UNDERSTANDING OUR WETLANDS:

A RESOURCE BOOK FOR SECONDARY SCHOOLS

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FOREWORD

The Nile Basin Initiative (NBI) is a partnership between riparian countries of the Nile; namely Burundi, Democratic Republic of Congo, Egypt, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, and Uganda. The NBI's shared vision is to "achieve sustainable socioeconomic development through the equitable utilization of, and benefit from the common Nile Basin water resources". To translate this shared vision into action, there are two complimentary programs: the Shared Vision Program (SVP) which creates a basin wide enabling environment for sustainable development; and the Subsidiary Action Programs (SAPs) engaged in concrete activities for long term sustainable development, economic growth and regional integration of the Nile Basin countries.

The Nile Trans boundary Environmental Action Project (NTEAP), one of the projects under the Nile Basin Initiative's (NBI) Shared Vision Program, was mandated to provide a strategic environmental framework for the management of the trans boundary waters and environmental challenges in the Nile River Basin. One of the ways NTEAP met this objective was to develop wetlands education, training and awareness materials for use at five stakeholder levels as follows:

a) Understanding our Wetlands – A Resource Book for Primary Schools;
b) Understanding our Wetlands – A Resource Book for Secondary Schools;
c) Understanding our Wetlands – A Resource Book for Tertiary Institutions;
d) Wetlands Awareness resource book for Communities;
e) Wetlands Awareness resource book for Policy Makers.

This Resource Book for Secondary Schools, has been produced through a consultative and interactive process with the Regional Working Group Members of the Nile Basin Wetlands and Biodiversity Component and the Environmental Education and Awareness Component. The book has been designed to guide teachers to confidently address wetlands education issues while conducting classes for environmental education as an efforts to address the challenges of wetlands degradation and promote their wise use.

This book is reference for enhancing wetlands education and awareness in secondary schools in the Nile basin countries, with a long term goal of motivating professionalism for wetlands and biodiversity management from lower levels of education through to secondary and tertiary institutions. It is user friendly, designed for the extra curriculum education systems prevailing in each of the Nile basin countries. Awareness, learning and outreach materials such as brochures, handouts, charts, radio and TV programmes, cartoons, drama, role plays, and songs can be prepared using this resource book.

We hope that this book will be useful to teachers and practitioners wishing secondary schools students to learn about wetlands and their importance as an efforts towards their sustainable conservation.

Gedion Asfaw
Regional Project Manager
Nile Trans boundary Environmental Action Project

HOW TO USE THIS BOOK

Wetlands are very important ecological, socio-economic and cultural resources. Despite this, awareness and understanding of their services, functions and uses remains low amongst a large proportion of the people in the Nile basin region. This challenge stems from the fact that wetland functions and values, that contribute to people's livelihoods are less visible and inadequately appreciated, yet they are resources that contribute to poverty reduction in Africa.

This book is designed to improve the understanding and appreciation of wetland functions and values. It is a generic Resource book, consisting of several units that can be adapted or modified to suit the various learning needs and the curriculum of a particular country in the Nile Basin region. This Resource book has been prepared to provide an interactive practical approach to learning and may be used by both teachers and learners in Secondary Schools, in order to address the rapid degradation of wetlands which is currently a threat in the Nile Basin .

This resource book provides an invaluable source of information and activities that take learners through experiences that awaken their interest in the proper care and use of wetlands. In preparation of this Resource book, an attempt was made to show a variety of strategies that the teachers can use to involve the learners to recognise the importance of wetlands conservation. The units have been presented chronologically to enable the learners move from the known to unknown through hands-on activities and self-reflection, which is the basis for experiential learning.

The Resource book contains five units, namely Unit 1: Wetlands and their uses; Unit 2: Wetlands and biodiversity; Unit 3: Wetlands and water; Unit 4: Assessing and monitoring wetland status; and Unit 5: Conservation and management of wetlands. Each unit is introduced and followed by Unit objectives, exposition of the key concepts and a presentation of activities, exercises and questions to support learning. The numerous illustrations in the form of pictures or photographs are meant to make learning easy and the teacher is encouraged to formulate other relevant questions that will help the learners to develop the essential process skills such as observation and communication.

In this resource book the teacher is a facilitator who guides an interactive process to learning. A wetland near a school would be appropriate as additional learning aid to promote understanding of wetlands conservation. The teacher is also encouraged to choose or design other relevant activities, questions or exercises that can be monitored over a period of time. Furthermore, the teacher is encouraged to seek other sources of information or resources that may be locally available to supplement the information available in this Resource book. Although some of activities can be done inside the classroom, it is recommended that much of the interactions be conducted outside the classroom in conjunction with established school environmental or science clubs

ACKNOWLEDGEMENT

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The Nile Basin Initiative - Nile Trans boundary Action Project

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UNIT 1: WETLANDS AND THEIR USES

1.1 INTRODUCTION

Many people in the Nile basin region and the world at large are beginning to appreciate wetlands and their importance. Wetlands are among the most productive ecosystems of the world and with benefits that are less visible such as flood control, water purification and ground water recharge. However, they are among the worlds most degraded of all ecological systems. This resource book is designed for secondary education students to improve their understand on what wetlands are and their benefits to us, both direct and indirect. In this unit we shall specifically examine the following;

- Definition of wetlands
- Component parts of a wetland
- Formation of wetlands
- Types of wetlands
- Uses of wetlands
- Examples of wetlands of international importance

Learning Objectives

- Define the term wetland
- Describe how wetlands are formed
- List down correctly the different types of wetlands
- Give examples of wetlands in your country
- Give and explain the various uses of wetlands
- Apply the knowledge learnt to conserve wetlands in their localities and beyond

1.2 WHAT ARE WETLANDS?

Wetlands are areas where water covers the soil or is present either at or near the surface of the soil, all year or for varying periods of time during the year. Water saturation (hydrology) largely determines how the soil develops and the types of plant and animal communities living in and on the soil. Wetlands may support both aquatic and terrestrial species. The prolonged presence of water creates conditions that favor the growth of adapted plants.

Wetlands are therefore lands where saturation with water 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. One common feature that most wetlands share is soil that is at least periodically saturated with or covered by water Water in wetlands may be on a temporary or permanent basis, usually shallow, slow moving or stationary.

Although definitions of wetlands vary considerably, the Ramsar convention gives a more universal definition of wetlands as, "areas of marsh, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, brackish or salt. Wetlands are dynamic and complex ecosystems.

Exercise 1.1

Instructions: Find out what you already know about wetlands. Attempt this exercise before you read through this module. Write a **T** for true and **F** for false in the box provided.

Statements	**T for True F for False**
1. Wetlands are always wet.	☐
2. There are many kinds of wetlands.	☐
3. All wetlands are covered with water or have very wet soil during most of the year.	☐
4. There are thousands of plants and animals that live in wetlands.	☐
5. There are special plants that grow in wetlands. These plants love water.	☐
6. You may find frogs, birds, ducks, snakes, and insects in a wetland.	☐
7. Wetlands provide food resources to humans	☐
8. Wetlands clean the water by collecting dirt and pollution just like a sponge.	☐
9. Wetland degradation can cause severe impacts to the local communities.	☐
10. Wetlands may be referred to as wastelands.	☐

You can now proceed and read this Unit about wetlands, then attempt this exercise again after you have studied the Unit to see how much you have learned by comparing your scores for the exercise before and after.

Ramsar definition

"Areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, flesh, brackish or salt including areas of marine water the depth of which at low tide does not exceed 6 metres (80% of wetlands of international importance are fresh water wetlands

While most wetlands are natural sites, water bodies such as fish ponds, reservoirs and artificial lakes are also included under the definition of wetlands in view of their ecological, economic and cultural importance.

Figure 1: An example of wetland dominated by papyrus vegetation

Main Components of a wetland

A wetland in its natural state is composed of five components or features. These include;

- Water
- Soils
- Plants
- Animals

Wetland water

Water is the key element in wetlands that is, water must be there for a limited time season or through the year. Water modifies soil types and influences the plants and animals that exist. Wetlands water comes from sources including direct rain fall, run off water or from the groundwater.

Wetland soils

Soils are another vital component of wetlands. The wetland water has a profound impact on the types of soils. Wetland soils are waterlogged permanently or seasonally. Water logging creates anaerobic conditions, which in turn result in environments that are different from dry land soils. Wetland soils have high organic matter, which gives them a darkish colour. Wetland soils may also have high clay content. The high organic matter binds wetland soils together. Once lost, the soil falls apart and can easily be carried away by water and wind.

Wetland soils are often considered to be good for agricultural production because of the water availability and nutrient content in the organic matter. However, their productivity is linked to the water logging. Once the water is drained, the wetland structure and chemical properties change quickly. The organic matter breaks down, resulting in an overall breakdown of the soil structure and quick loss of nutrients.

Wetland plats and animals

Wetlands are one of the most diverse ecosystems in the world. A wide range of plants and animals live at least, part or all their life cycle in wetlands. In order to be able to do so, many plants and animals have evolved special adaptations to survive with soggy soil, fluctuating water and little oxygen. Plants are a vital part of the ecology of the wetland and form the basis for many of its beneficial functions such as; flood control, food and habitat for animals.

Wetland fauna are the animals. Other organisms include microbes. Microbes are small in size and can only be seen by microscope. They play a vital role in nutrient cycling as the main decomposers. These are broken down by mechanical and microbial action, becoming more nutritious and made available to smaller animals. It is important to note that organic material from a wetland provides both physical support and food for a major food web outside the wetlands. The macro-fauna, although large and often conspicuous, are beneficiaries of the plants, soils and nutrients that are in the wetland ecosystems.

1.3 WETLAND FORMATION

Wetlands are formed when water is retained or delayed within catchments long enough. The crucial ingredients for wetland formation are water and a place for it to collect. Rainfall and dew, which precipitate on the catchments that do not return to the atmosphere by either evaporation or transpiration, flow downhill through the catchments towards its lowest point. This may be in a depression or basin or where the slope along the valley is very slight. A wetland therefore forms where water collects and soil beneath becomes waterlogged. They can be also formed from underground water sources.

Wetland vegetation then develops, and as it becomes established, the speed of water flowing through the wetland reduces. The low speed results in the sedimentation of suspended silt in the water. This in turn promotes more vegetation growth and further reduction in water speed, causes the wetland to fill its banks slowly sideways across the valley. In the desert, Oases are formed when the water table which is close to the surface is exposed by the removal or erosion of sand by the action of wind.

We have seen that:

- *Wetlands are formed from rain water-run offs. This gathers in a flat low lying area.*
- *Wetlands are also formed at a point where a stream or river is slowed*
- *Wetlands can also be formed by the exposure of the water table by the removal of sand as in the formation of an oasis*

1.4 TYPES OF WETLANDS

The Ramsar convention recognizes six major types of wetlands. These include;

- **Marine wetlands;** These are coastal wetlands including, rocky shores, and coral reefs.
- **Estuarine wetlands;** These include deltas, tidal marshes, and mangrove swamps.
- **Lacustrine wetlands;** These are wetlands associated with lakes.
- **Riverine wetlands;** These are wetlands along rivers and streams.
- **Palustrine wetlands;** These wetlands include marshes, swamps and bogs.
- **Artificial wetlands;** These include fish ponds, reservoirs and artificial lakes.

ACTIVITY 1.1 VISIT A WETLAND

Prepare to visit a nearby wetland.

(i) Preparations for the field visit should include:
- Clear formed objectives for the field visit and what is required
- Consultations with your head teacher who will help you to mobilize resources
- Consultations with the leaders in charge of the wetland that you intend to visit
- Preliminary visit to the area
- Explanation to students on the objectives of the visit and what is expected of them, including questions to be answered.

(ii) Try and encourage pupils to note the characteristic land forms of the area, drainage and peoples' activities in the wet land and its catchment.

(iii) Use figure 1. To explain to the students the boundaries of wetland catchment and encourage them to discuss the importance of proper use and management.

