for fish.
To society, wetlands are a source of products such as fish, water, building materials, wild game meat.
However, the distribution of wetlands is determined by following factors;

- climate
- land form
- hydrology
- biotic factors
- mineral characteristics of the soil

Climate determines distribution of wetlands through amount of water received through rainfall. In addition, the morphology of the land surface is important because it determines the distribution of the excess water from rainfall and hence location of wetlands. Source of water to wetlands may also be from floodplains, and coastal areas.

The physical and mineralogical characteristics of the surface materials are important. The texture of the soil determines the porosity of the soil and therefore proportion of water that can percolate into the soil.

Global climate change and wetland ecosystems

Although climate plays an important role in the formation, distribution and functioning of wetlands, it is difficult to precisely state how changes in climate will impact on wetland ecosystems. This is because of the multiple nature of causes climate change and wetlands diverse nature of wetlands. However, potential issues can be highlighted.

Changes in hydrology

Wetland ecosystems may significantly be affected by changes in hydrology. Increase in rainfall can result in wetland increase in wetlands; likewise, decrease in rainfall can reduce the number of wetlands. Changes in hydrology can also influence biological and biogeochemical functions of wetlands.

Diversity of wetland ecosystems

It is expected that shift in wetland distribution can be accompanied by changes in species composition of wetlands as individual species respond to changes in climate. This may cause changes in diversity of wetland ecosystems.

Wetlands as carbon sinks

Wetlands play a major role in the carbon cycle. Carbon dioxide taken by plants which die and some carbon is stored in form of organic matter in wetlands. Carbon leaves the wetland inform of methane gas and carbon dissolved in water. However, changes in temperature will affect organic mater formation and way the water leaves the wetlands, hence affecting their role as carbon sinks.

Wetland degradation and climate change

The links between peatland degradation and climate change is that clearance, drainage and fires in peatlands emit more than 3 billion tones of carbon dioxide every year, equivalent to 10% of global emissions from fossil fuels. Protection and restoration of peatlands are among the most cost- effective options for climate change mitigation.

Degraded wetland ecosystems have no capacity to withstand extreme climate conditions such as heavy rainfall, wind, storms and flooding. Extreme flood conditions are experienced worldwide. However, these extreme disasters can be used to raise awareness of the role of wetlands in mitigating severe impacts of global climate change.

Policies and programmes

There are policies and programmes on wetlands, nationally and internationally. Scrutinizing these policies to identify how they address climate change and wetland scenarios is important. For example; how does policy on wetland conservation address issues on how climate change may affect wetlands and how wetland degradation may influence climate change? Programmes on wetland conservation (awareness of communities of the link between wetlands and climate, and wetlands and climate change).

Activities

- Think of issues of global climate change related to wetlands
- What wetlands issues face your community?
- Which of the issues you have identified above are related to climate change?
- Is your community aware of any issues of wetlands that related to climate change?
- Any potential effect of global climate change on wetlands that may impact on socio-economic values of wetlands to society?
- Does your country have a policy on wetlands and climate change? What does it say and how is it being implemented?

Additional Questions

- Discuss the importance of climate change to a developing country such as yours.
- Write a simple newspaper article to create awareness of your local community about the importance of climate change and wetlands.
- Draw up a programme to raise awareness among the students and the community in the area surrounding the school about climate change and how it could impact on development.
- How is wetland assessment and monitoring important in the development of your Country?

Unit Summary

In this Unit, you have learnt about:

- Global climate change
- Importance of wetlands in global climate change
- Impact of global climate change on wetlands
- Impact of global change on economy and society resulting from wetland changes
- Policies (national and international) in relation to wetlands and climate change

Further reading

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UNIT 9

WETLAND RESTORATION

Introduction

The educational package presented here is aimed at helping you acquire knowledge and develop suitable skills and shape attitudes and values on wetlands. This educational package focuses on the wetlands restoration to remedy the lack of educational material for Environmental Education in this important ecological system. The educational material combines recent scientific knowledge about wetlands and creates a rich and attractive training environment that encourages exploratory, collaborative, active and creative learning that is supported by the interactive approach of the subject.

In specific terms, you will find the information quite useful and practical because in it, you come first hand with activities that degrade wetland and the steps to avoid these. Symptoms of degraded wetlands will be outlined to act as your pointers on such wet lands in your community. The principles and guidelines on restoring wetlands will empower you with skills to design and implement your own feasible restoration projects in your community. Case studies of restored wetlands will be laid out to draw examples and learn from.

The information is packaged to you into small themes and where possible, there are activities for you to handle. Your choice to carry out two to three research projects from the given activities will provide valuable data to guide individuals and policy makers on the steps to take towards wetland restoration. You might find the glossary helpful to define some of the key words used in the text.

Unit Objectives

By the end of this unit, you should be able to

1. Identify a degraded wetland
2. Design your own wetland restoration projects
3. Cite and describe successful case studies of restored wetland

Human activities that lead to loss and degradation of wetlands and their impacts

Activities resulting in wetlands loss and degradation include: agriculture; commercial and residential development; road construction; impoundment; resource extraction; industrial siting, processes, and waste disposal; silviculture; and mosquito control. The primary pollutants causing degradation are sediment, nutrients, pesticides, salinity, heavy metals, weeds, low dissolved oxygen, pH, and selenium.

Although wetlands can improve watershed water quality, their capacity to process pollutants without becoming degraded can be exceeded. Many wetlands have suffered functional degradation, although it is difficult to calculate the magnitude of the degradation. Wetlands are threatened by air and water pollutants and by hydrologic alteration.

Hydrologic Alterations of Wetlands

Wetlands form as a result of certain hydrologic conditions which cause the water table to saturate or flood the soil for a certain amount of time each year. The frequent or prolonged presence of water at or near the soil (hydrology) is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface. Wetlands can be identified by the presence of those plants (hydrophytes) that are adapted to life in the soils that form under flooded or saturated conditions (hydric soils) characteristic of all wetlands. Thus alteration of wetland hydrology can change the soil chemistry and the plant and animal community. Alteration which reduces or increases the natural amount of water entering a wetland or the period of saturation and inundation can, in time, cause the ecosystem to change to an upland system or, conversely, to a riverine or lacustrine system. Wetland loss and degradation through hydrologic alteration by man has occurred historically

through such actions as: drainage, dredging, stream channelization, ditching, levees, deposition of fill material, stream diversion, ground water withdrawal, and impoundment.

Implications of hydrologic alterations of wetlands

Habitat fragmentation

Habitat fragmentation, as wetlands are drained or hydrologically altered, may result in changes in species composition as wetlands species are replaced by upland species; loss of large, wide-ranging species; loss of genetic integrity when isolated habitats are too small to support viable populations; reduced populations of interior species that can only reproduce in large tracts; and increased numbers of competitor, predator, and parasite species tolerant of disturbed environments

Water diversion structures

Water diversion structures, such as canals (channels), ditches, and levees have been used to modify wetlands to achieve flood control, drainage, mosquito control, irrigation, timber harvest, navigation, transportation, and industrial activity. Canals and channelization change the hydrology of wetlands and increase the speed with which water moves into and through wetlands. As a result, patterns of sedimentation are altered and wetland functions and values that depend on the normal slow flow of water through a wetland can be affected. High sediment loads entering wetlands through channels, irrigation ditches and drainage ditches can smother aquatic vegetation, and contribute to increased turbidity. Channelization and channel modification alter in-stream water temperature and diminish habitat suitable for fish and wildlife.

Impoundments

Impoundment of natural wetlands for stormwater management or wildlife and habitat management may exploit one function of wetlands at the expense of others. Impoundment alters the natural wetlands' hydrology and decreases water circulation. Decreased water circulation causes increased water temperature, lower dissolved oxygen levels, and changes in salinity and pH; prevents nutrient outflow; and increases sedimentation. Sedimentation reduces the water storage capacity, smothers vegetation,

reduces light penetration, reduces oxygen content and affects the entire ecosystem richness, diversity, and productivity. Toxic substances, adhering to sediments, may accumulate in impoundments as a result of decreased water circulation and bioaccumulation of contaminants by wetland biota may occur.

Urbanization

Urbanization is a major cause of impairment of wetlands. Urbanization has resulted in direct loss of wetland acreage as well as degradation of wetlands. Degradation is due to changes in water quality, quantity, and flow rates; increases in pollutant inputs; and changes in species composition as a result of introduction of non-native species and disturbance. The major pollutants associated with urbanization are sediment, nutrients, oxygen-demanding substances, road salts, heavy metals, hydrocarbons, bacteria, and viruses (USEPA 1994b). These pollutants may enter wetlands from point sources or from nonpoint sources. Construction activities are a major source of suspended sediments that enter wetlands through urban runoff.

Research Activity
Investigating the effect of urbanization to your local wetland may prove beneficial to the restoration of that wet land. Determine the level of pollutants entering your wetland over a given period. You may limit yourself to some parameters like measuring the temperature pH of the water, heavy metals, nutrient loading, and oxygen demanding substances.

Impervious surfaces

As roads, buildings, and parking lots are constructed, the amount of impervious surface increases. Impervious surfaces prevent rainfall from percolating into the soil. Rainfall carries sediments; organic matter; pet wastes; pesticides and fertilizers from lawns, gardens, heavy metals; hydrocarbons; road salts; and debris into urban streams and wetlands. Increased salinity, turbidity, and toxicity; and decreased dissolved oxygen, all

affect aquatic life and, therefore, the food web. Excessive inputs of nutrients can lead to eutrophication or result in the release of pollutants from a wetland into adjacent water resources.

As runoff moves over warmed impervious surfaces, the water temperature rises and dissolved oxygen content of the runoff water decreases. Increased water temperature, as well as the lower dissolved oxygen levels, can cause stress or mortality of aquatic organisms. Rising water temperatures can trigger a release of nutrients from wetland sediment. For example, as temperature rises, sediments release phosphorus at an exponential rate. Thus water temperature increases can lead to eutrophication.

Impervious surfaces decrease ground water recharge within a watershed and can reduce water flow into wetlands. Significant increases in stormwater peakflow rates, and longer-term changes in wetland hydrology, as a result of stormwater discharge, can cause erosion and channelization in wetlands, as well as alteration of species composition and decreased pollutant removal efficiency. Changes in frequency, duration, and timing of the wetland hydroperiod may adversely affect spawning, migration, species composition, and thus the food web in a wetland as well as in associated ecosystems.

Research Activity:
Having determined the level of pollutants in your wetland, carry on to investigate their effect of the pollutants on the living organisms in the lake, this may include the phytplanktons and the zooplanktons.

Wastewater and storm water

Wastewater treatment plant effluent and urban storm water are a source of pollutants that continue to degrade wetlands. The “aging” of wetlands can occur when wetlands filter organic matter. “Aging” is the saturation of the ecosystem by nutrients and heavy metals over time that results in the reduced effectiveness and degradation of the wetland.

Wastewater and stormwater can alter the ecology of a wetland ecosystem if high nutrient levels cause extended eutrophication and metals cause plant and aquatic organism toxicity. Iron and magnesium, in particular, may reach toxic concentrations, immobilize available phosphorous, and coat roots with iron oxide, preventing nutrient uptake.

Heavy metals may bioaccumulate in estuarine wetlands, causing deformities, cancers, and death in aquatic animals and their terrestrial predators. Heavy metal ingestion by benthic organisms (including many shellfish) in estuarine wetlands occurs because the metals bind to the sediments or the suspended solids that such organisms feed on or settle on the substrate where such organisms live.

Urban and industrial storm water, sludge, and wastewater treatment plant effluent, rich in nitrogen and phosphorus, can lead to algal blooms in estuaries. Algal blooms deplete dissolved oxygen, leading to mortality of benthic organisms. Some algae are toxic to aquatic life. Excess algae can shade underwater sea grasses (part of the coastal wetland ecosystem), preventing photosynthesis and resulting in sea grass death. Because sea grass meadows reduce turbidity by stabilizing sediments and provide critical food, refuge, and habitat for a variety of organisms, including many commercially harvested fish, the death of these plants profoundly impairs the estuarine ecosystem.

Research activity
Carry out a survey on the algal blooms in your wetland. You may want to identify the algal species, count the algal cells, determine which of these are toxin producing and measure the concentrations of the toxins they produce.

Roads and bridges

Roads and bridges are frequently constructed across wetlands since wetlands have low land value. It is often considered to be more cost effective to build roads or bridges across wetlands than around them. Roads can impound a wetland, even if culverts are used. Such inadvertent impoundment and hydrologic alteration can change the functions of the

wetland. Road and bridge construction activities can increase sediment loading to wetlands. Roads can also disrupt habitat continuity, driving out more sensitive, interior species, and providing habitat for hardier opportunistic edge and non-native species. Roads can impede movement of certain species or result in increased mortality for animals crossing them. Borrow pits (used to provide fill for road construction) that are adjacent to wetlands can degrade water quality through sedimentation and increase turbidity in the wetland.

The maintenance and use of roads contribute many chemicals into the surrounding wetlands. Rock salt used for deicing roads can damage or kill vegetation and aquatic life. Herbicides, soil stabilizers, and dust palliatives used along roadways can damage wetland plants and the chemicals may concentrate in aquatic life or cause mortality. Runoff from bridges can increase loadings of hydrocarbons, heavy metals, toxic substances, and deicing chemicals directly into wetlands. Bridge maintenance may contribute lead, rust (iron), and the chemicals from paint, solvents, abrasives, and cleaners directly into wetlands below.

Innovative methods of constructing roads and bridges, and end-state (master) planning that reduces the need for new roads, can reduce the impacts of urbanization on wetlands.

Research Activity
Carry out an experiment on the sediments in your local wetland. Carry out extractions on them to determine, the heavy metals. Suggest ways for decreasing the level of sediments entering the wetland.

Non-native plants and animals

As a result of disturbance and habitat degradation, wetlands can be invaded by aggressive, highly-tolerant, non-native vegetation. Particularly in constructed wetlands, including restored wetlands, non-native and tolerant native species may out compete other species leading to a reduction in species diversity.

Non-native species may be introduced on purpose. For example, water hyacinth has been noted for its ability to sequester nutrients and is used for wastewater purification. Water hyacinth and similar species can rapidly fill a wetland and are a threat to water quality in some areas.

Research Activity
Carry out an investigation to find out if there are any non-native plants or animals in your local wetland. Report your finding to a nearby nature recourse urgency and suggest ways this plant can be removed.

Mosquito control programs

Mosquito control efforts in urbanized and resort communities has resulted in wetlands loss and degradation through drainage, channelization, and use of toxic pesticides. Mosquito control is one reason that wetlands have historically been drained and it remains a cause of wetlands loss today. Natural wetlands, as well as restored and created wetlands, are habitat for mosquitoes. Constructed wetlands in particular may stagnate and increase breeding of mosquitoes because they lack a hydroperiod or do not contain predatory fish species.

Mosquito control does not have to cause wetland impacts or loss. However, pesticides such as organophosphates (e.g., malathion) that are used to control mosquitoes may be toxic to wetlands fish and aquatic invertebrates. Other more natural pesticides or bacteria can provide a more directed approach to mosquito control. Careful application can avoid impacting other chironomid larvae that form the base of the food web in wetlands.

Research Activity

What mosquito control methods are being used in your community? Are any of the methods of harm to the wetlands, how would you sensitize the public about safe methods for mosquito control? What natural mosquito control methods would you adopt for your community?

Industry

Adverse effects of industry on wetlands can include: reduction of wetland acreage, alteration of wetland hydrology due to industrial water intake and discharge, water temperature increases, point and non-point source pollutant inputs, pH changes as a result of discharges, and atmospheric deposition.

Saline water discharges, hydrocarbon contamination, and radionuclide accumulation from oil and gas production can significantly degrade coastal wetlands.

Atmospheric Deposition

Nitrous oxides, sulfurous oxides, heavy metals, volatilized pesticides, hydrocarbons, radionuclides, and other organics and inorganics are released into the atmosphere by industrial and agricultural activities, and from vehicles. These compounds can enter wetlands through wet and dry atmospheric deposition and can adversely affect aquatic organisms and the terrestrial organisms that feed on them.

Research Activity
Is there an industry near you? Find out how they dispose off their waste. Are any effluents finding their way in the wetland? What are these?

Agriculture

Historically, agriculture has been the major factor in freshwater and estuarine wetland loss and degradation. Certain activities performed in wetlands can degrade wetlands:

- harvesting food, fiber, or forest products;
- minor drainage;
- maintenance of drainage ditches;
- construction and maintenance of irrigation ditches;

- construction and maintenance of farm or forest roads;
- maintenance of dams, dikes, and levees;
- direct and aerial application of damaging pesticides (herbicides, fungicides, insecticides, fumigants); and
- ground water withdrawals.

These activities can alter a wetland's hydrology, water quality, and species composition. Excessive amounts of fertilizers and animal waste reaching wetlands in runoff from agricultural operations, including confined animal facilities, can cause eutrophication.

Irrigation ditching can increase contamination of wetlands receiving irrigation drainage water, particularly where soil is alkaline or contains selenium or other heavy metals. Agricultural pesticides entering wetlands in runoff, as well as through atmospheric deposition, may bioaccumulate in fish and other aquatic organisms.

Research Activity
What pesticides are being used in the farming community around your local wetland? Are the pesticides entering the water? What is the effect of these pesticides on the living organisms in the wetland? Determine the level of some pesticides in fish. How would you sensitize the farming community about your findings?

Grazing

Grazing livestock can degrade wetlands that they use as a food and water source. Urea and manure can result in high nutrient inputs. Cattle traffic may cause dens and tunnels to collapse. Overgrazing of riparian areas by livestock reduces streamside vegetation, preventing runoff filtration, increasing stream temperatures, and eliminating food and cover for fish and wildlife. As vegetation is reduced, streambanks can be destroyed by

sloughing and erosion. If stocking of livestock is well managed, grazing can coexist with wetlands, benefiting farmers and increasing habitat diversity.

Timber Harvest

If best management practices are used and careful monitoring occurs, silviculture and timber removal may only minimally affect some wetland functions. Habitat and community structure, however, still may be seriously degraded. Drainage, clearing, haul road construction, rutting, and ditching of forested wetlands, all may affect wetlands in some way, although the impact may only be temporary. Adverse effects of timber harvest can include a rise in water table due to a decrease in transpiration, soil disturbance and compaction by heavy equipment, sedimentation and erosion from logging decks, skid trails, roads, and ditches, and drainage and altered hydrology from ditching, draining, and road construction. By utilizing best management practices, hydrology and biogeochemical processes of wetlands may be altered for only one to three years following timber harvest.

Wetland Loss and Degradation and the Ramsar Convention

The Ramsar Convention was established to address the issue of the loss and degradation of wetlands through concerted and coordinated action by the Contracting Parties, so that wetlands can contribute to the process of sustainable development. Almost the entire suite of obligations that are undertaken by the Contracting Parties relate to addressing this issue: the designation of sites to the Ramsar list, maintaining the ecological character of listed Ramsar sites; the establishment of reserves on wetlands, and making wise use of wetlands. Undoubtedly, the Ramsar Convention has succeeded in raising awareness and the level of actions for conservation of wetlands; yet wetlands continue to be lost and degraded at a rapid pace in many parts of the world. Our next focus focus therefore is to see how the Ramsar Convention could be made more effective to address these issues, both at a national policy level and at the level of individual Ramsar sites and the specific recommendations for consideration by the Ramsar Convention.

A strategic approach is required

A strategic approach is the only way to address the issue of the global loss and degradation of wetlands. A comprehensive strategy should incorporate the following vital steps, which are applicable both to sites (through a management plan, as covered well by the Ramsar guidelines) and to whole countries (through a national wetland policy):

1. Set a measurable goal

A measurable goal should be included in all national wetland policies. At present, the Ramsar Convention contains a measurable goal for the listed Ramsar sites, which is "to maintain their ecological character". While potentially measurable, the issue of "change in ecological character" is still poorly defined.

Unfortunately, at the national and international levels, neither the Convention text nor the draft Strategic Plan set measurable goals, making it difficult to measure the success of the Convention in future years. It is strongly recommended that each Contracting Party, and perhaps the Ramsar Convention as a whole, should include a measurable goal as it develops and adopts its national wetland policy.

2. Measure the resource baseline

Whether the goal is to maintain the ecological character of a wetland site, or to stop the loss and degradation of wetlands across the landscape as a whole, it is essential to measure the baseline of the wetland resource under consideration. This is achieved through a wetland inventory programme. A wetland inventory is one of the key elements in a conservation strategy for wetlands (WWF 1992). This is because, such inventories:

- identify where the wetlands are;
- assist in identifying priorities;
- provide the baseline for status and trends reports;
- provide a tool for planning and management;
- permit comparisons at national and international levels;

- provide information for awareness programmes;

The Convention, through the wise use guidelines, already calls upon Contracting Parties to execute national wetland inventories. However, recent regional reviews suggest that such programmes are, as yet, poorly developed.

3. Identify operational objectives, and 4. Prescribe and undertake actions

These two critical steps are the main subject of the Ramsar Convention Strategic Plan, and are not discussed here in any further detail.

5. Monitor performance against baseline

Monitoring the effects of the conservation actions undertaken should be an important feedback mechanism within any site management plan or national wetland policy. It is only through such monitoring programmes that the extent and causes of loss and degradation of wetlands can be determined, and the success of conservation actions be measured. However, the complexity and diversity of wetlands has been a serious constraint to the development of effective monitoring schemes, and it is notable that it is only after 25 years that the Convention is now beginning to address this issue systematically.

Monitoring programmes need to address both the issue of wetland integrity (i.e. change in wetland area) and change in wetland quality. While the Convention is addressing these needs at the level of individual Ramsar sites, a serious gap remains in the lack of quantitative information on changes in these parameters at national and therefore international level. Very few countries are able to provide information on the status of their wetlands or temporal trends in the rates of loss and degradation.

Given this lack of knowledge, it is recommended that Contracting Parties be encouraged to establish programmes to gather such information. Further investigation of the possibilities of using remote sensing to achieve these aims may provide the most cost-effective solution in the long term.

6. Report the results

The quality and quantity of information about the state of wetlands must be increased and communicated more effectively at all levels. Information on the loss and degradation of wetlands, and the consequences of this for people and for biodiversity, provide powerful tools for influencing public opinion and decision-makers.

It is strongly recommended that at both national and international levels, formal mechanisms are established for reporting on the status of the wetland resources. At international level, a first step would be to compile and publish a review of all the quantitative studies of wetland loss/gain.

Impact of wetland degradation

Healthy, functioning wetlands are vital for protection of the environment and public health. Simply put, wetlands are transitional areas that act as buffers between open waters and uplands and provide functions and values. Degradation leads to loss of wetland functions and Values such as;

- recharge groundwater aquifers
- absorb floodwaters, protecting coasts and homes from floods;
- habitat for plant and animal species, including threatened or endangered
- local tourism industries with opportunities to engage in activities associate with such wildlife.
- filter pollution, purifying our drinking water, and protecting rivers, lakes, and coastal waters from pollution, such as sediment, nutrients, chemical contaminants, and bacteria
- biodiversity loss, migratory species and endemics
- increased poverty and vulnerability
- climate mitigation roles

Wetland Restoration and Creation

Introduction

If you are to view efforts to reverse wetland degradation, in recognition of benefits associated with wetland restoration, you would find numerous restoration projects initiated globally. Degraded wetlands present restoration opportunities for improvements to water quality, habitat, water storage and other functions, and these opportunities can be particularly useful for watershed-scale environmental planning.

The goal of restoration is typically to reestablish wetland ecosystems to levels that existed prior to human influence. Wetland creation can include regulatory mitigation or commercial and private creation efforts outside of regulatory requirements.

Restoration or Rehabilitation?

Restoration is often used interchangeably with Rehabilitation within Ramsar documentation and within the conservation literature. The Ramsar Convention has not attempted to provide precise definitions of these terms. While it might be said that "restoration" implies a return to pre-disturbance conditions and that "rehabilitation" implies an improvement of wetland functions without necessarily returning to pre-disturbance conditions, Restoration is used in its broadest sense to include both projects that promote a return to original conditions and projects that improve wetland functions without necessarily promoting a return to pre-disturbance conditions.

What principles?

The Ramsar convention recommendation urged "the Scientific and Technical Review Panel [STRP], in collaboration with the Bureau and concerned Contracting Parties and partners, to define guidelines on principles for wetland restoration".

The principles you will find below provide the underlying ideas that form the foundation of a successful restoration project. However, you should remember that every restoration

project is unique, and whilst these principles and guidelines are designed to be useful in many situations, they are neither universally applicable nor definitive. The principles are as follows:

1. A national programme and priorities for wetland restoration should be established, based on a national inventory of wetlands with potential for restoration, as a component of the national wetland policy, plan or strategy, so as to maximise the benefit to the overall conservation status and wise use of wetlands of the efforts and resources applied to wetland restoration.

2. Clear understanding of statement of goals, objectives, and performance standards for wetland restoration projects is a critical part of restoration success.

In keeping with Ramsar Resolution on restoration as an element of national planning for wetland conservation and wise use, goals and objectives should recognize that wetlands perform multiple functions: "Multiple purposes such as conservation of biodiversity, provision of reliable food resources, fresh water supply, purification, flood control and recreation may often increase the sustainability and total benefits of a restoration project." If a project hopes to promote a return to pre-disturbance conditions, this should be stated as part of the project goals.