While in the field, the major skills to be developed are observation, drawing, note taking and interpretation
Make observations on the following:

- Nature of rainfall of the area.
- Type of wetland
- Drainage path of the area and patterns of the wetland
- Land forms of the area (hills, valleys and flatland)
- Peoples' activities in the area
- The boundaries of the wetland (Catchment area)
- The activities taking place in it

Photograph 1: The Wetland and their role in protecting river banks and biodiversity Photo by Abeelsalah Ahemed Suden

1.5 IMPORTANCE OF WETLANDS

Wetlands are among the most precious natural resources on earth, existing as multiple value systems. These highly varied ecosystems are natural areas where water accumulates for at least part of the year. Driven by the hydrological cycle, water in the wetland is continuously being recycled through the land, sea and atmosphere in a process which ensures the maintenance of ecological functions. Wetlands are among the most productive ecosystems in the world and providing resources upon which rural communities depend on for food, medicine, building material, and dry season grazing. The functions and services provided by wetlands are therefore many and varied. They may be divided into either natural/ecological or socio-economic functions.

Photograph 2: Some of the Products made from goods harvested from wetlands (Photo by Henry Busulwa)

1.5.1 Ecological (natural) uses of wetlands

These are the indirect uses of a wetland which are less visible (are hidden) to humans but should always be appreciated. They include the following;

- Flood control
- Ground water recharge and discharge
- Water filtration and waste water treatment
- Habitat for plants and animals
- Sediment retention
- Carbon retention
- Climate modulation

Flood control

Wetlands play an extremely important role in reducing harmful and costly effects of the flow of storm-water. They are Land slow down the speed of water flow from heavy rains. The reduction in speed lessens the harmful impacts of flooding during the rainy seasons. Wetlands therefore act as natural sponges that trap and slowly release surface water over time. When water pours into a wetland after a storm, the wetland will flood, but it will do so slowly and over an extended period of time. This ability to store water in periods of heavy rainfall means that wetlands can help reduce flooding. In areas where wetlands have been drained, heavy rains cause

floods that damage crops, livestock, infrastructure and humans may also drown in the flood waters. Conserving wetlands therefore offers opportunity for flood control. Many cities in the Nile basin region have faced serious problems of floods in the recent past due to wetland degradation.

Groundwater recharge and discharge

Wetlands play an important role in replenishing or "recharging" ground water supplies and maintaining ground water levels. By retaining the water for long, the wetland allows the water to infiltrate into the underground aquifer and discharge this water in the dry season thus feeding bore holes, wells and springs. Wetlands also discharge water into rivers and lakes.

Water filtration and waste water treatment

Wetlands have the remarkable ability of improving the quality of water by filtering runoff and removing sediment, nutrients, pesticides, metals, toxins, and other types of pollutants. This is because, the speed of the water reduces as it enters the wetland while it filters slowly through the vegetation.

These pollutants that are often dissolved in water are absorbed by wetland plants and microorganisms in the soil. In many cases, this filtration process removes much of the water's nutrient and pollutant load, so that by the time it leaves a wetland, the water quality has greatly improved.

Habitat for plants and animals

Wetlands provide important habitats to countless bird, fish, and native plant species. Because wetlands are among the most productive ecosystems in the world, they provide habitats for more aquatic and terrestrial species on wide area basis than any other habitat type, making them to be among the most ecologically important ecosystems on earth. The abundant vegetation and shallow water provide diverse habitats for wildlife species of plants and animals, including fish. Aquatic plant life flourishes in the nutrient-rich wetland environment and energy converted by the plants is passed up the food chain to fish, bird, other wildlife and to humans as well.

Sediment retention

Materials that are eroded from the surrounding catchment by rainfall and carried into wetlands by surface runoff can be trapped in the filtration and sedimentation processes that occur in wetlands. Sediment retention prevents downstream resources of dams, farmland, rivers and lakes from being silted up. Retention of sediment also helps to cleanse the water. Sediment retention by wetlands generally benefits those down stream. Facilities such as water storage dams and irrigation schemes that would fill with sediment are protected from in-filling and their lifespan increased. However, it may also gradually lead to in-filling of the wetland resulting eventually into dry land conditions, depending on the amount of silt being received from catchment.

Carbon retention

Wetlands absorb carbon dioxide from the atmosphere through photosynthesis by wetland plants thus acting as carbon sinks. In carrying out photosynthesis, wetland plants convert atmospheric carbon dioxide into biomass. This retention of carbon dioxide greatly reduces global warming of the atmosphere.

Climate modulation

Wetlands modulate local and regional climate by evaporating enormous quantities of water into the atmosphere. This process of evaporation reduces air temperature and increases humidity thus providing cool climate. Wetlands therefore act as local "air conditioners". Dust in the atmosphere is reduced, and the air quality is improved. The presence of a wetland also helps to trigger rainfall in its catchment.

1.5.2. Socio-economic uses of wetlands

These are the direct benefits of wetlands to man which are visible and appreciated. Despite of these direct benefits, wetlands continue to undergo serious degradation. These uses include the following;

Water supply

water is the most important product of wetlands. Water occurs in all wetlands either permanently or seasonally. Wetlands able to retain water for long periods once undisturbed thus making it available for local people and domestic animals. The water supplied by wetlands is free and usually clean. Generally the wetland water is used for, rural and urban domestic use, livestock and industrial use and for irrigation.

Wetland Fisheries

Wetlands have a great importance and potential in fisheries. Large amounts of fish are present in wetlands which provide valuable protein to local communities. This is important for those who are unable to afford other sources of proteins. The common types of fish found in wetlands include, the catfish, lungfish, and some tilapia. Wetlands also act as breeding and nursery grounds for commercial fish species, including tilapia and the Nile perch. Thus, the fish biomass in the lakes depends upon the existence of fringing wetlands.

Provision of craft and building materials

Wetlands provide a variety of craft and building materials such as reeds, grasses, sedges, papyrus and palm trees that are usually harvested for thatching and mulching or processed into items used domestically such as baskets, mats and furniture. Crafts like those shown in photograph 2, add beauty to the home, promote culture and provide employment and income when sold. Timber, sand and clay are often extracted from wetlands in many areas of the Nile basin region for building. Sand and clay are also used for making bricks, tiles and pottery, while wetland trees are used to make doors, roof supports furniture and fences.

Photograph 3: A fish caught and sold in the Nile Basin (Photo by Henry Busulwa)

Livestock grazing

The parts of wetlands, where the soil is permanently or seasonally moist are often used as grazing areas for livestock especially during the dry season. For example the Sudd wetland in southern Sudan supports large numbers of domestic animals during dry seasons.

Recreation and eco-tourism

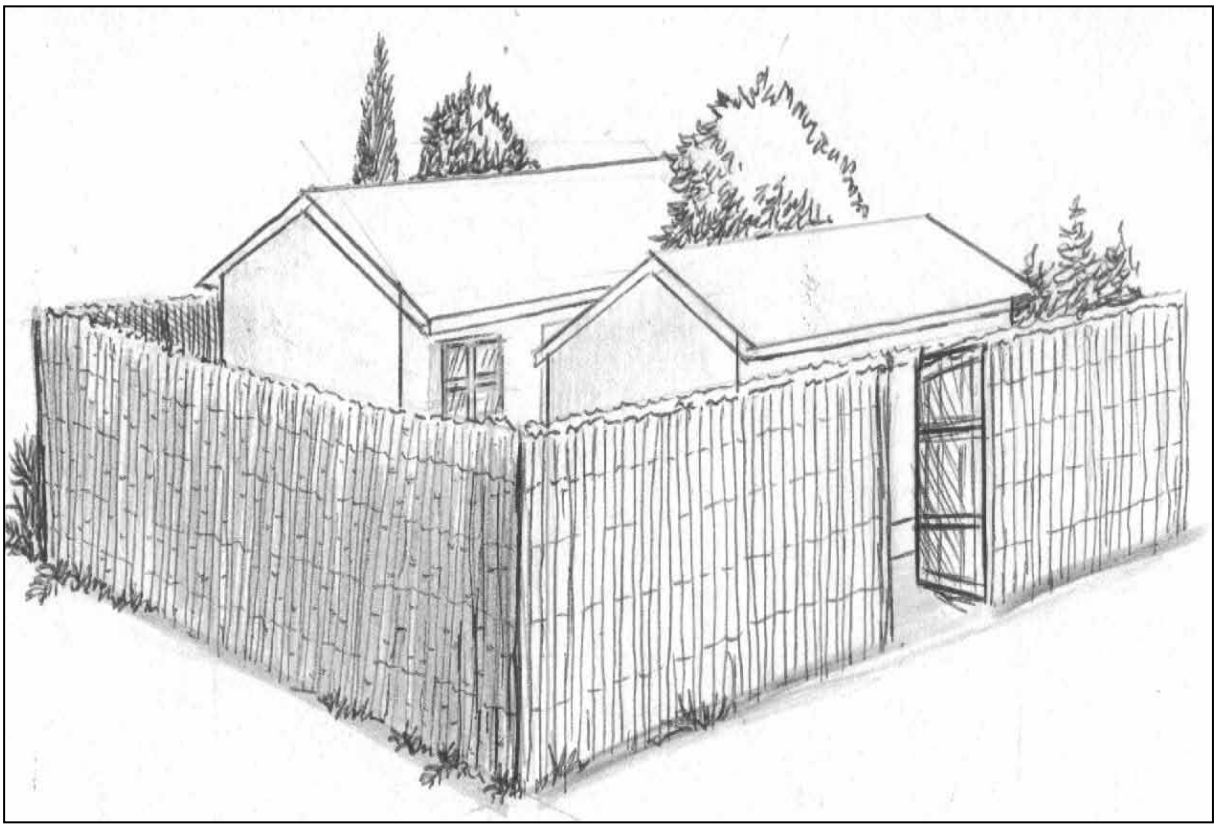


Figure 2: Wetlands materials used for building

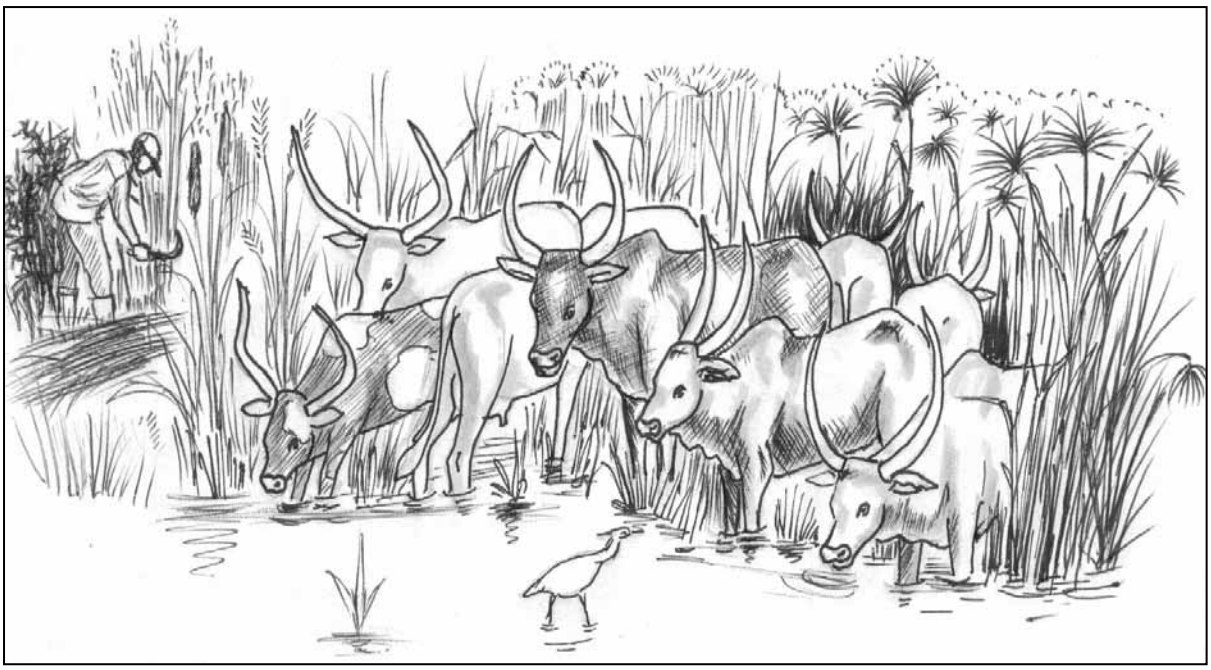


Figure 3: Wetland for grazing and are watering points for livestock and other animals

The diversity and beauty of wetland biological communities has a potential for earning tourism income. Some wetlands can be developed for recreation and eco-tourism, especially in national parks. There are many recreational activities that are dependent on wetlands such as hunting, bird watching, boating, and wildlife photography

ACTIVITY 1.2

Wetland uses

Having gone through the first part of this Unit, familiarize yourselves with the various wetland products and services.

- One of the most effective approaches is to use pictures and to help pupils to interpret them. The teacher should look for other pictures and photographs that can be used for this exercise.
- Take the class to a nearby wetland in order to consolidate students' knowledge on uses of wetlands. Prepare a series of questions for your class to respond to on wetland uses
- Encourage students to note the various uses of wetlands in the area that they are visiting and to quantify the different products.
- It should be easier for students to answer questions posed in the exercises, and to discuss their answers with class mates, giving clarification where necessary. Clarify these responses where necessary. The major skills to be developed among the students are observation critical thinking, drawing, taking down notes, interpretation and communication

Exercise 1.2:

i) Name the products got from wetlands near your school or community. What materials are they made of?
ii) What other products are got from wetlands in your country?
iii) Write down what happens when we over harvest the wetlands products
iv) In groups, discuss the ecological importance of wetlands. Write down the main points of your discussion and show it to your teacher.

Does your answer include any of the following?

1) Products such as water, sand and clay; Baskets, chairs and mats; Building poles and grass for thatching; Medicinal plants?
2) Ecological importance: Flood control, ground water recharge, water filtration, habitat, erosion control, sediment retention, and carbon retention and climate modification?

1.6 WETLANDS OF INTERNATIONAL IMPORTANCE

On page The international definition for wetland was given as

"Areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, flesh, brackish or salt including areas of marine water the depth of which at low tide does not exceed 6 metres

In response to the Ramsar Convention on wetlands of international importance, countries of the Nile basin region have so far gazetted the following sites as Ramsar sites or wetlands of international importance; Which of ramsar are in the Nile Basin region?

ACTIVITY 1.3

Wetland functions:

Another visit to a nearby wetland will help students to consolidate knowledge on wetland functions. A series of questions for the class to respond will be useful

- Encourage students to note and discuss the various functions of wetlands in the area that they are visiting.
- They should then answer questions posed in the exercises.
- Clarify students' ideas where necessary.
- List of the various functions of wetlands. How do wetlands perform these functions?

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	15/Sept/2006
	L. Opeta wetland system	15/Sept/2006
	Lutembe bay wetland system	15/Sept/2006
	Mabamba bay wetland system	15/Sept/2006
	Nabajjuzi wetland system	15/Sept/2006
	Murchison falls-Alberta Delta wetland	15/Sept/2006
	Sango-bay-Musambwa island-Kagera wetland system	15/Sept/2006
KENYA	L. Nakuru	5/June/1990
	L. Bogaria	27/Aug/2001
	L. Naivasha	10/April/1995
	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

- Discuss the role of plants in the water filtration process of wetlands.
- Write a story about the wetland you visited and things that happen in and to it.
- From your interaction with the wetland, compose a poem about wetlands and their value to you.

The major skills to be developed among the pupils are observation, drawing, taking down notes, interpretation and communication

Exercise 1.3

- What are wetlands?
- Describe how wetlands are formed.
- In which way can wetlands be source of wealth for your community?
- In the past, wetlands were regarded as wastelands. Why is this inaccurate perception?
- Discuss the likely consequences of wetland degradation to the communities in your country.

1.6 UNIT SUMMARY

In this Unit we have;

- Defined the term wetland
- Explained how wetlands are formed
- Given examples of wetlands in the Nile basin region
- Wetlands roles, values and uses.
- Reasons for conserving wetlands

1.7 FURTHER READING

Wetland Inspection Division (WID). 2004. Wetlands Resource Book. Ministry of Lands, Water and Environment, Uganda. Kampala: MOWLE Publications.
United Nations Development Programme (UNDP). 2005. State of World Environment Report. Nairobi: UNDP Publications.

UNIT 2: WETLANDS AND BIODIVERSITY

2.1 INTRODUCTION

In the previous Unit, we examined wetlands and their uses. This Unit is mainly concerned with the diversity or variety of life in wetland ecosystems. Wetland ecosystems are habitats of a diversity of living things. Wetlands provide the water and other nutrients essential to the life countless species of plants, animals and other organisms. In this Unit we shall therefore explore the various wetland plants (flora), animals (fauna) and other organisms, and how they are adapted to the wetland ecosystem. We shall also give examples of Important Bird Areas (IBA's) in the Nile Basin Region.

Learning Objectives

By the end of this unit, students' should be able to:

- Define the term biodiversity
- Explain the importance of biodiversity
- Identify the various flora and fauna that inhabit wetlands.
- Describe the adaptations of wetland fauna and flora.
- Identify some IBA's in the Nile basin region

Definition of Biodiversity

Biodiversity is the variety and variability among living organisms and the habitats in which they occur. The term includes different ecosystems, species, genes, and their relative abundance. In simple terms, this means the variation of life forms within a given ecosystem, biome or for the entire earth. It is a measure of the relative diversity among organisms.

Biodiversity can be classified into three levels of identification:

(i) **Genetic diversity:** This is the diversity due to different genes found within a population of a single species, and the pattern of variation found within different populations of the same species. Genetic adaptations to local conditions result in genetic differences between the populations of the same species.

(ii) **Species diversity:** This is the observable variety and abundance of different types of organisms which inhabit an area. "Biodiversity hotspots" are excellent examples of species diversity.

(iii) **Ecosystem diversity:** This encompasses the variety of habitats that occur within a region, or the mosaic of patches found within a landscape. Or it may refer to diversity at a higher level of organization, the ecosystem.

We have seen that:

"Biodiversity is the variety and variability among living organisms and the habitats in which they occur. The term includes different ecosystems, species, genes, and their relative abundance."

ACTIVITY 2.1

Visit a wetland near your school and make observations about the diversity of life in the wetland functions.

- Make a list of the various plants, animals and other organisms found in the wetland (and their numbers where possible). You may use both the local and scientific names.
- Design and describe a method that you can use to list the organisms in the various parts of the wetland. use your knowledge of ecology to help you do this.
- Compare the diversity of wetland with terrestrial habitats
- Discuss the role plants, animals and other organisms play in the wetland eco-system.
- What are the adaptations of the various plants and animals found in the wetland?

Note:

- Help students to identify the organisms in the wetland. They should be helped with the scientific names of common plants and animals
- Ask students to note down the relative abundance of plants and animals in the wetland using basic ecological techniques
- Students should also note the key adaptations of wetland plants and animals, and to discuss them in groups.
- The students should then list the adaptations of each wetland animal and explain the importance of each adaptation
- Guide them to clarify their views

The major skills to be developed are observation, investigation, drawing, note taking, communication, interpretation and social skills such as leadership

2.2 THE BIOLOGICAL DIVERSITY OF WETLANDS

Wetland ecosystems are habitats 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. Endemism refers to a place where an organism evolves and lives.

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. Look at figure 3. below identify and name common plants and animals

In Africa and the Nile Basin in particular, the biological diversity of wetlands is unevenly distributed, with some habitats being characterized by a richer range of species than others. Wetlands in areas of high rainfall and warm climates such as the Sudd in Sudan have richer species diversity than those of drier regions.

Wetland biodiversity is not only assessed by the overall richness in number of species present, but on the uniqueness of wetlands in terms of the number of localized species, particularly the endemic ones. Most wetlands in the Nile basin region display

both characteristics, that is richness in number of species and endemism. In this regard, wetland areas of highest endemism and of international significance in the Nile basin region include; the Sudd wetland of Sudan, the swamps of Western Tanzania, and Lakes Victoria, Kyoga and George in Uganda.

2.3 WETLAND FAUNA AND FLORA

Wetlands support a wide variety of plant and animal life, from floating water plants to marsh vegetation, from grazing mammals (e.g. Cattle, goats, sheep) to fish and invertebrates (mainly snails and insects). It's important to note that the biological diversity and biological productivity is great and exceeded only by some tropical rain forests.

Wetlands are one of the most diverse ecosystems in the world. A wide range of plants and animals live at least part of their life cycle in wetlands. However life in wetlands is not easy and many plants and animals have evolved special adaptations to survive with soggy soil, fluctuating water and little oxygen. Once they have developed functional systems and structures to survive they have a definite advantage over non adapted species.

2.3.1 Wetland Plants

Role of wetland plants

Wetlands support a high diversity of plants far in excess of what would be predicted when considering the relative land area they occupy. Each wetland community has a variety of plants which provide shelter and food for many of the animals living there. Wetland plants are therefore, an integral part of the ecology of the wetland and form the basis for many of its beneficial functions, including

- Plants are responsible for drainage and water control
- Plants provide the physical habitat or shelter for the animal populations
- Plants are a major food resource for the wetland fauna (animals).
- Plants provide food and goods (papyrus as building materials) for humans.
- Plants add oxygen to the water for underwater species

Wetland plants face serious challenges within the wetland ecosystem. These include;

- The soil is often weak or difficult for the roots of the plants to reach.
- Fluctuating water depth
- Oxygen levels in the soil are low
- Some wetlands are low in nutrients
- Some wetlands have little or no oxygen in the root zone.

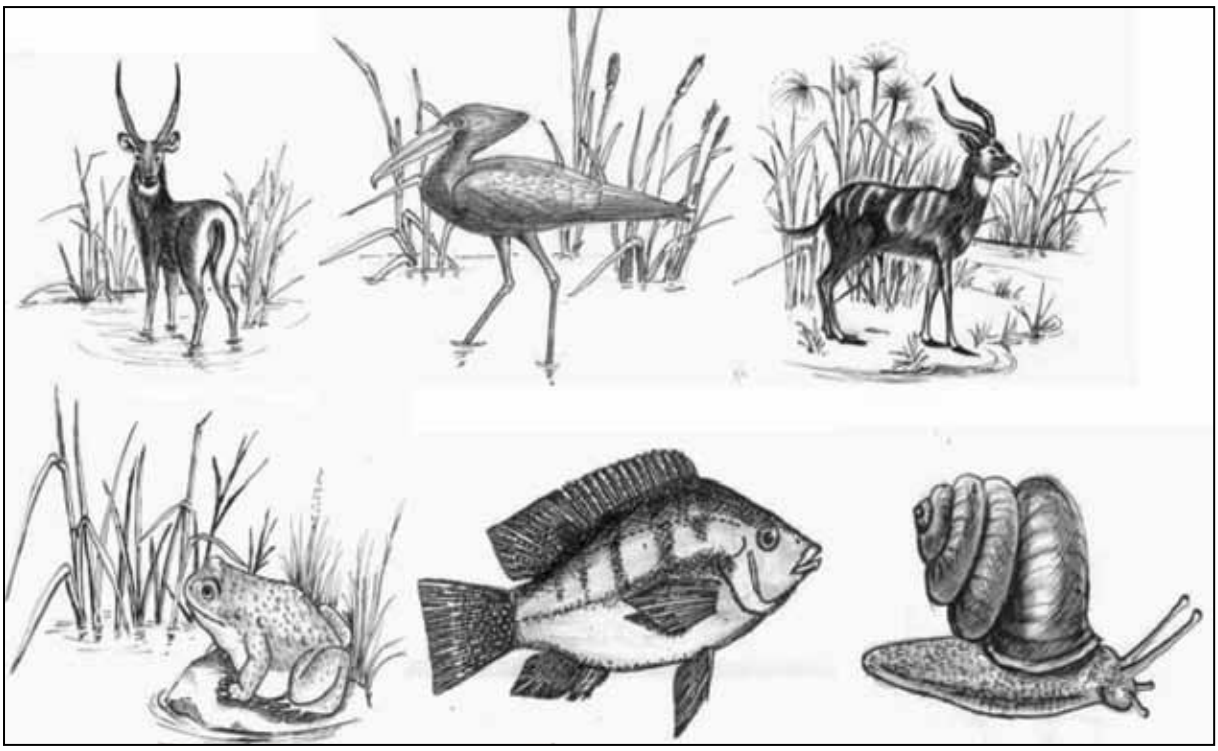


Figure 3; Some common wetland biodiversity

Adaptations of 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.