3. Careful planning will limit the possibility of undesirable side effects. For example, careful planning can allow restoration projects to avoid problems such as increased numbers of mosquitoes, unwanted flooding, or saltwater intrusion into sources of drinking water. To assist in planning, an assessment should be made of the features of the site under consideration, and the factors that may affect its feasibility and success.

Activity

What issues would you consider in the assessment of the usefulness and feasibility of wetland restoration projects?

4. Natural processes and existing conditions should be considered during project selection, design, and development. To the extent that is possible, ecological engineering principles should be applied in preference to methods requiring hard structures or extensive excavation.

5. Restoration schemes must not weaken efforts to conserve existing natural systems. However, restoration of individual sites can contribute to ongoing management of existing high quality wetlands by, for example, improving overall catchment condition and contributing to improved water allocation management.

6. Whenever possible, the minimum acceptable scale for wetland restoration planning should be within the context of the catchment. The planning should not ignore the value of upland habitats and linkages between upland and wetland habitats.

7. Wetland restoration planning should consider water allocation principles and the role that restoration can play in maintaining ecological functions of wetlands.

8. Wetland restoration should be an open process that involves local community stakeholders as well as stakeholders who will be affected by a project even though they may be geographically distant from the project, for example, stakeholders living well downstream. All stakeholders, including local communities and indigenous people should be fully involved in a wetland restoration project from its earliest stage of consideration through its implementation to its long-term stewardship.

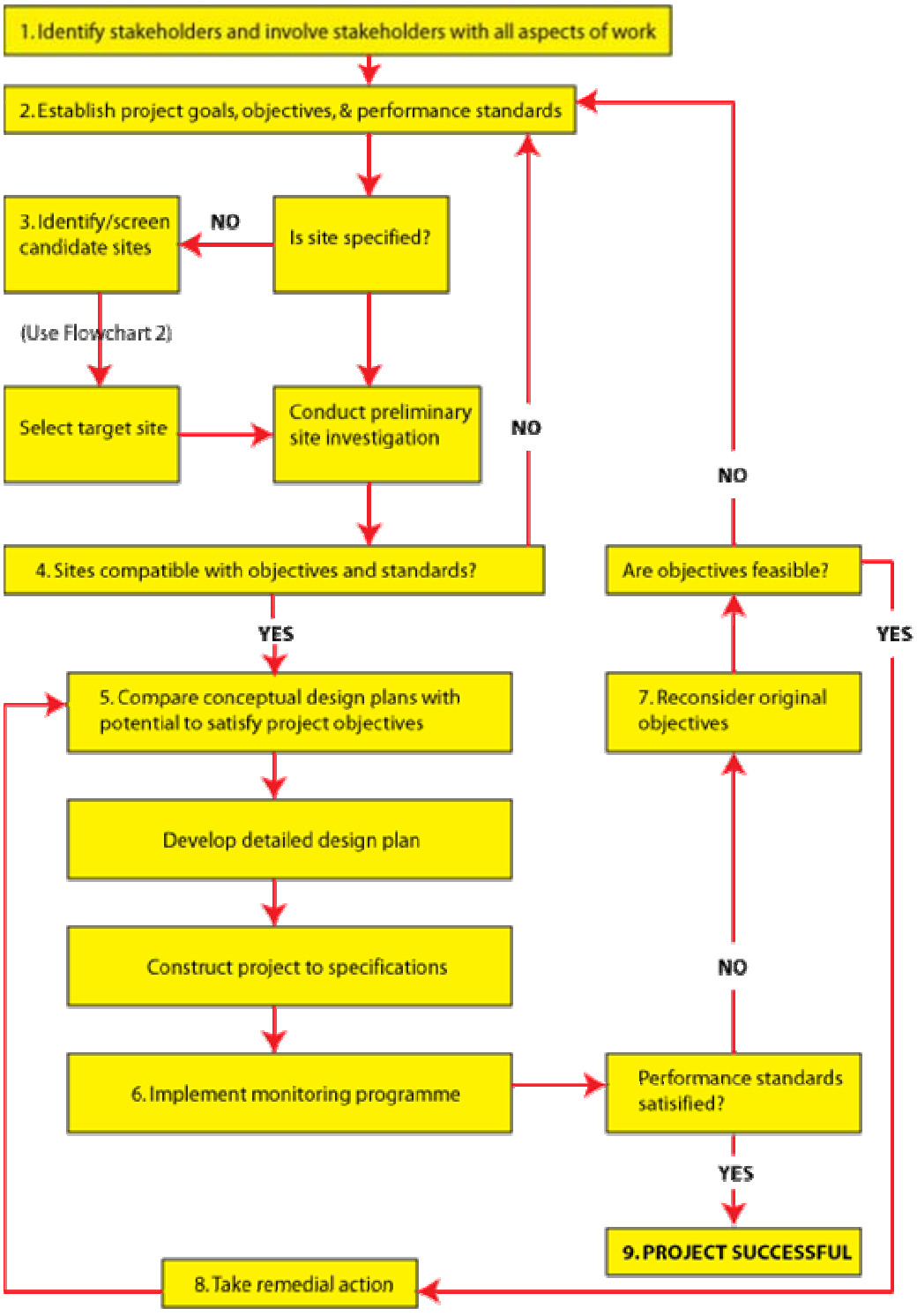
9. Restoration requires long-term stewardship, including ongoing management and monitoring. Successful restoration should be designed, as far as possible, for self-

maintenance. Development of incentive measures can make a valuable contribution to the long-term success of a restoration project.

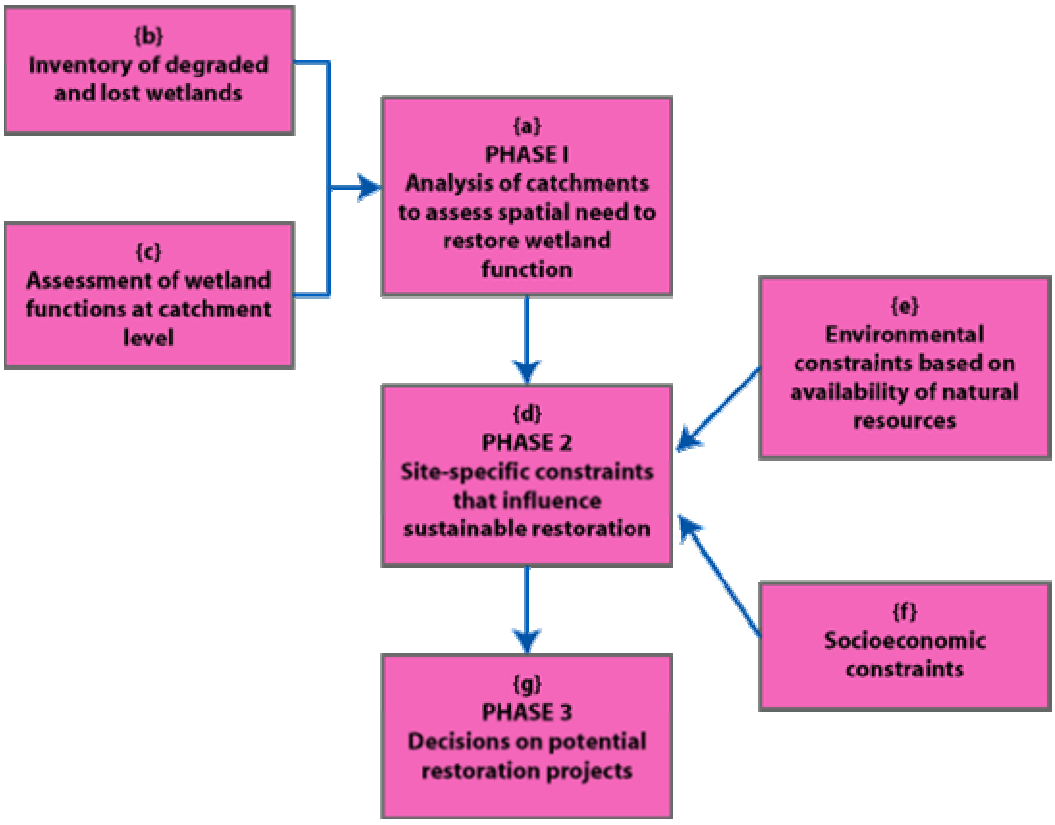
10. Wetland restoration planning should incorporate, where practicable, knowledge of the traditional resource management that contributed to shaping the landscape. Incorporation of traditional environmental knowledge, management, and sustainable harvesting practices by local people should be an integral component of restoration.

The guidelines

The guidelines presented here will take you step-by-step in the process of identification, development and implementation of a restoration project, and as such they can be integrated into administrative guidelines. The flowcharts below will lay out guidelines for your wetland restoration projects. Flow 1 **Guidelines for wetland restoration**



Flowchart 2: Process for identification of potential wetland restoration projects



Activity

Use flow charts 1 and 2 to develop a project that you would implement in a chosen degraded wetland in your locality.

Restoration Guidelines

Landscape Considerations in Wetland Restoration and Creation

Created wetlands for nonpoint source pollution control are advocated as an important part of any watershed or floodplain restoration plan. Location of constructed wetlands in the landscape is an important factor in determining their role. The most important wetlands to manage and protect as stream quality buffers may be those along first- and other low-order streams. Wetlands along first-order streams are very efficient at nitrate removal from groundwater and runoff, and sediment removal from surface water. Constructed wetlands bordering agricultural fields can be designed to intercept tile drainage with high nutrient levels that otherwise often flows directly into receiving streams, bypassing even riparian areas. Placing wetlands in a distributed pattern high in the watershed may incur less total runoff and erosion for the entire watershed than the same acreage put into large wetlands low in the watershed.

Wetlands (floodplains) along higher-order streams influence water quality to a much smaller degree, since the upland runoff that passes through them and joins the stream is a much smaller fraction of the total stream flow than it is for headwater wetlands. Wetlands along large streams do, however, provide water quality benefits during flood events, a function that headwater wetlands do not provide. The downstream wetlands could retain more mass of nutrients than upstream systems, and a placement tradeoff might be optimum.

From a management standpoint, creating many smaller wetlands around a watershed would mean dealing with more landowners, but taking less land out of production on any one farm than creating a few large wetlands, and is more fair in terms of not asking any landowner to contribute more than what is needed to treat the runoff from their land.

Riparian Restoration Guidelines for Water Quality

The U.S. Forest Service has published guidance on reforesting previously cleared riparian areas and renovating degraded riparian areas for the protection of receiving water quality.

The guidance is directed toward agricultural and silvicultural land uses and emphasizes that riparian buffers are meant to be used as part of a sound land management system including upland best management practices, and can be damaged and functionally impaired otherwise.

The design of the riparian buffers described above includes three zones intended to filter surface runoff and shallow groundwater flow. Beginning at the edge of the receiving water body, the first zone is a fixed 15 ft. wide, undisturbed native forest/shrub zone to provide a stable ecosystem at the water's edge, to perform nutrient buffering, to provide shade, and to contribute detritus and large woody debris to the water body. Landward of zone 1, zone 2 is the heart of the riparian buffer. A minimum of 60 ft. wide, it is composed primarily of native trees and shrubs, and it provides contact time and carbon energy source for buffering processes and for long-term sequestering of nutrients by trees. Periodic timber harvesting and stand improvement is acceptable in this zone. Livestock are to be excluded from both zones 1 and 2. At the landward margin, zone 3, a minimum of 20 ft. wide, is a graded, dense grass/forb strip for sediment control and nutrient uptake. Shaping into diversions, basins, and level spreaders toward this end is appropriate. This zone should be actively managed; mowing is recommended, grazing is acceptable, and periodic sediment removal, reshaping, and revegetating are necessary to maintain performance. Actual zone widths beyond the minimum can be determined based on the ratio of buffer area to source area.

Coastal Wetland Restoration

Coastal marsh restoration and creation efforts have been more successful than similar inland attempts. This success appears to be due largely to researchers' ability to predict more accurately the key component, hydrologic patterns, in tidally influenced areas than in freshwater settings. Also, coastal restoration efforts have perhaps had a longer history than freshwater wetland restoration.

Restoration of coastal marshes and creation of salt marshes on dredge spoil has been found to facilitate shoreline aggradation, stabilize beach erosion, and protect landowners

from the impacts of storms. Restoration of wetlands on eroding shorelines can protect critical habitat for marine life and freshwater aquatic life as well as reduce land subsidence.

Urban Wetland Restoration

Wetland restoration can be an important contributor to downstream habitat and water quality recovery in urbanized landscapes. Restored urban wetlands can help protect floodplains and streambeds that are otherwise degraded by urbanization forces, and can help to minimize downstream flooding that results from urbanization. Such wetlands can also reduce sedimentation of lagoons, bays, and other downstream water resources. Larger restoration projects are more cost effective and are typically more beneficial ecologically as well. Larger areas may provide habitat for interior species that an equivalent acreage of smaller parcels cannot support.