Summary of adaptations of plants to wetland conditions

Fluctuating water depths

- Plants have developed elongated stems.
- Plants have developed floating leaves or stems
- Plants have developed water retention structures

Oxygen deficiency

- Plants have developed porous stems and roots
- Plants undergo anaerobic respiration
- Plants have developed very fine root mat.
- Plants have developed lateral air roots

Toxic elements in the root zone

- Plants have developed (efficient) metabolism.
- Plants have developed immobilization techniques
- Plants have developed secretion structures

Nutrient deficiency

- Plants have developed (efficient) metabolism
- Plants have developed nutrient retention or withdrawal from mature stems

2.3.2 Wetland animals and microbes

Role of Wetland animals and Microbes

Wetland fauna includes microbes and animals. Microbes are the smallest in size but play a vital role in nutrients cycling as the main decomposer organisms in the system. Dead organic matter is broken down by mechanical and microbial action, becoming more nutritious and available to smaller animals and plants.

Wetlands are also habitats for large animals especially mammals. This heavy dependence of large mammals on wetlands and their products is of great economic value to the Nile Basin countries and Africa in general, since they are the main source of the tourist industry. These Animals include; elephants, buffalos, antelopes, hippos, zebras and the major predators lions, wild dogs, and hyenas. The lives of these mammals are often inextricably linked to wetlands, e.g. Amboseli swamp in Kenya is the main water source of Animals in the surrounding area during the dry season. In addition to mammals, wetland ecosystems also inhabit a great number of other animal species, such as birds, fish, reptiles, amphibian, and invertebrates.

Adaptations of animals to wetland conditions

Like wetland vegetation the animals have adapted to conditions in 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 brings about competition for food and enables large 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.

Summary of adaptations of wetland animals to wetland conditions

Breathing

- Fish, amphibians and insects breathe through gills
- Lung fish uses lung like structure to supplement gill filaments

Mobility

- Some animals have long hooves for easy movement
- Some have webbed and elongated toes eg birds.
- Developed water proof bodies
- Have muscular and streamlined smooth bodies for swimming

Feeding

- Adapted to feeding a various levels e.g. Sitatunga
- Have well developed feet and beak for feeding at different depth in the mud or water.

Note the following:

- Several environmental factors affect an organism's survival in a wetland. Each species living in a wet land has developed special adaptations for its survival.
- The ability to stay under water for extended periods of time, whether

to get food or avoid becoming food, is essential for the survival of many wetland animals.

- Staying under water can have severe drawbacks, like drowning unless an organism is specially adapted to the conditions.
- Many wetland animals have gills that take in oxygen from water, but others may not but continue to live in water. They have special behavioral adaptations to survive in the wetland conditions?
- Wetland plants survive under conditions of low oxygen. They have capacity to collect oxygen from the air and use it in the roots where it is little or none at all

2.4 ASSESSING BIODIVERSITY

In order to recognize biodiversity loss, and set conservation priorities efficiently, it is necessary to accurately assess biodiversity. There are two main methods of assessing biodiversity

a) Full Biodiversity Assessment

Assessment of the biodiversity of a given area requires identifying every individual species, from the smallest worm to the largest tree. Besides the compilation of a species list, it is also necessary to note the sizes and abundance of each organism in order to build up accurate pictures of the population. In most cases some ecological notes are also made, particularly with regard to organisms that do not move from place to place. This is a very comprehensive study, although time consuming.

b) Spot check Analysis

A spot check analysis will identify most of the species in an area, particularly those that dominate or are particularly common. This allows us to create a fairly accurate assessment of an area's biodiversity, without the time required to search out the less common and more elusive species.

In the above two cases biodiversity assessment is affected by an ever changing ecosystem. It is therefore important to carry out repeated assessments to get much better idea of conservation status.

Biodiversity can also be assessed through the "ecosystem approach" which is the primary framework for the implementation of the Convention on Biodiversity. This approach requires that, in the assessment of biodiversity all the components of biodiversity are considered. The ecosystem approach is described as a strategy for management of land, water and living resources that promotes conservation and sustainable use in an equitable way. It is based on the application of appropriate scientific methodologies focused on levels of biological organization which encompass the essential processes, functions and interactions among organisms and

their environment, and among ecosystems. It recognizes that humans, with their cultural diversity, are an integral component of ecosystems.

The assessment of biodiversity should include identification and monitoring of ecosystems and habitats as well as identification, monitoring and assessment of species. In order to accelerate environmental research without having to wait for results from traditional taxonomy, which is perceived to be slow to deliver because it is based on monographic treatments, new methodologies have been developed for assessing biodiversity. These include inventories, surveys, rapid biodiversity assessment, monitoring, and the use of indicator species.

c) Identification, monitoring and assessment of species

The major problem with species is that there are a very large number of them, a high proportion of which, particularly invertebrates, are not described. Moreover, the identification of described species often requires a high level of expertise. Identifying all species in a limited area is thus a very hectic task and generally impractical.

d) Identifying and monitoring ecosystems and habitats

The classification of the natural environment is highly variable can be done in many ways. Ecosystem structure variables are the most promising indicators of biodiversity because they can offer a lot of information on the state of ecosystems. There are variables which can indicate if the ecosystem is functioning correctly or not. For example, a measure of a number of species in a habitat types observed within an areas can give an indication of how that ecosystems functions.

ACTIVITY 2.2

Monitoring of biodiversity

Visit a wetland near your school and observe the diversity of life in the wetland.

- Identify and make a list of selected plants, animals and other organisms found in the wetland. You may use both the local and scientific names.
- Observe changes in the types and numbers of these organisms over time.
- What changes have you observed in the diversity of these organisms?
- Discuss the reasons that may have been responsible for the changes in the numbers and types of these organisms in the wetland
- Why is it important to monitor biodiversity in our wetlands?
- Select animals to be monitored in the wetland and
- Ask students to periodically monitor changes in the numbers of the selected species and to advance possible reasons for the observed fluctuations
- Note the key adaptations of wetland plants and animals, and to discuss them in group and team work.

The major skills to be developed are observation, investigation, communication, interpretation and social skills such as leadership

2.5 IMPORTANT BIRD AREAS IN THE NILE BASIN

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, based on up-to-date knowledge of the sizes and trends of bird populations. The criteria ensures that the sites selected as IBAs have true significance for the international conservation of bird populations, and provide a common measure 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 criterion have 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, 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; that is 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 congregated birds; i.e. if a site is known to hold on a regular basis, a large number of congregated 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.

REMINDER:

An Important Bird Area (IBA) is an area designated as globally important habitat for the conservation of bird populations. IBAs are determined by an internationally agreed set of criterion. To be listed as an IBA, a site must satisfy at least one of the following conditions:

- Provide habitat to sustain a population of an internationally threatened species.
- Provide a habitat for large numbers or concentrations of migratory birds, shorebirds, or seabirds.
- Be part of a large number of range-restricted or biome-restricted species.

Some examples of IBAs in the Nile basin region

Uganda; Thirty sites have been identified as IBAs in Uganda, covering roughly 7% of the country. Ten sites are National Parks, seven are Forest Reserves and three are Wildlife Reserves, the rest have no formal protection status. One of the IBAs is the Nabugabo wetland which consists of Lake Nabugabo, a shallow freshwater lake, and extensive swamps and small forests to the north, east and south, where Sango Bay adjoins. Three much smaller satellite lakes, Birinzi (formerly Kayanja), Manywa and Kayugi are located to the north-west at a slightly higher altitude. Conservation issues Expanding tourism developments along the north end of the western shore, burning of the swamp and overfishing are all potential threats to this IBA. Land-use of the catchment is mainly rough grazing, and there are areas of mature, but degraded, forest and woodland. The species under protection include;

- Shoebill *(Balaeniceps rex)*
- Red chested sunbird *(Nectarinia erythrocerca)*
- Nothern Brown-throated weaver *(Ploceus castanops)*
- Papyrus Gonolex *(Lanarius mufumbiri)*

Burundi: Rusizi National park protects many of endangered species in the area. It is located north-west of Bujumbura against the international frontier with Democratic Republic of Congo. It is made up of two parts; a strip of flood-plain about 2 km. wide and 35 km. long beside the east bank of the Rusizi river and, to the south, a smaller area comprising the delta of the Rusizi at the point where it enters Lake Tanganyika.

Rwanda: Has a number of among which IBAs which is the Rugezi marsh which is located in a water logged valley, in the north of Rwanda, to the east of Lake Burera on Uganda border. The vegetation of the marsh is dominated by *Miscanthidium violaceum* with stands of *Cyperus latifolius* around the fringes and an area of papyrus *(C. Papyrus)* near the point of outflow.
The Rugezi marsh has no legal protection and is under pressure from agriculture. The vegetation of the marsh is cut and burned during the dry season, resulting in progressive habitat degradation. The need to conserve Rugezi is urgent.
A management programme involving local communities is required. Fires sweep the area during the dry season, (June-September). Despite the intense human pressures on the area, it has remained in relatively good condition, especially in the north.
Common species of birds endangered include;

- White-winged tern *(Chlidonias leucepterus)*
- African skimmer *(Rynchops flvirostris)*

Threats to IBAs

The main threats affecting IBAs in the Nile basin region are;

- Agricultural encroachment and habitat clearance
- Over-exploitation such as hunting and clearance for fuel wood
- Commercial logging.

Way forward

Bird life International which is an NGO raising awareness about birds recommends the following actions to conserve Africa's IBAs and birds:

- Designation and protection of IBAs under international agreements where the relevant criteria are
- Designation of IBAs as protected areas under national law
- Adherence to national and international law regarding site protection
- Involvement of local communities, NGOs, land-users and the public in IBA protection
- Effective and adequate management of IBAs
- Integration of environmental objectives into all policy sectors
- Maximization of the use and dissemination of data; and
- Monitoring of IBAs in order to help refine conservation and policy mechanisms

Examples of wetland bird species


Egret


Egyptian Geese


Pied African wagtail

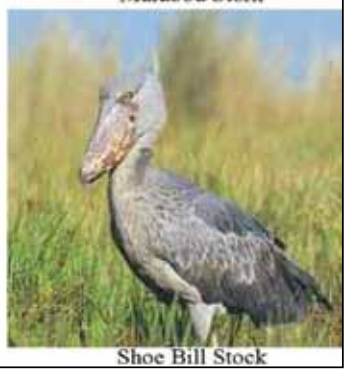

Marabou Stork


African Snipe


Hammerkop


Pied Kingfisher


Glossy Ibis


Shoe Bill Stock

ACTIVITY 2.3 A VISIT TO AN IBA

Each country in the Nile basin region has at least one Important Bird Area (IBA). Make efforts to visit the nearest IBA in your country, and observe the various bird species in the area.

- What type of bird species do you think were the basis for the selection of the area as an IBA?
- What human activities around the area that might threaten the IBA that you have visited?
- Other than the bird species in the area, what other species of plants and animals do you think need protection? Explain why.
- Make a list of IBAs that exist in your country.
- Using the criteria provided, what other sites in your country do you think can qualify to be IBAs?

2.6 UNIT SUMMARY

In this Unit, we have been able to;

- Define the term biodiversity
- Explain the importance of biodiversity
- Identify the various flora and fauna that inhabit wetlands.
- Describe the adaptations of wetland fauna and flora.
- Identify some IBA's in the Nile basin region
- Techniques for monitoring and assessing biodiversity

2.7 FURTHER READING

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- http://www.eoearth.org/article/Eastern_Africa_and_freshwater_resources

UNIT 3: WETLANDS AND WATER

3.1 INTRODUCTION

Fresh water is among the most critical natural resource with out which life on earth would be very difficult. The largest amount of the water on earth, about 97 percent, is stored in the oceans but this is not fresh water. The next largest amount of water, about 2 percent, is stored as ice in glaciers and polar ice sheets. A little more than half of the remaining one percent of water is stored underground as groundwater. The remaining less than one-half percent of the water on earth is stored in lakes, rivers, and wetlands, and as vapor in the atmosphere.

Fresh water available on earth for human survival is becoming one of the world's major concerns due to uncertainty in terms of availability, quality and quantity. Fresh water resources including lakes, rivers, streams and wetlands are slowly but surely deteriorating in quality and quantity due to pollution and other activities caused by humans and effects of climatic change respectively. The processes involved in the water or hydrological cycle such as precipitation and evaporation are greatly affected by human activities hence consequences such as drought and floods in different regions of the world, including Africa.
This unit will expose you to the key roles of wetlands in the hydrological cycle, water supply, storage and purification. The specific learning objectives are identified below.

Learning objectives

By the end of this unit, students' should be able to:

- Outline the major water uses of wetlands
- Explain the role of wetlands in maintaining the hydrological cycle
- Describe the hydrological cycle and how human activities in wetlands affect its processes.
- Explain the relationship between wetlands and hydrology of a given area in terms of water availability/supply, quantity and quality.
- Carry out simple water quality and quantity assessment in wetlands and their catchments.

3.2 THE HYDROLOGICAL CYCLE

It is important to note that water does not remain locked up in the oceans, icecaps, groundwater systems, or the atmosphere. Instead, it is continually moving from one reservoir to another. This movement of water is called the hydrologic cycle. The hydrological cycle involves three main phases and these include; precipitation (in form of rain, hail dew and frost or snow), evaporation (from land, water bodies and plant surfaces) and surface and ground water run off.

- Precipitation involves all processes by which water moves from the atmosphere to the earth's surface.
- Evaporation is the process by which water returns to the atmosphere as water vapor

It is widely accepted that wetlands have a significant influence on the hydrological cycle. Wetlands have therefore become important elements in water management policy at national, regional and international level. There are many examples where wetlands reduce floods, recharge groundwater and other global water balance aspects. Understanding the hydrological cycle is therefore the cornerstone of understanding our wetlands.

Water that falls to earth as precipitation follows many paths on its way back to the atmosphere. Precipitated water may be intercepted and taken up by plants; it may infiltrate the soil; or it may flow over the land surface or through the subsurface to reach streams, lakes, wetlands, and ultimately the ocean. Some of the discharged water is evaporated from surfaces and transpired by plants to reenter the atmosphere, and the hydrological cycle continues.

Wetlands form part of the essential fresh water resources and play a key role in the hydrological cycle. They store and purify water naturally, control floods and pollution. If you want to assess the role of wetlands, go down in the valley and look up the surrounding hills especially during or after a heavy down pour (rain), you are likely to see the effects of various human activities such as agriculture, infrastructure development, farms and industries on the quality of the water. You are likely to see or to find out that water contains solid wastes, plastic bottles, agriculture and industrial chemicals, decomposing organic matter and eroded top soil being washed down into the valley where wetlands are normally found.

ACTIVITY 3.1:

The Hydrological Cycle

- Using the information provided, draw a diagram of the hydrological cycle and illustrate the role wetlands play in the cycle.
- Identify and discuss the various human activities that could have a big impact on the hydrological cycle in your area.
- In groups of six people, discuss the various ways in which climate change could have an impact on the hydrological cycle. Share your answers with the teacher and draw up a joint class list of impacts of climate change on the cycle.

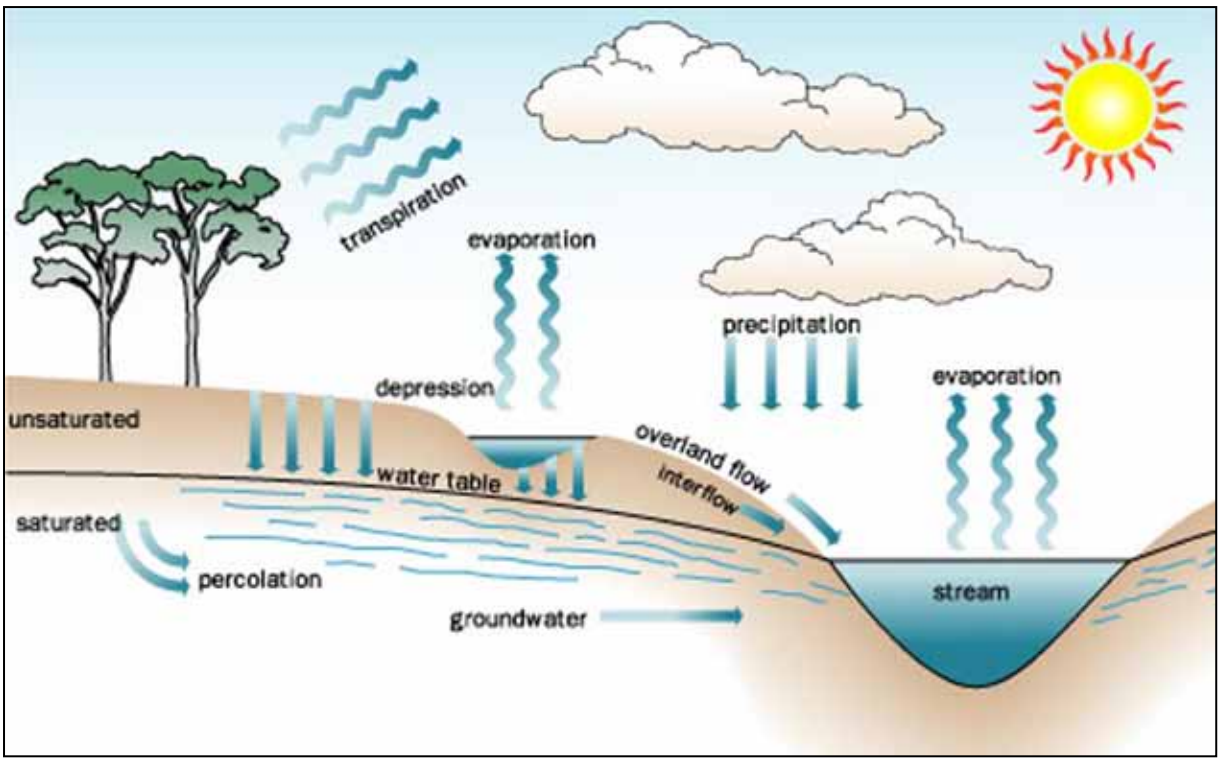

Figure 4 . The hydrological cycle.

3.3 FLOOD CONTROL

When water flows into a wetland from rivers, streams, rain or surface run off, it normally spreads the water over a wide surface area. The gradient reduces the speed of the water and this enables it to gradually pecorates and while the rest moves into the wetland an even much reduced speed. Wetlands therefore have the ability to soak or absorb a huge volume of water throughout the year and release it slowly through streams and rivers. This is an essential function of a wetland through which water is stored and at the same time being able to control flooding in the catchments areas.

Many cases of floods reported in Africa are directly or indirectly a result of wetlands clearance, in-filling, industrial or infrastructure development. This illustrates the lack of awareness of the people about the role wetlands play in the water cycle (hydrological cycle). If you interfere with the water way by any means, like digging channels or encroaching on wetlands, the water will always find, locate, trace and follow its natural path. The water will in the process cause destruction of property.

The effectiveness of wetlands flood control and water storage depends on the:-

- **Size of the wetland:** A larger wetland provides a greater surface area over which water is stored and reduction in flow speed (velocity). If a wetland is reduced in size due to encroachment or reclamation, then its ability to store water and control floods reduces significantly.

- **Type and density of vegetation:** The presence of emergent papyrus, reeds and other sedges with numerous fibrous roots enables a wetland to effectively slow down the speed of water flow and at the same time increase the wetland's ability to hold and purify water.
- **Slope across and a long a wetland:** A small gradient/slope reduces the water flow speed.
- **Drainage channels:** These increase the speed of water flow through the wetland. Agricultural activities in this respect therefore have a significant impact on the water storage and storage functions of a wetland.
- **Location of the wetland with in the drainage basin:** The most effective location for flood control wetlands are at the foot of hills and in the upper regions of the main valley of the system.

ACTIVITY 3.2: WETLANDS AND WATER

Arrange a visit to the wetland to enable students to conduct field activities on water discharge, purification and quality.

- Students may group themselves for this exercise
- Clearly state the objectives of the exercise.
- Remind the students of the requirements and the procedure to follow
- Carry out a reconnaissance of the area and make final arrangements for the visit.
- Guide the students to carry out the exercise.

The major skills to be developed are observation, investigation, communication, interpretation and social skills such as leadership and teamwork

Materials required:

- Protective gear (e.g. Gumboots, Gloves, Overall coats, etc)
- Note book
- Pencil
- Camera (if you have access to one)
- Water quality assessment equipment e.g. Thermometer, pH meter etc

Main objective of the study:

To make a general survey of the water related functions/services of your local wetlands and examine the water quality, quantity and potential pollution sources mainly due to human activities.

Observation stage:

- Divide your selves into groups and select a coordinator/group leader for each group.

- Set specific objectives of your survey based on the set general objective (aim).
- Identify all the necessary requirements for your fieldwork and make a checklist.
- Choose a day for your fieldwork with very clear guidelines on the scope of the study, safety measures including First Aid facilities, time frame (duration for different activities), general conduct and specific responsibilities for each group and group member. Remember teamwork is very important!
- Identify the common human activities within or near wetlands that have potential impacts on the water quality and quantity.
- What do you think can be done to regulate these activities?
- How can your school come in to help or work with the community to prevent the possible impacts of the floods in your locality due to wetlands destruction?
- Discuss the major uses of water from wetlands to the community.

In the field:

The following should be investigated in the different groups:

a) **The wetland location and general nearby community characteristics:**
Observe and draw a sketch map of the wetland to show the main features including vegetation cover, stream (S.) if any, human settlements, industrial and agricultural activities, main roads and other features that may directly or indirectly affect the wetland water system. You can also take photographs of some features of interest e.g., water stream, vegetation cover, human settlements and industries near the wetland, agricultural activities etc.

b) **The water system of the wetland:**
Identify the main water channels/streams if any. Comment on the speed of water flow in relation to the vegetation cover or the absence and presence of dug water channels (drainage channels). What other factors do you think may influence the speed of water flow with in the wetland? If there is a main water stream, note the inlet point into the wetland and outlet point. Can you identify any specific waste discharge point (s) along the stream? Are there any other potential sources of pollution with in or outside the wetland due to water flow? Can you identify the nature of pollution? Is it agro-chemicals, wastes from industries, hospitals, human settlements or schools?

c) **The wetland water uses:**
Make a list of the different direct water uses e.g. cattle watering, domestic use, car washing, industrial use, irrigation etc. Do these uses have an impact on the water quality, quantity or water supply to the community nearby?

d) **Simple Water quality analysis:**
Take a sample of water (e.g. from a well or spring with in or near the

wetland) for domestic use if any and observe the colour, note the smell, suspended particles, measure the temperature (using a thermometer), pH (using a pH meter or laboratory universal colour indicator), dissolved oxygen/percentage oxygen saturation (using an oxygen meter probe) and conductivity (using a conductivity meter). In the general group discuss your results about the water quality with your teacher and make general conclusions.

e) Interact with the people who use the water from the wetland and find out from them how they benefit from the wetlands. Draw up a programme to create awareness among community members of how their activities may affect the water quality and quantity for now and future use.

f) Also Study the students case study in Appendix 1

g) Each group should make a report and present to the whole class.