Upland buffer zones adjacent to urban restoration projects are important to protect them from degrading forces and provide important habitat used by many wetland species. Such projects require other protective measures as well to sustain their functions long-term.

Management for Wildlife

Wetlands are especially critical habitats for wildlife, and exceed all other land types in wildlife productivity. Historically, wetland wildlife management was overwhelmingly concerned with maximizing production of waterfowl and furbearing mammals, and was focused largely on game species.

Marsh creation or restoration is a good opportunity to manage wetlands for broad wildlife habitat goals. Not only can a restored marsh provide enhanced wildlife benefits, but other functions can be improved concurrently. Whether created or restored, wetlands designed for wildlife should take into consideration: minimum habitat area of anticipated species, their tolerance for disturbance, and the system's functional relationship to other water resources and adjacent ecosystems.

It should be noted that while created wetlands can be suitable for some species, such as waterfowl, other, particularly threatened and endangered, species do not colonize artificially created wetland systems as readily or consistently as they do restored natural wetlands.

For a given wetland site, a restoration or creation management strategy must involve determination of the most important values to be obtained, and of whether a single, exclusive value outweighs the suite of values to be obtained from historic restoration. If a single-purpose wildlife use is sought, such as certain fish utilization, management may result in manipulation of marsh hydrology at the expense of other species and wetland functions. For example, game fish species require consistently deep water, yet shallow, emergent-plant-depth water levels provide the highest plant species diversity and greatest overall wildlife use of marshes.

Creation of a marsh adjacent to agriculture will likely provide elevated nutrient levels that will stimulate productivity and, if not too great, facilitate establishment of the wetland community while improving downstream water quality over previous levels.

Additional Considerations for all Types of Restoration

Several long-term management issues accompany successful wetland restoration, including grazing and browsing control, pest control, and weed control.

Grazing and Browsing Control

Grazing or browsing by domestic and wild animals can prevent or severely limit establishment of wetland plant communities. Livestock, waterfowl, beaver, nutria, and deer can cause serious problems. How best to control problems will vary based on site-specific conditions. If alternative feeding and denning sites are available nearby, grazing and browsing problems will be easier to address than if they are available only at the restoration site. If grazing or browsing becomes a problem, controls will be necessary until the wetland community is well enough established that it can withstand these impacts.

Fencing may restrict animal access to sites, plant communities, or individual plants. The type of fence and design will vary according to objectives. Livestock can often be excluded from an area by a simple single-wire electric fence. These fences need to be sturdy enough to prevent animals from pushing them over. They can also be defeated by both nutria and beavers, which have the ability to dig under them, and waterfowl, which can fly over them. Areas where exclusion of birds is necessary can be covered with the nylon netting available at most farm supply and builder supply stores. PVC pipe or electrical conduit can be used to support netting above the ground.

Fencing to prevent geese from swimming into smaller areas can be constructed by driving posts into the soil and connecting them with 1/8-inch nylon line rails spaced 6 inches apart. Rails should extend from 6 inches above the low water mark to 6 inches above the high water mark. Highly visible materials should be used.

Animals can be discouraged from digging up tubers and rhizomes by fastening chicken wire directly over them after planting. Wire should be removed after plants become established.

Individual plants can be protected by installing wire cylinders or tree shelters around them during planting. Be sure to use heavy enough material that animals up to 50-75 lbs. won't cave them in or crush them when leaning against them. Cylinders should be at least four feet tall and held in place by post. Tree shelters such as Tubex® or Treehouse®, which are made of plastic tubes ranging from 8 inches to 6 feet in length, may be used to protect seedlings from browsing. Tubes of ridged netting are also available in heights from 18-36 inches. Protective structures should be removed once plants become well established. If beaver damage is a potential problem, larger cylinders should be placed around plants as they grow.

Repellents and scare devices have limited effectiveness in keeping animals away. Repellents such as Big Game Repellent®, Deer Away®, and Ropel® can be applied to plants to deter deer. However, the wet climate of the Willamette Valley quickly washes these chemicals off, making them ineffective. Scarecrows often work for a short period of

time but animals quickly become accustomed to them. Zon guns or propane cannons produce loud detonations that can be set to occur at regular or random time intervals. These may be effective in keeping animals away but animals can become accustomed to them.

Case Studies of Restored Wetlands in the Nile Basin Region

1. Lake George in Uganda

Uganda ratified the Ramsar Convention in 1988, and designated Lake George a Ramsar site. Located astride the equator, the lake and associated wetlands support a wide variety of biological resources. The reasons for this are varied, ranging from the good climate to shallow stratified waters (average 2.4m) which allow for a thorough mixing of the different layers, and a high alkalinity and photosynthetic activity.

The status of Lake George is varied with most of the wetlands fringing the Lake being part of the Queen Elizabeth National Park. The open water of the lake is not part of the National Park and is managed by the Fisheries and Water Departments. This has had implications for management because of inter-sectoral inconsistencies.

Lake George is renowned both for its high productivity and its flagship species such as the Shoebill *Balaeniceps rex*. Over the years the lake has attracted a lot of attention: it was part of the International Biological Programme in the late 1960s; it is located within the Queen Elizabeth National Park which is a Man and the Biosphere Reserve of UNESCO; and finally the listing of Lake George as Uganda's first Ramsar site was further recognition of the importance of the lake as a centre for biological diversity. Decades ago the initial management interest was in commercial fisheries on the lake. Today, the commercial fisheries are on a much smaller scale supplying mainly local needs, the management focus has changed considerably, and the lake has become an important tourist destination.

Diversity of the Wetland

Seen from the air, the waters of Lake George appear green as a result of thick concentrations of blue-green algae. The entire lake can be considered as a wetland since its average depth is about 2.4m and it hosts a mosaic of wetland types dominated by Papyrus swamps *Cyperus papyrus*. Around the edge of these swamps is a dense fringe of the wetland grass *Vossia cuspidata*. *Vossia* forms mats which are anchored to the lake bed whereas Papyrus is either emergent in shallow water or forms thick, floating mats which extend into deeper waters. These support Black Crakes *Amaurornis flavirostra* and Malachite Kingfishers *Alcedo cristata*.

A rare plant found in the area is the cycad *Encephalartos hildebrandtii*. This primitive fern-like plant is known only from the gorge of the Mpanga River to the east of Lake George and from an area on the East African coast. The other plant not commonly found in Uganda is the sedge *Cladium mariscus* which forms swamps around Lake George; its only other known location is in some pockets in the Kigezi region of southwestern Uganda.

Lake George wetlands provide habitat for over 150 species of birds including some rare species. These include the Saddle-billed Stork *Ephippiorhynchus senegalensis*, seven 'papyrus endemics' including Papyrus Gonolek *Laniarius mufumbiri*, Papyrus Canary *Serinus koliensis*, and the threatened Papyrus Yellow Warbler *Chloropeta gracilirostris* (IUCN Red List, 1994). The Madagascar Squacco Heron *Ardeola idae* has also been recorded within the Lake George Basin. The associated crater lakes provide the only habitat for Greater and Lesser Flamingos *Phoenicopterus ruber* and *P. minor* in Uganda.

The most spectacular of all is the Shoebill, a very large, grey water bird with a gigantic shoe-shaped bill. It is often confused with members of the stork family because of its resemblance to storks but it is in fact the only species within the family Balaenicipitidae. It is found in an enclave of the Lake commonly referred to as Shoebill Swamp.

Utilization of Lake George's Resources

The potential of Lake George is not yet fully exploited largely because of its inaccessibility. Nevertheless, Lake George wetlands are utilized in several ways. The Lake supports a thriving fishery with more than 50 species recorded in catches. Most of these are cichlids of which the most abundant is the phytoplankton-eating *Haplochromis nigripennis*. Up to 3,500 tonnes of fish were recorded annually between 1952 and 1972, and the catches are equally high in recent years. There is low endemicity compared to other lakes in the region. The most common fish include; tilapias, the catfish *Clarius lazera* and *Bagrus docmac*, a species of lungfish *Protopterus* sp., the electric fish *Mormyrus kannume* and the cichlid *Haplochromis squamipinis*. The presence of large quantities of fish led to the establishment of a fish factory in the 1960s to process tilapia. Although the factory is now disused and the scale of commercial fisheries has diminished, the lake still supports important fishery activities. Fishing villages are established in several of its bays, supplying fish locally to Kasese town and the surrounding area and to far destinations such as Kampala (450km away) and Zaire to the west.

The other important human activity is the harvesting of Papyrus and the woody plant Ambatch, *Aeschynomene elaphroxylon* which grows in marshy soil, in swamps and on the edge of the lake. Papyrus is used for roofing material and screens while Ambatch stems, with their cork-like texture, are used as floats and buoys for fishing nets.

Tourism is another activity that occurs in the area, but to a lesser extent because most of the wetlands are inaccessible due to the impenetrable swamp forest.

Threats to the Diversity of the Area

There are some problems which threaten the high diversity of the area and could jeopardize its existence if appropriate measures are not taken in time to address them:

The lake is affected by pollution from copper and cobalt pyrites as the site is close to a copper mine and many of the rivers and streams that feed into the lake go past the mine.

However the establishment of Kilembe Cobalt Company to carry out cobalt production using bioleaching and solvent extraction and electro-winning is expected to address some of the problems of cobalt pollution through rehabilitation of the degraded environment.

There is uncontrolled charcoal burning to the east of the Lake George wetlands which could become disastrous if not checked: this is bound to deplete the tree resources of Lake George leading to loss of the natural organisms which they support.

Horticultural activities such as vegetable growing to supply the fast growing Kasese town, also pose a threat to the lake and its associated wetlands. Many of these activities involve modification and in some cases drainage of wetlands and could reduce the buffering capacity of the wetlands. In addition the use of pesticides and agrochemicals in horticulture pose a danger to Lake George's biodiversity.

There is a potential problem of silting from poor management practices in the water catchment area of the wetland as a result of intensive agricultural activities in the surrounding slopes of Mt Ruwenzori to the north, and the Bunyaruguru escarpment to the south.

Although Lake George supports a high diversity of biological resources and a high human population which is dependent on the fishing, the future of the lake, in the face of these threats, is uncertain. However recent government policy on wetlands in particular and the environment in general provide hope for the future.

2. Dinder Mayas wetlands in Sudan

Sudan’s obligatory first Wetland of International Importance was effected on 7 January 2005 by Ramsar. This was **Dinder National Park (DNP)** (1,084,600 hectares, 12°19'N 034°47'E), a very large complex of about 40 wetlands, or “mayas”, and pools formed by meanders and oxbows that are part of the Rahad and Dinder river drainage systems bordering the frontier with Ethiopia in southeastern Sudan. Both rivers and their tributaries, coming from the Ethiopian highlands across the flat plain of the Park, are seasonal and flow from June to November, peaking in August. The wetlands are vital as a

source of water and of the most nutritious grasses for herbivores, especially during the most severe part of the dry season. A large number of animal species are supported, some of which, like the tiang *Damaliscus korrigum*, are endangered. Located in the center of migration routes among three continents, the site is visited by a large number of species of migratory birds, and some of the mayas contain quantities of fish throughout the dry season. Recent archaeological investigations at many locations within the park show promise of important finds from ancient Meroitic and medieval Fung sultanate periods. The local population practices agriculture and pastoralism and many are nomadic within the park during dry and rainy seasons. Illegal fires set by non-local nomadic grazers, poachers, and honey collectors are cited as among the chief threats to the site.

Constructed Wetlands

Overview

Constructed wetlands have received the greatest attention for treatment of point source pollution. They have been further defined as: engineered systems designed to simulate natural wetlands to exploit the water purification functional value for human use and benefits. Constructed wetlands consist of former upland environments that have been modified to create poorly drained soils and wetlands flora and fauna for the primary purpose of contaminant or pollutant removal from wastewaters or runoff (Hammer, 1992).

Constructed wetlands can provide many of the water quality improvement functions of natural wetlands with the advantage of control over location, design, and management to optimize those water quality functions. Constructed wetlands are not typically intended to replace all of the functions of natural wetlands, but emphasize certain features to maximize pollutant removal efficiency and to minimize point source and non-point source pollution prior to its entry into streams, natural wetlands, and other receiving waters. Wetlands created for habitat, water quantity, aesthetic and other functions as well

as water quality functions typically call for different design considerations than those used solely for water quality improvement.

This tailored design approach to constructed systems generally makes them less suitable as wildlife habitat than natural wetlands. Nevertheless, constructed wetlands are often designed with ancillary wildlife values in mind, for example, incorporating open water for waterfowl usage. While species diversity of vegetation and microflora and fauna are lower in treatment wetlands, bird usage can be higher than that in adjacent natural wetlands because of the more eutrophic, and hence more productive, aquatic conditions in the loaded systems.

A major concern with the use of constructed wetlands for wildlife habitat is the potential for concentrating accumulated pollutants up the food chain, with deleterious effects to birds and other consumers. While wildlife impacts have been observed in several instances with wetlands created for habitat these appear related to agricultural irrigation return flows. So far, no similar problems are documented for constructed treatment wetlands but the potential for harm exists with some metals and other compounds and the issue requires continued evaluation.

Constructed wetlands are becoming an increasingly common method for treatment of all forms of water pollution, including confined animal wastewater, cropland runoff, urban stormwater, septic tank effluent, municipal wastewater effluent, acid mine drainage, industrial process waters, and landfill leachate

The beginnings of constructed wetland technology are dated to the 1950's in Germany for municipal wastewater treatment. This use is the most established and advanced, with hundreds of systems in place in Europe and the United States.

Most constructed wetlands installed to date are used for advanced (nutrient reduction) treatment of municipal wastewater, with a large number also in place for secondary (solids and BOD) wastewater treatment. Use of these systems for primary wastewater treatment without prior or adequate settling and solids removal quickly overloads them and degrades performance capabilities, and is largely avoided. Other than primary

wastewater uses, the range of potential applications for constructed wetlands is great and

Activity

Are there any constructed wetlands in your locality? Carry out an investigation to determine the efficiency of a constructed wet on reduction of: suspended solids, BOD, and fecal coliforms, and nutrients, e.g., total Nitrogen and total Phosphorus.

the record of actual applications is rapidly expanding.

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Unit 8

WETLANDS AND GLOBAL CLIMATE CHANGE

Introduction

Wetlands have the ability to trap and lock away huge quantities of carbon dioxide. Plants assimilate carbon dioxide from the atmosphere, but hold onto that carbon after they have died because decomposition is extremely slow in wetlands. The result is an accumulation of the partially decayed plant material that called peat. The process of accumulating plant carbon is often described as carbon sequestration and has resulted in our peatlands becoming a major global carbon sink. Warmer conditions speed reactions - including decomposition reactions - and so this could release carbon that was previously stored away. In addition, global climate change may impact on drivers of wetland degradation. For example, decreased precipitation as a result of climate change will increase problems associated with the demand for water. This unit gives an overview of the nature of climate change issues related to wetlands. It is intended to examine these issues and to explore ways of incorporating them into wetlands conservation efforts.

Objectives

By the end of the unit the learners should be able to

- Define climate change
- Examine impact of climate change on wetlands
- Discuss role of wetlands in climate change
- Examine existing policies (national, international) in relation to climate change and wetlands

Content

- Global climate change
- Importance of wetlands in global climate change
- Impact of global climate change on wetlands

- Impact of global change on economy and society resulting from wetland changes
- Policies (national and international) in relation to wetlands and climate change

What is global climate change?

Climate average patterns of weather over long periods of time. Global climate change therefore refers to the variation in the earth's global climate or in regional climates over time scales ranging from decades to millions of years. These changes cab be caused by processes internal to earth, external (variation in sunlight intensity) and human activities.

The single human activity that is most likely to have a large impact on the climate is the burning of "fossil fuels" such as coal, oil and gas. These fuels contain carbon. Burning them makes carbon dioxide gas. Carbon dioxide gas traps solar heat in the atmosphere, partly in the same way as glass traps solar heat in a sunroom or a greenhouse. For this reason, carbon dioxide is sometimes called a "greenhouse gas." As more carbon dioxide is added to the atmosphere, more solar heat cannot get out of the atmosphere leading to increase in temperature of the atmosphere.

What is the role of wetlands in mitigating climate change?

Wetland ecosystems provide a range of functions such as climate regulation, carbon recycling, flood control, purifying water, breeding grounds for fish.
To society, wetlands are a source of products such as fish, water, building materials, wild game meat.
However, the distribution of wetlands is determined by following factors;

- climate
- land form
- hydrology
- biotic factors
- mineral characteristics of the soil

Climate determines distribution of wetlands through amount of water received through rainfall. In addition, the morphology of the land surface is important because it determines the distribution of the excess water from rainfall and hence location of wetlands. Source of water to wetlands may also be from floodplains, and coastal areas.

The physical and mineralogical characteristics of the surface materials are important. The texture of the soil determines the porosity of the soil and therefore proportion of water that can percolate into the soil.

Global climate change and wetland ecosystems

Although climate plays an important role in the formation, distribution and functioning of wetlands, it is difficult to precisely state how changes in climate will impact on wetland ecosystems. This is because of the multiple nature of causes climate change and wetlands diverse nature of wetlands. However, potential issues can be highlighted.

Changes in hydrology

Wetland ecosystems may significantly be affected by changes in hydrology. Increase in rainfall can result in wetland increase in wetlands; likewise, decrease in rainfall can reduce the number of wetlands. Changes in hydrology can also influence biological and biogeochemical functions of wetlands.

Diversity of wetland ecosystems

It is expected that shift in wetland distribution can be accompanied by changes in species composition of wetlands as individual species respond to changes in climate. This may cause changes in diversity of wetland ecosystems.

Wetlands as carbon sinks

Wetlands play a major role in the carbon cycle. Carbon dioxide taken by plants which die and some carbon is stored in form of organic matter in wetlands. Carbon leaves the wetland inform of methane gas and carbon dissolved in water. However, changes in temperature will affect organic mater formation and way the water leaves the wetlands, hence affecting their role as carbon sinks.

Wetland degradation and climate change

The links between peatland degradation and climate change is that clearance, drainage and fires in peatlands emit more than 3 billion tones of carbon dioxide every year, equivalent to 10% of global emissions from fossil fuels. Protection and restoration of peatlands are among the most cost- effective options for climate change mitigation.

Degraded wetland ecosystems have no capacity to withstand extreme climate conditions such as heavy rainfall, wind, storms and flooding. Extreme flood conditions are experienced worldwide. However, these extreme disasters can be used to raise awareness of the role of wetlands in mitigating severe impacts of global climate change.

Policies and programmes

There are policies and programmes on wetlands, nationally and internationally. Scrutinizing these policies to identify how they address climate change and wetland scenarios is important. For example; how does policy on wetland conservation address issues on how climate change may affect wetlands and how wetland degradation may influence climate change? Programmes on wetland conservation (awareness of communities of the link between wetlands and climate, and wetlands and climate change).

Activities

- Think of issues of global climate change related to wetlands
- What wetlands issues face your community?
- Which of the issues you have identified above are related to climate change?
- Is your community aware of any issues of wetlands that related to climate change?
- Any potential effect of global climate change on wetlands that may impact on socio-economic values of wetlands to society?
- Does your country have a policy on wetlands and climate change? What does it say and how is it being implemented?

Additional Questions

- Discuss the importance of climate change to a developing country such as yours.
- Write a simple newspaper article to create awareness of your local community about the importance of climate change and wetlands.
- Draw up a programme to raise awareness among the students and the community in the area surrounding the school about climate change and how it could impact on development.
- How is wetland assessment and monitoring important in the development of your Country?

Unit Summary

In this Unit, you have learnt about:

- Global climate change
- Importance of wetlands in global climate change
- Impact of global climate change on wetlands
- Impact of global change on economy and society resulting from wetland changes
- Policies (national and international) in relation to wetlands and climate change

Further reading

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GLOSSARY OF COMMON TERMS

Constructed wetlands - are wetlands intentionally created from non-wetland sites for the sole purpose of wastewater or stormwater treatment" (Hammer 1997).

Creation -Wetland creation is "the construction of wetlands where they did not exist before and can involve engineering of hydrology and soils" (Mitsch and Gosselink 1993).

Enhancement - **"**is improving the structure or function of an already existing wetland" (Middleton 1999). "In the context of restoration ecology, enhancement is any improvement of a structural or functional attribute" (National Research Council 1992).

Goals are general statements about desired project outcomes - stating goals allows all stakeholders to understand, in general terms, the desired direction of a project. Projects may have more than one goal, reflecting the multiple functions that individual wetlands perform.

Objectives are specific statements about desired project outcomes - projects typically have more than one objective, reflecting the multiple functions that individual wetlands perform.

Performance standards (sometimes called success criteria) are observable or measurable attributes that can be used to determine if a project meets its intended multiple objectives - each objective will have one or more associated performance standards.

Mitigation - Mitigation is the actual restoration, creation, or enhancement of wetlands to compensate for permitted wetland losses" (Lewis 1990). "Wetland mitigation is the replacing of wetland areas destroyed or impacted by proposed land disturbances with artificially created wetland areas" (National Research Council 1992). " Mitigation is actions taken to avoid, reduce, or compensate for the effects of environmental damage.

Reclamation - Ecological restoration as reclamation is any deliberate attempt to return a damaged ecosystem to some kind of productive use or socially acceptable condition short

of restoration" (Jordan et al. 1988). "Reclamation is an alteration in an ecosystem that creates another type of ecosystem of value to humans" (Middleton 1999).

Reforestation- In reforestation specific components (e.g., trees) are restored such that structural replication of the previous ecosystem is achieved; with an implicit assumption the restoration will succeed reforestation" (Wilson et al. in press).

Rehabilitation - Rehabilitation can be used as an umbrella term that includes both 'restoration' and 'creation' (Streever 1999). Rehabilitation is used primarily to indicate improvements of a visual nature to a natural resource; putting back into good condition or working order" (National Research Council 1992).

Restoration – "Restoration is the return of a system to some previous condition" (Streever 1999). Restoration requires recreating both the structural and functional attributes of a damaged ecosystem (Cairns 1991).

"Restored wetlands are areas that previously supported a natural wetland ecosystem but were modified or changed, eliminating typical flora and fauna and used for other purposes but then subsequently altered to return poorly drained soils and wetland flora and fauna to enhance life support, flood control, recreational, educational, or other functional values" (Hammer 1997).

"The ultimate goal of ecological restoration is perhaps the achieving of a status something very close to the ecosystem's original conditions" (Hamilton 1990).

"Wetland restoration is the rehabilitation of wetlands that may be degraded or hydrologically altered and often involves reestablishing the vegetation" Mitsch and Gosselink 1993).

Riparian Reforestation- "is the replanting of the banks and floodplains of a stream with native forest and shrub species to stabilize erodible soil, improve both surface and ground water quality, increase stream shading, and enhance wildlife habitat" (National Research Council 1992).

Self-design

Self-design is “the idea that over time a restored wetland will organize itself around and eventually alter its engineered components…it is the environmental conditions there that determine the vegetative outcome” (Middleton 1999).

Wetland degradation

A process by which the vital and valuable functions of a wetland are reduced or completely destroyed.

Wetland encroachment

The act or process of converting or changing a wetland to some other use e.g. building a house/industry or gardening. During the encroachment process, a small area of the wetland is taken and then increased little by little.

Ground water

Water beneath the earth's surface, often between saturated soil and rocks. This water supplies wells and springs from which millions of people depend especially in rural areas. Ground water also refers to water that occurs below the surface of the Earth, where it occupies spaces in soils or rock layers.

Water table

Surface of a body of underground water below which the soil or rocks are permanently saturated with water.

The water table fluctuates both with the seasons and from year to year because it is affected by climatic variations and by the amount of water used by vegetation, evaporation from land, water and plant surface. It also is affected by withdrawing excessive amounts of water from wells, streams and springs.

Hydrology

The scientific study of the properties, distribution, and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere.

Hydrological cycle

Hydrological cycle is the succession of water movement from the atmosphere to the earth and return to the atmosphere through various stages such as precipitation, interception, runoff, infiltration, percolation, storage, evaporation, and transpiration

Precipitation

Rain, snow, or hails, all of which are formed by condensation of moisture in the atmosphere and fall to the ground/earth's surface.

Watershed

It describes an area of land that drains down slope to the lowest point. In a watershed water moves through a network of drainage pathways, both underground and on the surface. Generally, these pathways include streams and rivers, which become progressively larger as the water moves downstream.

Wetland Catchment area

The entire geographical area drained by a wetland and its streams or river system; an area characterized by all surface water runoff being conveyed to the wetland system.

Water pollution

A change in the chemical, physical and biological quality or characteristics of water that is harmful to its existing, intended, or potential uses. (For example, drinking, cooking swimming, the consumption of fish, and the health of aquatic organisms)

The term "water pollution" generally refers to human-induced changes to water quality. Thus, the discharge of potentially toxic wastes and chemicals or the release of wastewater into a nearby water body is considered as water pollution.

Sewage

Water-carried wastes, in either solution or suspension, that flows away from a community, home, industry or any other institution. Also known as, wastewater characterized by distinct physical condition, chemical constituents, and bacteriological organisms. Depending on its origin, wastewater can be classified as sanitary, commercial, industrial, or surface runoff.