3.4 WETLANDS AS A FRESH WATER SOURCE

Wherever the location, a wetland will remain valuable to the community around it in terms of water supply. Water in wetlands is for domestic, agriculture, livestock watering and industrial use. The wetland water is normally free, clean and with minimal pollutants compared to other natural surface water sources. The term "valuable" is used in this case to illustrate the social-economic importance of a wetland in terms of water supply.

One can live with out food for a few days but not without water. If we are to calculate the volume of water used by the community and attach a monitory value (cost) per liter, then you should be able to appreciate the need for the wise use of our wetlands. Do you know that the impact of water scarcity in any community can cause more health risks and conflicts than any other natural resource!

Think about:

The impacts of a week with out money, food, electricity, firewood and sunlight, and another week with all the above but without access to even a single drop of water! Share your experience with your friends.

We noted earlier that wetlands slow down water movement. Imagine what happens when you soak a sponge in water! That is what a wetland does in terms of water storage. The stored water seeps out slowly and evenly over a period, usually much longer than the actual rainy season.

The released water is available to sustain stream flow for long periods for the community and other ecological functions. This water can also be source for wells and bore holes which are used throughout the year including the dry season. Large wetlands help to maintain the base flow of rivers throughout the year. This significantly reduces the effect of drought and water shortages in dry areas.

Photograph 6: Water harvesting can also be a good source of water

Photograph 7: Sources of water: Obtaining water from a spring - Common source of water in the East African countries

Do you know your main water source?

- What is your main water source for daily use?
- How reliable is your water source?
- If your water source is a spring, well, bore hole, river or lake, do you know how its supply is maintained? (refer to hydrological cycle)
- Can you think of environmental factors or human activities that may interfere with your supply?
- Can you think of possible ways to keep that water supply for your immediate use and for generations to come?

3.5 WATER RECHARGE AND DISCHARGE

Wetlands like other surface water bodies are connected to ground water systems and help in maintaining their levels through water recharge. As water percolates into the surrounding soil or rocks, it joins the under ground system hence replacing water that has been released or replenishing the water table.

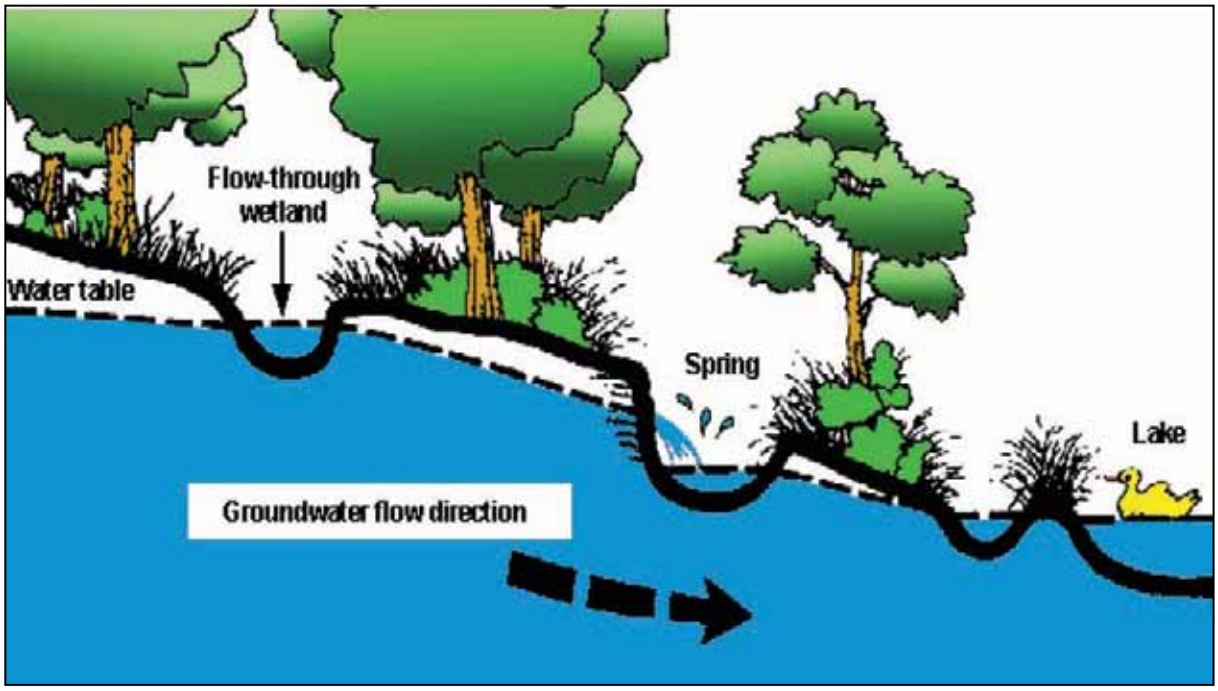

Figure 3: Water recharge and discharge

3.6 WATER PURIFICATION AND POLLUTION CONTROL

Urban and industrial developments greatly affect surface water quality due to pollution caused by human activities. The limited freshwater reservoirs are deteriorating at an alarming rate posing health and survival risks to humans of the current and future generation.

Lack of adequate access to sanitation and clean drinking and cooking water poses significant health threats and economic losses on the population. According to the

Photograph 8 : Wetlands can remove clean such heavily silted water

World Health Organization (2002), 80% of all sickness and diseases in the world are caused by inadequate sanitation, feacal polluted water and unavailability of water. One of the Millennium Development Goals (MDGs) is to reduce the proportion of people unable to access safe drinking water by half between 1990 and 2015. This is proving rather difficult since the population without access to safe drinking water in the sub-Saharan Africa has even increased by 23% between 1990 and 2004.

Wetlands are essential systems that maintain water quality through purification and pollution control. They act as fillers, physically, chemically and biologically removing pollutants and sediments from the water. Wetlands purify water through various process and functions as outlined below:

- Surface water spreads over a wide area in a wetland, giving greater opportunity for chemical exchanges between the water and the soil.
- Many chemical processes occur in wetland water and soils. These processes remove or render pollutants harmless e.g., nitrates and ammonium salts are converted into nitrogen gas by denitrifying bacteria.

Photograph 9: Note how water is spreading in a wide area in this wetland during the rainy season

ACTIVITY 3.4:

The Nitrogen Cycle

- Can you recall what the nitrogen cycle is?
- In groups of 5-6 people, outline the main stages of the nitrogen cycle
- Present the information with the help of a schematic diagram
- What is the importance of the nitrogen cycle?

Did you know the role of wetlands in water purification?

- Organic substances are slowly decomposed by microorganisms present in wetlands and associated with wetland plants.
- Some wetland plants or animals consume certain pollutants especially those that are in form of nutrients e.g. nitrates, phosphorus etc.
- As wetland plants photosynthesize, oxygen gas is produced. This oxygen gas is used in the oxidation of some chemicals in solution into less harmful substances.
- The abundance of organic debris in wetland sediments provides suitable surfaces for the attachment and trapping of some pollutants such as heavy metals.
- Other pollutants become strongly attached to clay particles in the bottom sediment of wetlands thereby rendering them harmless

Sediments in form of materials and soils eroded from the surrounding catchment by rainfall and carried into wetlands by surface runoff can be trapped by filtration and

sedimentation processes with in the wetland. Removal of sediment from water helps to clean it but may eventually destroy the wetland due to infilling. Sediment retention by wetlands generally benefits downstream. Facilities such as water storage dams and irrigation schemes that would fill with sediment are protected from infilling and their working life span increased.

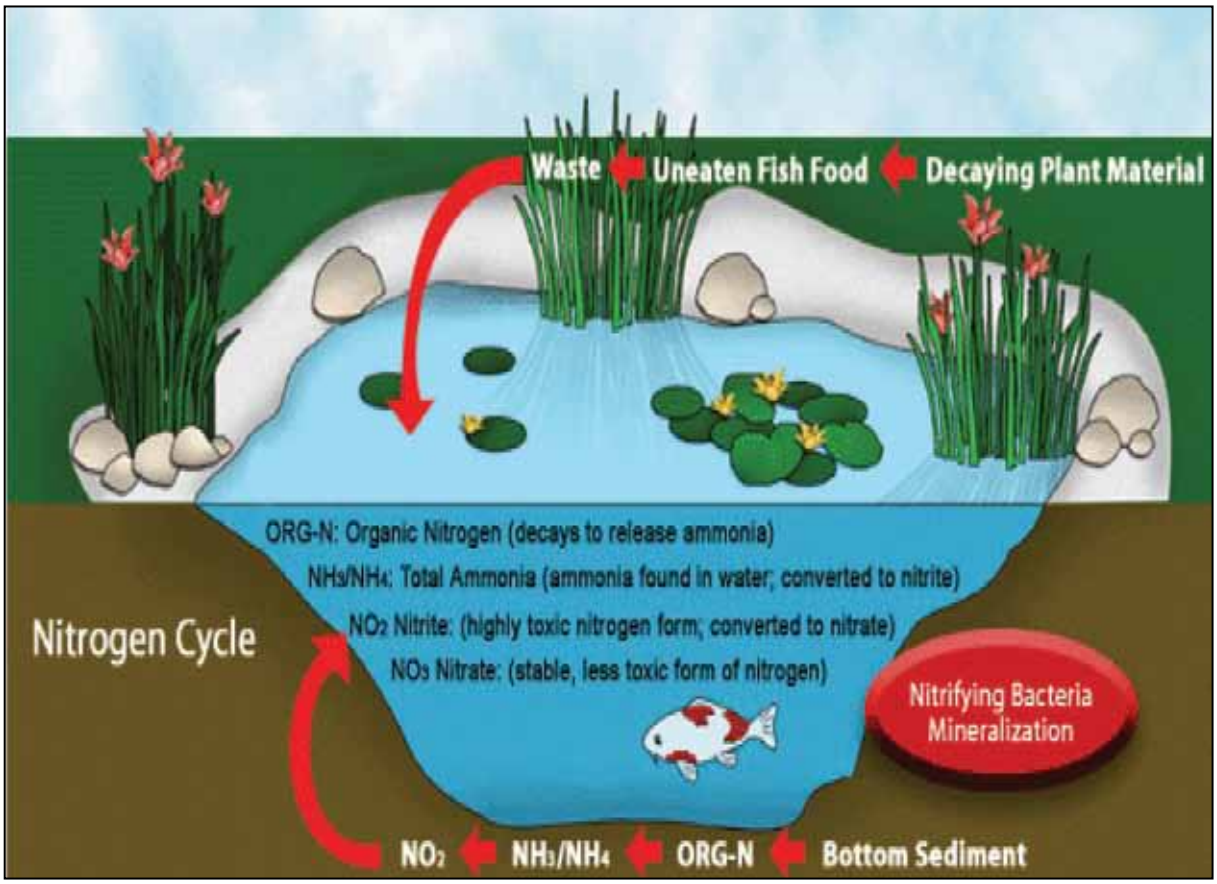

Figure 4: A schematic diagram of the Nitrogen Cycle

Did you know that the efficiency of waste water treatment:

Depends on:

- The rate of primary production of wetland plants through which nutrients especially phosphorus and nitrogen are removed.
- The rate of settlement of suspended solids which gradually settle in wetland bottom sediments along with any pollutants and pathogenic organisms e.g. bacteria.
- The oxygen free environment (anaerobic conditions) in the bottom sediments which permit the conversion of soluble forms of heavy metals to insoluble forms hence their removal from the water system. Soluble nitrogen containing compounds are also converted and emoved from the water system as free nitrogen through the denitrification process by bacteria.
- Large populations of decomposer organisms (mainly bacteria, and fungi) that reside in wetlands on sub merged surfaces of wetland plants

also greatly assist in the conversion of some harmful pollutant substances to less harmful forms and help to eliminate many pathogens from water.
Sedimentation in wetlands is dangerous . This is because; with time the wetland may becomes filled with sediments. This means that water can no longer remain in the wetland, ecological succession also sets in and it may eventually be changed into a grassland or forest. The best way to assess the purification function of a wetland is during the rainy season. Just look out side and critically observe the surface water run-off flowing in any direction. This water has a characteristic brown colour and different solid components. Think about its destination as it flows along the slope gradient; valley, well, wetland, river, stream or a lake. Immediately after it has stopped raining try to assess the water in the stream, river, well etc. The color changes significantly due to the rain surface run-off. If you have a functional wetland near by, the results will be different; the brown color of the water gradually clears and eventually becomes clean especially at the wetland outlet.