Pathogens

Microorganisms (e.g., bacteria, viruses, or parasites) that can cause disease in humans, animals and plants.Also refered to as a disease causing organism or an infectious agent that causes illness to its host

Waterborne diseases

Diseases caused by pathogenic microorganisms which are directly transmitted when contaminated drinking water is consumed. Contaminated drinking water, used in the preparation of food, can be the source of foodborne disease through consumption of the same microorganisms.A waterborne disease can be caused by protozoa, viruses, bacteria, and intestinal parasites. (Examples include; Diarrhoea, Dysentry, Cholera,Trachoma,Typhoid e.t.c)

Ecological succession

The gradual and orderly process of change in an ecosystem brought about by the progressive replacement of one community by another until a stable climax is established. It is also referred to as the gradual process incurred by the change in the number of individuals of each species of a community and by establishment of new

species populations that may gradually replace the original inhabitants.

Water Quality

Water Quality is a term used to describe the biological, chemical and physical characteristics of water and its general composition. These attributes affect water's ability to sustain life and its suitability for human consumption.

Wetland economic value

The total economic value of a given wetland includes direct values, indirect values, option values, heritage values and existence values

APPENDICES

Appendix I: Articles of the Ramsar convention

Article 1

1. For the purpose of this Convention wetlands are areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters.

2. For the purpose of this Convention waterfowl are birds ecologically dependent on wetlands.

Article 2

l. Each Contracting Party shall designate suitable wetlands within its territory for inclusion in a List of Wetlands of International Importance, hereinafter referred to as "the List" which is maintained by the bureau established under Article 8. The boundaries of each wetland shall be precisely described and also delimited on a map and they may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands, especially where these have importance as waterfowl habitat.

2. Wetlands should be selected for the List because of their international significance in terms of ecology, botany, zoology, limnology or hydrology. In the first instance wetlands of international importance to waterfowl at any season should be included.

3. The inclusion of a wetland in the List does not prejudice the exclusive sovereign rights of the Contracting Party in whose territory the wetland is situated.

4. Each Contracting Party shall designate at least one wetland to be included in the List when signing this Convention or when depositing its instrument of ratification or accession, as provided in Article 9.

5. Any Contracting Party shall have the right to add to the List further wetlands situated within its territory, to extend the boundaries of those wetlands already included by it in the List, or, because of its urgent national interests, to delete or restrict the boundaries of wetlands already included by

it in the List and shall, at the earliest possible time, inform the organization or government responsible for the continuing bureau duties specified in Article 8 of any such changes.

6. Each Contracting Party shall consider its international responsibilities for the conservation, management and wise use of migratory stocks of waterfowl, both when designating entries for the List and when exercising its right to change entries in the List relating to wetlands within its territory.

Article 3

1. The Contracting Parties shall formulate and implement their planning to promote the conservation of the wetlands included in the List, and as far as possible the wise use of wetlands in their territory.

2. Each Contracting Party shall arrange to be informed at the earliest possible time if the ecological character of any wetland in its territory and included in the List has changed, is changing or is likely to change as the result of technological developments, pollution or other human interference. Information on such changes shall be passed immediately to the organization or government responsible for the continuing bureau duties specified in Article 8.

Article 4

1. Each Contracting Party shall promote the conservation of wetlands and waterfowl by establishing nature reserves on wetlands, whether they are included in the List or not, and provide adequately for their wardening.

2. Where a Contracting Party in its urgent national interest, deletes or restricts the boundaries of a wetland included in the List, it should as far as possible compensate for any loss of wetland resources, and in particular it should create additional nature reserves for waterfowl and for the protection, either in the same area or elsewhere, of an adequate portion of the original habitat.

3. The Contracting Parties shall encourage research and the exchange of data and publications regarding wetlands and their flora and fauna.

4. The Contracting Parties shall endeavour through management to increase waterfowl populations on appropriate wetlands.

5. The Contracting Parties shall promote the training of personnel competent in the fields of wetland research, management and wardening.

Article 5

The Contracting Parties shall consult with each other about implementing obligations arising from the Convention especially in the case of a wetland extending over the territories of more than one Contracting Party or where a water system is shared by Contracting Parties.

They shall at the same time endeavour to co-ordinate and support present and future policies and regulations concerning the conservation of wetlands and their flora and fauna.

Article 6

1. The Contracting Parties shall, as the necessity arises, convene Conferences on the Conservation of Wetlands and Waterfowl.

2. These Conferences shall have an advisory character and shall be competent inter alia:

(a) to discuss the implementation of this Convention;

(b) to discuss additions to and changes in the List;

(c) to consider information regarding changes in the ecological character of wetlands included in the List provided in accordance with paragraph 2 of Article 3;

(d) to make general or specific recommendations to the Contracting Parties regarding the conservation, management and wise use of wetlands and their flora and fauna;

(e) to request relevant international bodies to prepare reports and statistics on matters which are essentially international in character affecting wetlands.

3. The Contracting Parties shall ensure that those responsible at all levels for wetlands management shall be informed of, and take into consideration, recommendations of such Conferences concerning the conservation, management and wise use of wetlands and their flora and fauna.

Article 7

1. The representatives of the Contracting Parties at such Conferences should include persons who are experts on wetlands or waterfowl by reasons of knowledge and experience gained in scientific, administrative or other appropriate capacities.

2. Each of the Contracting Parties represented at a Conference shall have one vote, recommendations being adopted by a simple majority of the votes cast, provided that not less than half the Contracting Parties cast votes.

Article 8

1. The International Union for the Conservation of Nature and Natural Resources shall perform the continuing bureau duties under this Convention until such time as another organization or government is appointed by a majority of two-thirds of all Contracting Parties.

2. The continuing bureau duties shall be, inter alia:

(a) to assist in the convening and organizing of Conferences specified in Article 6;

(b) to maintain the List of Wetlands of International Importance and to be informed by the Contracting Parties of any additions, extensions, deletions or restrictions concerning wetlands included in the List provided in accordance with paragraph 5 of Article 2;

(c) to be informed by the Contracting Parties of any changes in the ecological character of wetlands included in the List provided in accordance with paragraph 2 of Article 3;

(d) to forward notification of any alterations to the List, or changes in character of wetlands included therein, to all Contracting Parties and to arrange for these matters to be discussed at the next Conference;

(e) to make known to the Contracting Party concerned, the recommendations of the Conferences in respect of such alterations to the List or of changes in the character of wetlands included therein.

Article 9

1. This Convention shall remain open for signature indefinitely.

2. Any member of the United Nations or of one of the Specialized Agencies or of the International Atomic Energy Agency or Party to the Statute of the International Court of Justice may become a party to this Convention by:

(a) signature without reservation as to ratification;

(b) signature subject to ratification followed by ratification;

(c) accession.

3. Ratification or accession shall be effected by the deposit of an instrument of ratification or accession with the Director-General of the United Nations Educational, Scientific and Cultural Organization, (hereinafter referred to as "the Depository").

Article 10

1. This Convention shall enter into force four months after seven States have become Parties to this Convention in accordance with paragraph 2 of Article 9.

2. Thereafter this Convention shall enter into force for each Contracting Party four months after the day of its signature without reservation as to ratification, or its deposit of an instrument of ratification or accession.

Article 11

l. This Convention shall continue in force for an indefinite period.

2. Any Contracting Party may denounce this Convention after a period of five years from the date on which it entered into force for that Party by giving written notice thereof to the Depository. Denunciation shall take effect four months after the day on which the Depository receives notice thereof.

Article 12

1. The Depository shall inform all States that have signed and acceded to this Convention as soon as possible of:

(a) signatures to the Convention;

(b) deposits of instruments of ratification of this Convention;

(c) deposits of instruments of accession to this Convention;

(d) the date of entry into force of this Convention;

(e) notifications of denunciation of this Convention.

2. When this Convention has entered into force, the Depository shall have it registered with the Secretariat of the United Nations in accordance with Article 102 of the Charter.

IN WITNESS WHEREOF, the undersigned, being duly authorized to that effect, have signed this Convention**.**

DONE at Ramsar this 2nd day of February 1971, in a single original in the English, French, German and Russian languages, in any case of divergency the English text prevailing, which shall be deposited with the Depository which shall send true copies thereof to all Contracting Parties.

Appendix II: Contracting parties to the Ramsar convention on Wetlands as at 19/Nov/2007

Country	Entry into force	Number of Ramsar sites	Surface area(Sq/Km)
Albania	29.02.96	3	83,062
Algeria	04.03.84	42	2,959,615
Antigua and Barbuda	02.10.05	1	3,600
Argentina	04.09.92	15	3,992,201
Armenia	06.11.93	2	492,239
Australia	21.12.75	64	7,371,873
Austria	16.04.83	19	122,277
Azerbaijan	21.05.01	2	99,560
Bahamas	07.06.97	1	32,600
Bahrain	27.02.98	2	6,810
Bangladesh	21.09.92	2	611,200
Barbados	12.04.06	1	33
Belarus	25.08.91	8	283,107
Belgium	04.07.86	9	42,938
Belize	22.08.98	2	23,592

Bolivia	**27.10.90**	**8**	**6,518,073**
Bosnia and Herzegovina	**01.03.92**	**2**	**10,911**
Botswana	**09.04.97**	**1**	**5,537,400**
Brazil	**24.09.93**	**8**	**6,434,086**
Bulgaria	**24.01.76**	**10**	**20,306**
Burkina Faso	**27.10.90**	**3**	**299,200**
Burundi	**05.10.02**	**1**	**1,000**
Cambodia	**23.10.99**	**3**	**54,600**
Cameroon	**20.07.06**	**2**	**600,415**
Canada	**15.05.81**	**37**	**13,066,675**
Cape Verde	**18.11.05**	**3**	**...**
Central African Republic	**05.04.06**	**1**	**101,300**
Chad	**13.10.90**	**5**	**9,879,068**
Chile	**27.11.81**	**9**	**159,154**
China	**31.07.92**	**30**	**2,937,481**
Colombia	**18.10.98**	**3**	**447,888**
Comoros	**09.06.95**	**3**	**16,030**
Congo	**18.10.98**	**1**	**438,960**
Costa Rica	**27.04.92**	**11**	**510,050**
Côte d'Ivoire	**27.06.96**	**6**	**127,344**

Cuba	**12.08.01**	**6**	**1,188,411**
Cyprus	**11.11.01**	**1**	**1,585**
Czech Republic	**01.01.93**	**12**	**54,656**
Democratic Republic of Congo	**18.05.96**	**2**	**866,000**
Denmark	**02.01.78**	**38**	**2,078,823**
Djibouti	**22.03.03**	**1**	**3,000**
Dominican Republic	**15.09.02**	**1**	**20,000**
Ecuador	**07.01.91**	**12**	**170,771**
Egypt	**09.09.88**	**2**	**105,700**
El Salvador	**22.05.99**	**3**	**125,769**
Equatorial Guinea	**02.10.03**	**3**	**136,000**
Estonia	**29.07.94**	**11**	**218,344**
Fiji	**11.08.06**	**1**	**615**
Finland	**21.12.75**	**49**	**799,518**
France	**01.12.86**	**24**	**828,803**
Gabon	**30.04.87**	**6**	**1,763,769**
Gambia	**16.01.97**	**2**	**26,304**
Georgia	**07.06.97**	**2**	**34,480**
Germany	**26.06.76**	**33**	**843,109**
Ghana	**22.06.88**	**6**	**178,410**

Guatemala	**26.10.90**	**7**	**628,592**
Guinea	**18.03.93**	**16**	**6,422,361**
Guinea-Bissau	**14.05.90**	**1**	**39,098**
Honduras	**23.10.93**	**6**	**223,320**
Hungary	**11.08.79**	**26**	**207,176**
Iceland	**02.04.78**	**3**	**58,970**
India	**01.02.82**	**25**	**677,131**
Indonesia	**08.08.92**	**3**	**656,510**
Iran, Islamic Republic of	**21.12.75**	**22**	**1,481,147**
Iraq	**17.02.08**	**1**	**137,700**
Ireland	**15.03.85**	**45**	**66,994**
Israel	**12.03.97**	**2**	**366**
Italy	**14.04.77**	**50**	**59,796**
Jamaica	**07.02.98**	**3**	**37,765**
Japan	**17.10.80**	**33**	**130,293**
Jordan	**10.05.77**	**1**	**7,372**
Kazakhstan	**02.05.07**	**1**	**353,341**
Kenya	**05.10.90**	**5**	**101,849**
Kyrgyz Republic	**12.03.03**	**2**	**639,700**
Latvia	**25.11.95**	**6**	**148,363**