Constructed or artificial wetlands for water purification

Several "environmentally conscious" institutions in wastewater treatment currently adopt the idea of constructed wetlands (man-made wetlands) in wastewater purification. Constructed wetlands purify the water that flows through them. Compared to conventional treatment methods, they tend to be simple, inexpensive, and environmentally friendly. Constructed wetlands may be used to treat water from many different sources:

- Sewage (from small communities, individual homes, and businesses)
- Storm water
- Agricultural wastewater (including livestock waste, runoff, and drainage water)
- Partially treated industrial wastewater
- Drainage water from mines
- Runoff from highways

Constructed wetlands also provide food and habitat for wildlife and create pleasant landscapes. Constructed wetlands differ from natural wetlands in several ways:

- They remain constant in size
- They are not directly connected with groundwater
- They accommodate greater volumes of sediment depending on their size
- A diversity of plants and associated organisms colonise the wetland faster than the nearby land

Do you know your main water source?

(i) Can a constructed wetland help your school or nearby institutions and com munities in wastewater treatment before discharging it in the natural water systems?

Photograph 10: A river carrying large quantities of sediments which could have resulted from disturbance of wetlands

(ii) Are there agricultural activities that use chemicals like herbicides, pesticides etc in your community? Don't you think all these chemicals may end up into the water you drink untreated? Can constructed wetlands or protection of natural wetlands save your community from this pollution?

ACTIVITY 3.5

An inventory of wetland animals and plants

Design a project to conduct an inventory of wetland animals and plants, and investigate the growth of wetland animals and plants.

- Consider your wetland to be the school's waste water collection pool.
- Ask students to note down the characteristics of wetland plants and animals.
- The students should keep a record of these changes over time
- Guide them to clarify their views by explaining the observed patterns in growth
- Develop a simple proposal for your club to construct a small wetland that can be used for your Biology and other related natural science subjects
- The waste water pool can be modified into constructed wetland using simple domestic tools like hoes

- Follow the colonisation pattern of the wetland vegetation and make a regular follow up on their growth.
- Observe the animals that get into the system gradually e.g. amphibians with guidance from your teacher or an ecologist.
- A small aquarium can also be constructed at the edge of your wetland and in it introduce some aquatic organisms like fish.
- It is important to get expert opinion from ecologists on how to go about this project with the help of your teacher or club patron

Think about the water cycle in your institution; the source, the uses within and how it is discharged into the environment. Critical analysis of the whole cycle shows that some how that dirty water you are carelessly discharging to the environment will get back to you. How? It will gradually percolate or drain into streams, lakes, rivers, valley dams, wells, springs etc. you have no choice but to keep recycling it back. This is where our natural water purification systems in! The toxic chemicals, decomposing organic matter, domestic wastes and other water pollutants are relatively eliminated from water and retained by these natural water treatment plants, the wetlands.
The dirty water you see flowing during a heavy rain down pour is the same water that you will drink or use for cooking. It is cleaned through natural systems like wetlands or man-made water treatment plants. It is therefore important to avoid practices that lead to wetlands degradation to conserve their social, economic, cultural and ecological functions, water purification being one of the key aspects we all appreciate.

Water pollutants and control:
The most significant waterborne pollutants entering wetlands include nutrients, toxic substances and disease causing organisms. The nutrients mainly come from domestic sewerage, and agricultural and industrial waste in the catchment of the wetland. Excess nitrogen and phosphorous nutrients have significant pollution impacts in water system causing degradation or massive damage of drinking water quality.

a) Wetlands remove phosphorus by plant uptake, chemical absorption and precipitation reactions (removal as a solid) at the sediment water interface/ boundary.

b) Nitrogen is removed by plant uptake and through the nitrification / denitrification process mainly at the water-sediment interface/boundary where bacteria are abundant.

c) Toxic substances mainly include heavy metals, pharmaceutical wastes, pesticides and herbicides. Through chemical and biological processes with in the wetland, many of these substances are either changed to harmless non-toxic state or rendered harmless by being buried in the bottom sediments of a wetland.

d) Pathogens or disease causing organisms enter wetlands mainly through sew age discharge and excreted wastes from people, livestock and wildlife. The waste management practices of people in the wetland catchment area have a great impact on the pathogen levels with in the water system.

ACTIVITY 3.6

School Club Project

- Have you taken a glass of water today? From the tap? Pot? Water can or Borehole? Well or spring?
- Is the water source well protected and free from contamination?
- Look around your main water source and describe the extent to which it is protected from contamination
- List the possible water borne diseases you are likely to suffer from when you drink contaminated water
- Draw up a programme on how you would educate communities living around your water source about the best ways of protecting it

Imagine a community where there are many shallow pit latrines, solid waste disposal sites including human feaces in polythene bags, hospital wastes disposal sites etc. The surface water run-off on a rainy day washes away all that which can move along in our water systems. Remember this water gets back to us either before or after purification.

In wetlands, water is retained for a long period and in the process, pathogens are effectively eliminated through natural death, effect of temperature and pH, predation and sedimentation. This wetland function reduces the effect of waterborne pathogens that cause diseases such as cholera, dysentery, typhoid, polio etc.

3.7 UNIT SUMMARY

In this Unit, we have been able to;

- Outline the major water uses of wetlands
- Explain the role of wetlands in maintaining the hydrological cycle
- Describe the hydrological cycle and how human activities in wetlands affect its processes.
- Explain the relationship between wetlands and hydrology of a given area in terms of water availability/supply, quantity and quality.
- Wetlands place a very important role in nutrient cycles for example the Nitrogen Cycle

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UNIT 4: WETLAND THREATS, ASSESSMENT AND MONITORING

4.1 INTRODUCTION:

It is now widely accepted that wetland ecosystems are under threat worldwide. Many communities are now trying to establish wetland rehabilitation programs, but the situation is made worse by a lack of objective and factual information on wetland conditions or their importance.

In the previous units, we looked at the importance of our wetlands and hence a need for their wise use and protection. One of the key aspects of conservation or wise use is keeping a close watch on them and taking note of the human activities and other conservation concerns. This is what we mean by assessment and monitoring. In this Unit therefore, we shall review the activities that degrade or destroy the quality of our wetlands, impacts and indicators of degradation, water assessment criteria or parameters and techniques. A set of activities have been suggested for you to try out in each sub-section. The specific learning outcomes will be:

Learning Objectives

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

- To know the threats to wetlands
- Identify degraded wetlands and give their symptoms
- Discuss the impacts of wetland degradation on the ecology, hydrology and socio-economic aspects of life of the people living in adjacent areas
- Give indicators that can be used to assess and monitor wetland condition or status
- Explain how wetlands can be assessed and monitored using various techniques
- Design ways of solving the problem of wetland degradation in the locality

What is wetland assessment and monitoring?

- In assessment, we make a survey of the wetland status in terms of biodiversity and general functions, services and uses. Any impacts on these aspects are also recorded and evaluated for monitoring purposes.
- Wetland monitoring is the process of maintaining regular checks to assess the status and make a report on them.

During assessment and monitoring the focus, is on finding out if our wetlands can perform vital roles (functions), that is if they offer the services and produce goods of local, regional, national or international importance. This prevents wetland abuse and degradation especially through human activities. You must remember that wetlands are very fragile ecosystems which means that they are easily affected by our activities.

4.2 THREATS THAT DEGRADE WETLANDS

The following are some of the major activities that degrade or negatively affect the state of our wetlands:

(i) **Drainage:** This is an activity that denies the wetland water access or retention. Water drainage can be in form of

- Diversion of water to prevent it from entering the wetland
- Water removal by digging drainage channels
- Excess removal of water for industrial, agricultural or other use.
- Damming of upstream water sources
- In filling with municipal industrial solid waste in a landfill situation or with earth soil or rocks in a landmaking process.
- Planting trees or other plants after channelling the water out of the wetlands with the aim of lowering the water table.

(ii) **Encroachment:** This means taking part of the wetland and utilizing it for a specific purpose. This changes the natural state and the functions of the wetland. Encroachment may be in form of activities such as large scale agriculture, live stock grazing and watering, fishing (including aquaculture), in-filling for industrial and residential developments, mining for minerals and materials e.g. sand and clay, and road and railway construction.

(iii) **Over exploitation of resources (over-harvesting):** This involves large scale harvesting of wetland products which is not sustainable i.e. an act which compromises the wise-use concept for now and future generations e.g. over harvesting papyrus and rattan canes for crafts.

(iv) **Some activities are off-site / away from the wetland but within the surrounding (catchment).** The impacts of these activities affect the quality, quantity and timing of water entering the wetland.

(v) **Some activities that pollute water lead to the decline of quality** e.g. sewage discharge, effluents from septic tanks of oil, etc.

(vi) Land use activities also affect the quantity of water flowing into the wetland.

Photograph 11: Drainage channels in a wetland due to in filling can be disastrous. The channels should be made in such a way that the wetland continues to perform its functions. In this case the capacity to reduce flooding may be impaired.

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)		

ACTIVITY 4.1

(a) Impact Of Drainage

- In groups of 5-6, discuss the likely impacts of drainage of wetlands to communities living in adjacent areas. Write them down
- Draw a programme detailing how you would sensitize the communities about the dangers of excessive drainage of wetlands. Your programme should include practical solutions or alternatives for the people.

(b) Visit a nearby wetland and use the sheet below to make a rapid land use assessment.

4.3 IMPACTS AND INDICATORS OF WETLANDS DEGRADATION

Despite the usefulness of wetlands, pressure has been exerted on them in both rural and urban areas. Many wetlands have been converted to land for industrial or agricultural use, residential areas, waste disposal points etc.

The main impacts and indicators of wetlands degradation include;

- Increased flooding
- Outbreak of water borne diseases e.g. cholera
- Pollution of surface and under ground water
- Loss of biodiversity (especially plants and animals due to over harvesting).
- Hydrological effects such as increased water flow due to drainage channels, decreased water retention time, water quality deterioration, etc.

4.4 WETLANDS ASSESSMENT CRITERIA AND TECHNIQUES

4.4.1 Wetland Assessment Criteria

For proper wetland management, we have 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. This is what we refer to as their hydrological, ecological and socio-economic environment. We also need to know where, how and at what rate the wetland characteristics (status) are 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 resources) required to properly manage and monitor important 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 what they contain (stock)
- The detailed assessment of wetland functions and use
- The permanent monitoring of changes in wetland ecology and other characteristics (status)
- Assessment of a cross-section of wetlands that have a common service, function or use of interest.

4.4.2 Wetland Assessment Approaches

Approaches used in wetland assessment include:

a) Wetland mapping based on satellite imagery. This activity is carried out by GIS (Geographical Information System) experts. It is highly technical and requires specialized people with the ability to interpret satellite images according to colors to produce land use/land cover maps.

b) Local wetland descriptions based on physical observation of the wetlands in a given administrative area such as a division, district, province or region. In this approach 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 re corded using a wetland characteristics observation sheet. This information is essential for monitoring interventions and cannot be generated by the satellite imagery approach.

c) A wetlands inventory report is prepared based on analysis of the wetland descriptions showing the state 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 practices.

4.5 WATER QUALITY ASSESSMENT IN WETLANDS

4.5.1 Water Quality

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 things to consider while monitoring wetlands.

The quality of water entirely depends on the intended use such as 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 such as ions such as Mg^{2+}, Ca^{2+}, Na^{+} and Cl^{-} are removed. Since these ions are important nutrients for bone and teeth development, distilled water is therefore not good for drinking.