Lesotho	**01.11.04**	**1**	**434**
Liberia	**02.11.03**	**5**	**95,879**
Libyan Arab Jamahiriya	**05.08.00**	**2**	**83**
Liechtenstein	**06.12.91**	**1**	**101**
Lithuania	**20.12.93**	**5**	**50,451**
Luxembourg	**15.08.98**	**2**	**17,213**
Madagascar	**25.01.99**	**6**	**787,555**
Malawi	**14.03.97**	**1**	**224,800**
Malaysia	**10.03.95**	**5**	**55,355**
Mali	**25.09.87**	**1**	**4,119,500**
Malta	**30.01.89**	**2**	**16**
Marshall Islands	**13.11.04**	**1**	**69,000**
Mauritania	**22.02.83**	**3**	**1,231,100**
Mauritius	**30.09.01**	**1**	**26**
Mexico	**04.11.86**	**67**	**5,317,857**
Moldova	**20.10.00**	**3**	**94,705**
Monaco	**20.12.97**	**1**	**10**
Mongolia	**08.04.98**	**11**	**1,439,530**
Montenegro	**03.06.06**	**1**	**20,000**
Morocco	**20.10.80**	**24**	**272,010**

Myanmar	**17.03.05**	**1**	**256**
Namibia	**23.12.95**	**4**	**629,600**
Nepal	**17.04.88**	**4**	**23,488**
Netherlands	**23.09.80**	**49**	**818,908**
New Zealand	**13.12.76**	**6**	**39,068**
Nicaragua	**30.11.97**	**8**	**405,691**
Niger	**30.08.87**	**12**	**4,317,869**
Nigeria	**02.02.01**	**1**	**58,100**
Norway	**21.12.75**	**37**	**116,369**
Pakistan	**23.11.76**	**19**	**1,343,627**
Palau	**18.02.03**	**1**	**493**
Panama	**26.11.90**	**4**	**159,903**
Papua New Guinea	**16.07.93**	**2**	**594,924**
Paraguay	**07.10.95**	**6**	**785,970**
Peru	**30.03.92**	**12**	**6,780,643**
Philippines	**08.11.94**	**4**	**68,404**
Poland	**22.03.78**	**13**	**145,075**
Portugal	**24.03.81**	**17**	**73,784**
Republic of Korea	**28.07.97**	**5**	**4,550**
Romania	**21.09.91**	**4**	**682,166**

Rwanda	**01.04.06**	**1**	**...**
Saint Lucia	**19.06.02**	**2**	**85**
Samoa	**06.02.05**	**1**	**...**
Sao Tome and Principe	**21.12.06**	**1**	**23**
Senegal	**11.11.77**	**4**	**99,720**
Serbia	**27.04.92**	**6**	**28,025**
Seychelles	**22.03.05**	**1**	**121**
Sierra Leone	**13.04.00**	**1**	**295,000**
Slovakia	**01.01.93**	**14**	**40,697**
Slovenia	**25.06.91**	**3**	**8,205**
South Africa	**21.12.75**	**19**	**543,978**
Spain	**04.09.82**	**63**	**281,768**
Sri Lanka	**15.10.90**	**3**	**8,522**
Sudan	**07.05.05**	**2**	**6,784,600**
Suriname	**22.11.85**	**1**	**12,000**
Sweden	**21.12.75**	**51**	**514,506**
Switzerland	**16.05.76**	**11**	**8,676**
Syrian Arab Republic	**05.07.98**	**1**	**10,000**
Tajikistan	**18.11.01**	**5**	**94,600**
Thailand	**13.09.98**	**10**	**370,600**

Togo	**04.11.95**	**4**	**1,210,400**
Trinidad & Tobago	**21.04.93**	**3**	**15,919**
Tunisia	**24.03.81**	**20**	**726,541**
Turkey	**13.11.94**	**12**	**179,482**
Uganda	**04.07.88**	**11**	**354,803**
Ukraine	**01.12.91**	**33**	**744,651**
United Arab Emirates	**29.12.07**	**1**	**620**
United Kingdom	**05.05.76**	**166**	**917,988**
United Republic of Tanzania	**13.08.00**	**4**	**4,868,424**
United States of America	**18.04.87**	**22**	**1,305,860**
Uruguay	**22.09.84**	**2**	**424,904**
Uzbekistan	**08.02.02**	**1**	**31,300**
Venezuela	**23.11.88**	**5**	**263,636**
Viet Nam	**20.01.89**	**2**	**25,759**
Zambia	**28.12.91**	**8**	**4,030,500**
former USSR		**3**	**669,200**

Appendix III: Criteria for identifying wetlands of international importance.

Criteria for the designation of Wetlands of International Importance

Group A of the criteria Sites containing representative, rare or unique wetland types		**Criterion 1**: A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.
Group B of the criteria Sites of international importance for conserving biodiversity	Criteria based on species and ecological communities	**Criterion 2**: A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.
		Criterion 3: A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.
		Criterion 4: A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.
	Specific criteria based on waterbirds	**Criterion 5**: A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds.
		Criterion 6: A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.
	Specific criteria based on fish	**Criterion 7**: A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.
		Criterion 8: A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.
	Specific criteria based on other taxa	**Criterion 9**: A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species.

Appendix IV: Articles of the African Eurasian Waterbird Agreement

ARTICLE I: Scope, Definitions and Interpretation

1. The geographic scope of this Agreement is the area of the migration systems of African-Eurasian waterbirds, as defined in Annex 1 to this Agreement, hereafter referred to as the "Agreement Area".

2. For the purpose of this Agreement:

(a) "Convention" means the Convention on the Conservation of Migratory Species of Wild Animals, 1979;

(b) "Convention Secretariat" means the body established under Article IX of the Convention;

(c) "Waterbirds" means those species of birds that are ecologically dependent on wetlands for at least part of their annual cycle, have a range which lies entirely or partly within the Agreement Area and are listed in Annex 2 to this Agreement;

(d) "Agreement secretariat" means the body established under Article VI, paragraph 7, subparagraph (b), of this Agreement;

(e) "Parties" means, unless the context otherwise indicates, Parties to this Agreement; and

(f) "Parties present and voting" means the Parties present and casting an affirmative or negative vote; those abstaining from voting shall not be counted amongst the Parties present and voting.

In addition, the terms defined in Article I, subparagraphs 1(a) to (k), of the Convention shall have the same meaning, *mutatis mutandis*, in this Agreement.

3. This Agreement is an AGREEMENT within the meaning of Article IV, paragraph 3, of the Convention.

4. The annexes to this Agreement form an integral part thereof. Any reference to the Agreement includes a reference to its annexes.

ARTICLE II: **Fundamental Principles**

1. Parties shall take co-ordinated measures to maintain migratory waterbird species in a favourable conservation status or to restore them to such a status. To this end, they shall apply within the limits of their national jurisdiction the measures prescribed in Article III, together with the specific actions determined in the Action Plan provided for in Article IV, of this Agreement.

2. In implementing the measures prescribed in paragraph 1 above, Parties should take into account the precautionary principle.

ARTICLE III: General Conservation Measures

1. The Parties shall take measures to conserve migratory waterbirds, giving special attention to endangered species as well as to those with an unfavorable conservation status.

2. To this end, the Parties shall:

(a) accord the same strict protection for endangered migratory waterbird species in the Agreement Area as is provided for under Article III, paragraphs 4 and 5, of the Convention;

(b) ensure that any use of migratory waterbirds is based on an assessment of the best available knowledge of their ecology and is sustainable for the species as well as for the ecological systems that support them;

(c) identify sites and habitats for migratory waterbirds occurring within their territory and encourage the protection, management, rehabilitation and restoration of these sites, in liaison with those bodies listed in Article IX, paragraphs (a) and (b) of this Agreement, concerned with habitat conservation;

(d) coordinate their efforts to ensure that a network of suitable habitats is maintained or, where appropriate, re-established throughout the entire range of each migratory waterbird species

concerned, in particular where wetlands extend over the area of more than one Party to this Agreement;

(e) investigate problems that are posed or are likely to be posed by human activities and endeavour to implement remedial measures, including habitat rehabilitation and restoration, and compensatory measures for loss of habitat;

(f) cooperate in emergency situations requiring international concerted action and in identifying the species of migratory waterbirds which are the most vulnerable to these situations as well as cooperate in developing appropriate emergency procedures to provide increased protection to these species in such situations and in the preparation of guidelines to assist individual Parties in tackling these situations;

(g) prohibit the deliberate introduction of non-native waterbird species into the environment and take all appropriate measures to prevent the unintentional release of such species if this introduction or release would prejudice the conservation status of wild flora and fauna; when non-native waterbird species have already been introduced, the Parties shall take all appropriate measures to prevent these species from becoming a potential threat to indigenous species;

(h) initiate or support research into the biology and ecology of migratory waterbirds including the harmonization of research and monitoring methods and, where appropriate, the establishment of joint or cooperative research and monitoring programmes;

(i) analyze their training requirements for, *inter alia*, migratory waterbird surveys, monitoring, ringing and wetland management to identify priority topics and areas for training and cooperate in the development and provision of appropriate training programmes;

(j) develop and maintain programmes to raise awareness and understanding of migratory waterbird conservation issues in general and of the particular objectives and provisions of this Agreement;

(k) exchange information and results from research, monitoring, conservation and education programmes; and

(l) cooperate with a view to assisting each other to implement this Agreement, particularly in the areas of research and monitoring.

ARTICLE IV: Action Plan and Conservation Guidelines

1. An Action Plan is appended as Annex 3 to this Agreement. It specifies actions, which the Parties shall undertake in relation to priority species and issues, under the following headings, consistent with the general conservation measures specified in Article III of this Agreement:

(a) species conservation;

(b) habitat conservation;

(c) management of human activities;

(d) research and monitoring;

(e) education and information; and

(f) implementation.

2. The Action Plan shall be reviewed at each ordinary session of the Meeting of the Parties, taking into account the Conservation Guidelines.

3. Any amendment to the Action Plan shall be adopted by the Meeting of the Parties, taking into consideration the provisions of Article III of this Agreement.

4. The Conservation Guidelines shall be submitted to the Meeting of the Parties for adoption at its first session, and shall be regularly reviewed.

ARTICLE V: Implementation and Financing

1. Each Party shall:

(a) designate the Authority or Authorities to implement this Agreement which shall, *inter alia*, monitor all activities that may have impact on the conservation status of those migratory waterbird species of which the Party is a Range State;

(b) designate a contact point for the other Parties, and communicate without delay its name and address to the Agreement secretariat to be circulated forthwith to the other Parties; and

(c) prepare for each ordinary session of the Meeting of the Parties, beginning with the second session, a report on its implementation of the Agreement with particular reference to the conservation measures it has undertaken. The format of such reports shall be determined by the first session of the Meeting of the Parties and reviewed as may be necessary at any subsequent session of the Meeting of the Parties. Each report shall be submitted to the Agreement secretariat not less than one hundred and twenty days before the ordinary session of the Meeting of the Parties for which it has been prepared, and copies shall be circulated forthwith to the other Parties by the Agreement secretariat.

2. (a) Each Party shall contribute to the budget of the Agreement in accordance with the United Nations scale of assessment. The contributions shall be restricted to a maximum of 25 per cent of the total budget for any Party that is a Range State. No regional economic integration organization shall be required to contribute more than 2.5 per cent of the administrative costs.

(b) Decisions relating to the budget and any changes to the scale of assessment that may be found necessary shall be adopted by the Meeting of the Parties by consensus.

3. The Meeting of the Parties may establish a conservation fund from voluntary contributions of Parties or from any other source for the purpose of financing monitoring, research, training and projects relating to the conservation, including protection and management, of migratory waterbirds.

4. Parties are encouraged to provide training and technical and financial support to other Parties on a multilateral or bilateral basis to assist them in implementing the provisions of this

Agreement.

ARTICLE VI: Meeting of the Parties

1. The Meeting of the Parties shall be the decision-making body of this Agreement.

2. The Depositary shall, in consultation with the Convention Secretariat, convene a session of the Meeting of the Parties not later than one year after the date of the entry into force of this Agreement. Thereafter, the Agreement secretariat shall convene, in consultation with the Convention Secretariat, ordinary sessions of the Meeting of the Parties at intervals of not more than three years, unless the

Meeting of the Parties decides otherwise. Where it is possible to do so, such sessions should be held in conjunction with the ordinary meetings of the Conference of the Parties to the Convention.

3. On the written request of at least one third of the Parties, the Agreement secretariat shall convene an extraordinary session of the Meeting of the Parties.

4. The United Nations, its Specialized Agencies, the International Atomic Energy Agency, any State not a Party to the Agreement, and the secretariats of international conventions concerned *inter alia* with the conservation, including protection and management, of migratory waterbirds may be represented by observers in sessions of the Meeting of the Parties. Any agency or body technically qualified in such conservation matters or in research on migratory waterbirds may also be represented at sessions of the Meeting of the Parties by observers, unless at least one third of the Parties present object.

5. Only Parties have the right to vote. Each Party shall have one vote, but regional economic integration organizations which are Parties to this Agreement shall, in matters within their competence, exercise their right to vote with a number of votes equal to the number of their Member States which are Parties to the Agreement. A regional economic integration organization shall not exercise its right to vote if its Member States exercise theirs, and *vice versa*.

6. Unless provided otherwise in this Agreement, decisions of the Meeting of the Parties shall be adopted by consensus or, if consensus cannot be achieved, by a two-thirds majority of the Parties present and voting.

7. At its first session, the Meeting of the Parties shall:

(a) adopt its rules of procedure by consensus;

(b) establish an Agreement secretariat within the Convention Secretariat to perform the secretariat functions listed in Article VIII of this Agreement;

(c) establish the Technical Committee provided for in Article VII of this Agreement;

(d) adopt a format for the reports to be prepared according to Article V, paragraph 1, subparagraph (c), of this Agreement; and

(e) adopt criteria to define emergency situations which require urgent conservation measures, and determine the modalities for assigning responsibility for action to be taken.

8. At each of its ordinary sessions, the Meeting of the Parties shall:

(a) consider actual and potential changes in the conservation status of migratory waterbirds and the habitats important for their survival, as well as the factors which may affect them;

(b) review the progress made and any difficulty encountered in the implementation of this Agreement;

(c) adopt a budget and consider any matters relating to the financial arrangements for this Agreement;

(d) deal with any matter relating to the Agreement secretariat and the membership of the Technical Committee;

(e) adopt a report for communication to the Parties to this Agreement and to the Conference of the Parties of the Convention; and

(f) determine the time and venue of the next session.

9. At any of its sessions, the Meeting of the Parties may:

(a) make recommendations to the Parties as it deems necessary or appropriate;

(b) adopt specific actions to improve the effectiveness of this Agreement and, as the case may be, emergency measures as provided for in Article VII, paragraph 4, of this Agreement;

(c) consider and decide upon proposals to amend this Agreement;

(d) amend the Action Plan in accordance with Article IV, paragraph 3, of this Agreement;

(e) establish such subsidiary bodies as it deems necessary to assist in the implementation of this Agreement, in particular for coordination with bodies established under other international treaties, conventions and agreements with overlapping geographic and taxonomic coverage; and

(f) decide on any other matter relating to the implementation of this Agreement.

ARTICLE VII: Technical Committee

1. The Technical Committee shall comprise:

(a) nine experts representing different regions of the Agreement Area, in accordance with a balanced geographical distribution;

(b) one representative from the International Union for Conservation of Nature and Natural Resources (IUCN), one from the International Waterfowl and Wetlands Research Bureau (IWRB) and one from the International Council for Game and Wildlife Conservation (CIC); and

(c) one expert from each of the following fields: rural economics, game management, and environmental law.

The procedure for the appointment of the experts, the term of their appointment and the procedure for designation of the Chairman of the Technical Committee shall be determined by the Meeting of the Parties. The Chairman may admit a maximum of four observers from specialized international inter-governmental and non-governmental organizations.

2. Unless the Meeting of the Parties decides otherwise, meetings of the Technical Committee shall be convened by the Agreement secretariat in conjunction with each ordinary session of the Meeting of the Parties and at least once between ordinary sessions of the Meeting of the Parties.

3. The Technical Committee shall:

(a) provide scientific and technical advice and information to the Meeting of the Parties and, through the Agreement secretariat, to Parties;

(b) make recommendations to the Meeting of the Parties concerning the Action Plan, implementation of the Agreement and further research to be carried out;

(c) prepare for each ordinary session of the Meeting of the Parties a report on its activities, which shall be submitted to the Agreement secretariat not less than

one hundred and twenty days before the session of the Meeting of the Parties, and copies shall be circulated forthwith by the Agreement secretariat to the Parties; and

(d) carry out any other tasks referred to it by the Meeting of the Parties.

4. Where in the opinion of the Technical Committee there has arisen an emergency which requires the adoption of immediate measures to avoid deterioration of the conservation status of one or more migratory waterbird species, the Technical Committee may request the Agreement secretariat to convene urgently a meeting of the Parties concerned. These Parties shall meet as soon as possible thereafter to establish rapidly a mechanism to give protection to the species identified as being subject to particularly adverse threat. Where a recommendation has been adopted at such a meeting, the Parties concerned shall inform each other and the Agreement secretariat of measures they have taken to implement it, or of the reasons why the recommendation could not be implemented.

5. The Technical Committee may establish such working groups as may be necessary to deal with specific tasks.

ARTICLE VIII: **Agreement Secretariat**

The functions of the Agreement secretariat shall be:

(a) to arrange and service the sessions of the Meeting of the Parties as well as the meetings of the Technical Committee;

(b) to execute the decisions addressed to it by the Meeting of the Parties;

(c) to promote and coordinate activities under the Agreement, including the Action Plan, in accordance with decisions of the Meeting of the Parties;

(d) to liaise with non-Party Range States and to facilitate coordination between the Parties and with international and national organizations, the activities of which are directly or indirectly relevant to the conservation, including protection and management, of migratory waterbirds;

(e) to gather and evaluate information which will further the objectives and implementation of the Agreement and to arrange for appropriate dissemination of such information;

(f) to invite the attention of the Meeting of the Parties to matters pertaining to the objectives of this Agreement;

(g) to circulate copies of the reports of the Authorities referred to in Article V, paragraph 1, subparagraph (a), of this Agreement and of the Technical Committee, along with copies of the reports it must provide pursuant to paragraph (h) of this Article, to each Party not less than sixty days before the commencement of each ordinary session of the Meeting of the Parties;

(h) to prepare, on an annual basis and for each ordinary session of the Meeting of the Parties, reports on the work of the secretariat and on the implementation of the Agreement;

(i) to administer the budget for the Agreement and, if established, its conservation fund;

(j) to provide information for the general public concerning the Agreement and its objectives; and

(k) to perform such other functions as may be entrusted to it under the Agreement or by the Meeting of the Parties.

ARTICLE IX: Relations with International Bodies dealing with Migratory Waterbirds and their Habitats

The Agreement secretariat shall consult:

(a) on a regular basis, the Convention Secretariat and, where appropriate, the bodies responsible for the secretariat functions under Agreements concluded pursuant to Article IV, paragraphs 3 and 4, of the Convention which are relevant to migratory waterbirds, the Convention on Wetlands of International Importance, especially as Waterfowl Habitat, 1971, the Convention on International Trade in Endangered Species of Wild Fauna and Flora, 1973, the African Convention on the Conservation of Nature and Natural Resources, 1968, the Convention on the Conservation of European Wildlife and Natural Habitats, 1979, and the Convention on Biological Diversity, 1992, with a view to the Meeting of the Parties cooperating with the Parties to these conventions on all matters of common interest and, in particular, in the development and implementation of the Action Plan;

(b) the secretariats of other pertinent conventions and international instruments in respect of matters of common interest; and

(c) other organizations competent in the field of conservation, including protection and management, of migratory waterbirds and their habitats, as well as in the fields of research, education and awareness raising.

ARTICLE X: **Amendment of the Agreement**

1. This Agreement may be amended at any ordinary or extraordinary session of the Meeting of the Parties.

2. Proposals for amendment may be made by any Party.

3. The text of any proposed amendment and the reasons for it shall be communicated to the Agreement secretariat not less than one hundred and fifty days before the opening of the session. The Agreement secretariat shall transmit copies forthwith to the Parties. Any comments on the text by the Parties shall be communicated to the Agreement secretariat not less than sixty days

before the opening of the session. The Secretariat shall, as soon as possible after the last day for submission of comments, communicate to the Parties all comments submitted by that day.

4. An amendment to the Agreement other than an amendment to its annexes shall be adopted by a two-thirds majority of the Parties present and voting and shall enter into force for those Parties which have accepted it on the thirtieth day after the date on which two thirds of the Parties to the Agreement at the date of the adoption of the amendment have deposited their instruments of acceptance of the amendment with the Depositary. For each Party which deposits an instrument of acceptance after the date on which two thirds of the Parties have deposited their instruments of acceptance, the amendment shall enter into force on the thirtieth day after the date on which it deposits its instrument of acceptance.

5. Any additional annexes and any amendment to an annex shall be adopted by a two-thirds majority of the Parties present and voting and shall enter into force for all Parties on the ninetieth day after the date of its adoption by the Meeting of the Parties, except for Parties which have entered a reservation in accordance with paragraph 6 of this Article.

6. During the period of ninety days provided for in paragraph 5 of this Article, any Party may by written notification to the Depositary enter a reservation with respect to an additional annex or an amendment to an annex. Such reservation may be withdrawn at any time by written notification to the Depositary, and thereupon the additional annex or the amendment shall enter into force for that Party on the thirtieth day after the date of withdrawal of the reservation.

ARTICLE XI: **Effect of this Agreement on International Conventions and Legislation**

1. The provisions of this Agreement do not affect the rights and obligations of any Party deriving from existing international treaties, conventions or agreements.

2. The provisions of this Agreement shall in no way affect the right of any Party to maintain or adopt stricter measures for the conservation of migratory waterbirds and their habitats.

ARTICLE XII: **Settlement of Disputes**

1. Any dispute which may arise between two or more Parties with respect to the interpretation or application of the provisions of this Agreement shall be subject to negotiation between the Parties involved in the dispute.

2. If the dispute cannot be resolved in accordance with paragraph 1 of this Article, the Parties may, by mutual consent, submit the dispute to arbitration, in particular that of the Permanent Court of Arbitration at The Hague, and the Parties submitting the dispute shall be bound by the arbitral decision.

ARTICLE XIII: **Signature, Ratification, Acceptance, Approval, Accession**

1. This Agreement shall be open for signature by any Range State, whether or not areas under its jurisdiction lie within the Agreement Area, or regional economic integration organization, at least one member of which is a Range State, either by:

(a) signature without reservation in respect of ratification, acceptance or approval; or

(b) signature with reservation in respect of ratification, acceptance or approval, followed by ratification, acceptance or approval.

2. This Agreement shall remain open for signature at The Hague until the date of its entry into force.

3. This Agreement shall be open for accession by any Range State or regional economic integration organization mentioned in paragraph 1 above on and after the date of entry into force of the Agreement.

4. Instruments of ratification, acceptance, approval or accession shall be deposited with the Depositary.

ARTICLE XIV: **Entry into Force**

1. This Agreement shall enter into force on the first day of the third month after at least fourteen Range States or regional economic integration organizations, comprising at least seven from Africa and seven from Eurasia, have signed without reservation in respect of ratification, acceptance or approval, or have deposited their instruments of ratification, acceptance or approval in accordance with Article XIII of this Agreement.

2. For any Range State or regional economic integration organization which has:

(a) signed without reservation in respect of ratification, acceptance, or approval;

(b) ratified, accepted, or approved; or

(c) acceded to

this Agreement after the date on which the number of Range States and regional economic integration organizations necessary to enable entry into force have signed it without reservation or have ratified, accepted or approved it, this Agreement shall enter into force on the first day of the third month following the signature without reservation, or deposit, by that State or organization, of its instrument of ratification, acceptance, approval or accession.

ARTICLE XV: **Reservations**

The provisions of this Agreement shall not be subject to general reservations. However, a specific reservation may be entered by any State or regional economic integration organization on signature without reservation in respect of ratification, acceptance or approval or, as the case may be, on depositing its instrument of ratification, acceptance, approval or accession in respect of any species covered by the Agreement or any specific provision of the Action Plan. Such a reservation may be withdrawn at any time by the State or regional economic integration organization which had entered it, by notification

in writing to the Depositary; such a State or organization shall not be bound by the provisions which are the object of the reservation until thirty days after the date on which the reservation has been withdrawn.

ARTICLE XVI: **Denunciation**

Any Party may denounce this Agreement by written notification to the Depositary at any time. The denunciation shall take effect twelve months after the date on which the Depositary has received the notification.

ARTICLE XVII: **Depositary**

1. The original of this Agreement, in the Arabic, English, French and Russian languages, each version being equally authentic, shall be deposited with the Government of the Kingdom of the Netherlands which shall be the Depositary. The Depositary shall transmit certified copies of these versions to all States and regional economic integration organizations referred to in Article XIII, paragraph 1, of this Agreement, and to the Agreement secretariat after it has been established.

2. As soon as this Agreement enters into force, a certified copy thereof shall be transmitted by the Depositary to the Secretariat of the United Nations for registration and publication in accordance with Article 102 of the Charter of the United Nations.

3. The Depositary shall inform all States and regional economic integration organizations that have signed or acceded to the Agreement, and the Agreement secretariat, of:

(a) Any signature;

(b) Any deposit of instruments of ratification, acceptance, approval or accession;

(c) The date of entry into force of this Agreement and of any additional annex as well as of any amendment to the Agreement or to its annexes;

(d) Any reservation with respect to an additional annex or to an amendment to an annex;

(e) Any notification of withdrawal of a reservation; and

(f) Any notification of denunciation of the Agreement.

The Depositary shall transmit to all States and regional economic integration organizations that have signed or acceded to this Agreement, and to the Agreement secretariat, the text of any reservation, of any additional annex and of any amendment to the Agreement or to its annexes.