4.5.2 Water Quality Parameters

The quality of water for any intended use is determined by both physical and chemical parameters (characteristics). The physical parameters that determine water quality include colour, temperature, smell and turbidity; determined by the number of suspended particles or TSS (Total Suspended Solids). While some of the essential chemical parameters include; the pH, conductivity, 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 in Appendix 3 and are summarized below:

1. Temperature

Temperature is measured using a thermometer, and is recorded in either degrees Celsius (° C) or degrees Fahrenheit (° F).

2. pH

pH represents the effective concentration (activity) of hydrogen ions (H^+) in water. The pH of water can be measured with a pH meter or with pH paper or by using the Universal indicator solution) and recording the change in colour.

3. Dissolved Oxygen (DO)

Dissolved Oxygen (DO) is a very important indicator of a water body's ability to support aquatic life. Dissolved Oxygen can be measured with an electrode and meter or with field test kits.

4. 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 is measured by titration.

5. 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 including nitrates (NO_3), nitrites (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. Nitrogen is most abundant in earth's environment as N_2 gas, which makes up about 78 percent of the air we breathe. Nitrogen is recycled continually by plants and animals through the "Nitrogen Cycle

Do You Recall Nitrogen Cycle in Section 3.6

1) Draw a nitrogen cycle and in groups of 5-6, discuss the various processes by which nitrogen is converted into the various inorganic and organic forms in the nitrogen cycle. Write these processes down.
2) Compare your answer with an essay that was written by Master Abed in Sudan. What points did you miss in your group?

Master Abed's essay of the main processes that take place during the Nitrogen cycle

Most organisms (including humans) can't use nitrogen in the gaseous form N_2 for their nutrition, so they are depend on other organisms to change 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, 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.

To complete 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.

Both nitrogen and phosphorus can be measured using the colorimetric method, which your teacher will explain to you or by titration. 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 in a process called Eutrophication.

What is Eutrophication?

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. The organism in water are staved due to low oxygen, This process is called "eutrophication."

ACTIVITY 4.2

Eutrophication

- Using a named example in your country, discuss the role of wetlands in prevention of Eutrophication of large water bodies in Africa. Write these processes down.
- Using the national action plans, propose guidelines to assess and monitor wetlands in your locality.

6. Water hardness

Hardness generally represents the concentration of calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions. Waters with high hardness values are referred to as "hard," while those with low hardness values are "soft". Hardness is generally measured by titration.

7. Turbidity and Total Suspended Solids (TSS)

Turbidity is a measure of the cloudiness of water caused by suspended matter such as clay, silt, and organic matter and microscopic organisms. Turbidity is a measure of how much of the light traveling through water is scattered by suspended particles.

Impact Of Development On The Functions Of The Wetland	Yes	No	Other Comments
Increase Food Effect			
Reduce Capacity To Store Water			
Pollute The Wetland At The Site Or Downstream			
Lead to loss of plants (flora) and animals (fauna)			
Lead to loss of rare or endangered species			
Loss of access to wetland products and services			
Elimination of wetland resources			
Lead to conflict among different users			
Any other impact (s); (specify)			

8. Total and Fecal Coliform Bacteria

Fecal coliform bacteria are present in large numbers in the feces and intestinal tracts of humans and other animals, and are indicator organisms. There are several ways coliform bacteria can be measured. Your teacher may explain to you how these methods work.

DO THE FOLLOWING EXERCISE ON WETLAND ASSESSMENT

(a) Assessing the impact of development on the functions of a wetland.
Make a survey of the major developments with in or around a wetland near your school or home area and carry out a simple assessment on their potential impacts using the data sheet below.

Type of development (specify) ----------

Ownership of development/project ----------
(b) Assessment and monitoring of hydrology, ecology and socio-economic aspects of your local wetland.
Use the guidelines summarized in the table below to carry out a simple fieldwork on wetland monitoring and assessment.

Name/Location of wetland ----------

Activities with in and around the wetland (With potential wetland hydrology, Ecology and socio-economic impacts)

Hydrology

Potential impacts of activities in a wetland.	**YES**	**NO**	**Any other comment(s)**
Water Pollution (wastewater/sewage discharge, solid wastes disposal etc)			
Changes in water Quantity (Drying of wells, decrease in water level/water table, water abstraction, Diversion of water etc)			
Reduction in capacity to purify and treat water (Change in vegetation cover, sedimentation etc)			
Reduction in capacity of wetland to store water (Increased water runoff, flooding, destruction of property e.t.c)			

Ecology

Potential impacts of activities in a wetland.	YES	NO	Any other comment(s)
Loss of rare species if any.			
Loss of biodiversity (key wetland plants and animals in your locality)			
Siltation and sedimentation			
Loss or change/modification of wetland habitats(destruction of animal movements roots, homes breeding/mating places.			

Socio-Economic

Potential impacts of activities in a wetland.	YES	NO	Any other comment(s)
Access to wetland resources by potential users of the wetland (any conflicts?)			
Wetland resources abundance and diversity (Any critical loss or massive clearance?)			
Does the activity contravene any wetland law or regulation in your area or country?			

ACTIVITY 4.3

Activity: Field study

- Make a checklist of wetland degradation activities within the catchment area to be surveyed and outline their potential impacts on quantity, and quality of water entering the wetland
- Proceed to the wetland site and outline on-site and off-site activities that degrade the wetland
- With the guidance of your teacher try to reach the people that live or interact with in or around the wet land 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.
- Discuss the importance of water quality assessment in wetland monitoring.
- Write a simple news article to create awareness to your local community about the importance of wetland assessment, monitoring and conservation.
- Why is wetland assessment and monitoring important in the development of your country?

4.6 UNIT SUMMARY

In this Unit, you looked at:

- The meaning of the terms wetlands assessment and monitoring Pollution, Eutrophication
- The symptoms of a degraded wetland
- The impacts of wetland degradation to communities
- Key parameters that are used in assessment and monitoring of wetland status
- Examples of the various techniques to assess and manage wetlands and how to apply them
- How water quality can be assessed using various parameters and tools
- How to carry out various wetland assessment and monitoring activities in your locality

4.7 FURTHER READING

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UNIT 5: WETLANDS MANAGEMENT

5.1 INTRODUCTION:

This is an important Unit because at the end of it, you are going to be involved in helping to conserve wetlands, which are a wonderful nature's treasure. But first, you will learn about the concept of wise use, which is associated with sustainable utilization, and review why it is important to manage wetlands effectively. You will learn about conservation and management wetlands. Case studies will be cited to help you understand the rational for wetland management. You will meet the partners in wetland management and how they co-ordinate their effort at local, regional and international levels. Watch out for the World Wetlands Day, and mark it on your calendar incase you want to create awareness of the importance of wetlands to your community on that day. Familiarize yourself with the Ramsar Convention and its guiding principles. You will meet the world's heroes of wetland management some of whom are school children like you. Finally, you are urged to take individual action to protect wetlands. Activities on how you can participate are given at the end of the unit.

Learning Objectives

At the end of this Unit, you should be able to:

- Explain the term wise use
- Explain why it is important to ensure proper use and management of our wetlands
- Distinguish between wetland management and wetland conservation
- Discuss approaches that can be used to manage wetlands well
- Identify an activity you can do towards conservation of wetlands.

ACTIVITY 5.1

Field Trip

- Make a field trip to observe how wetlands looks like and how it's many parts function together.
- Note the human activities around the wetlands and discuss how they are affecting the wetlands.
- Identify wetlands that need conservation and suggest how this can be done.
- Carry out an interview with some members of the local community to find out how they value the wetlands and whether they are taking any steps towards their conservation.
- Identify animals and plant species in the local wetlands that are endangered.
- See if you can help to protect the identified animal and plant. Visiting a wetland or wild life resource centre may enrich your knowledge on research findings on endangered wetland species and you may give suggestions on the steps to curb this.

5.2 CONCEPT OF WISE USE

The 'wise use of wetlands' is a term encouraged by the Ramsar convention. The Ramsar Convention signed in Ramsar, in Iran in 1971 is an intergovernmental treaty which provides the framework for national actions and international cooperation for the conservation and wise use of wetlands and their resources. The broad aim of the convention is to halt the worldwide loss of wetlands and to conserve them through wise use and management. This requires cooperation at all levels, from communities, national, regional and international.

The convention emphasizes the wise use which is defined as the "Sustainable utilization for the benefit of mankind in a way compatible with the maintenance of the natural properties of the ecosystem"

This means that the wetlands should continue to benefit the people of the present generation while maintaining its potential to meet the needs and aspirations of future generations. Natural properties of the wetland ecosystem, is defined also defined by Ramsar Convention as the harmonious interactions between the physical, chemical and biological components of a wetland such as water, soil, plants, animals and nutrients. In the management of wetlands, it is therefore important to be mindful of the wise use concept.

5.3 MANAGEMENT OF WETLANDS

5.3.1 What is wetlands management?

Management of wetlands requires participation of different people and organizations as we shall see briefly. In most of the countries of the world, there are some examples of effective wetland management in which sustainable use is encouraged while benefiting local communities. Conservation as we have seen may be defined as the wise use of natural resources, while management is the regulation of all human activities which have a significant impact on the wetlands ecosystem. The goal of wetland management is to ensure that there is optimum use of wetland resources in order to satisfy human needs now and in the future, to conserve and where possible to add. This implies that management refers to the procedures and regulations that are put in place to ensure the use of wetlands for optimal benefits. Effective management leads to wise use.

Ask yourself:

But before we go any further, ask yourself why we should effectively manage a wetland?

Photograph 12. Wetlands sites like this are common in the Nile Basin

5.3.2 Why Manage Wetlands?

Wetlands serve a variety of uses and the management of these threatened ecosystems is very important. Wetlands are breeding grounds for wonderful plants and animals, some of which are themselves endangered. Wetlands are also generous to us, storing and purifying water, controlling soil erosion, regulating floodwaters and streams, and recharging the groundwater. In other words, they protect us from natural threats and offer drinking water. They also offer a variety of recreational activities, from fishing to boat riding and more.

Therefore, it is important that we learn to balance our own needs with the ever-increasing need for wetland conservation. Education and research of these complex ecosystems is vital. There is need to persistently learn more about these natural environments, and learn how we can coexist peacefully and fruitfully with them. That is why the proper management of our wetlands is important.

5.3.3 Principles of Wetlands Management

Wetland management is based on guiding principles, which are normally drawn from the broad aims and objectives of wetlands conservation. The overall aim for promoting the conservation of wetlands is to sustain their ecological and socio – economic functions for the present and future well being of people and the environment. In support of this aim, governments in the Nile Basin region strive to achieve the following goals;

- Establish principles by which wetland resources can be optimally used, and ensure that their productivity is maintained
- End existing un sustainable exploitative practices
- Maintain a biological diversity either in the natural community of plants and animals or in the diverse agricultural activities.

- Promote the integration of wetland functions in economic development programmes such as forestry, agriculture, fisheries, wildlife and aim at sound environment management.

To achieve the above goals, some guiding principles have been put in place to guide individual governments. Some of the three principle are:

a) The conservation of wetlands must consider overall development strategies and activities.

b) Wetland conservation must adopt a coordinated and cooperative approach involving all the concerned stakeholders and organizations in the country, including the local communities.

c) The present attitudes and perceptions of the people in the Nile Basin re garding wetlands needs to change towards positive practices that encourage sustainable uses and management of the wetlands

5.3.4 Wetlands Management Approaches

A brief overview on the common wetland management approaches are outlined below.

1. Environmentally sound management approach

Sometimes, the management of a natural resource maybe debatable in line with whether its use causes adverse effects on the environment or not. A typical example is the production of bricks from clay soils. This may lead to deforestation around the brick making kilns (areas) since they may cut the trees to burn the bricks. However, the smoking of fish using papyrus (which could be sustainable harvested) may be environmentally sound and can reduce the exploitation of fuel wood supplies in the area. In such scenarios, since most users of wetland resources do not take into account other aspects of the environment, only those uses that have been proved to be non destructive to wetlands and their surroundings are encouraged and promoted. These include water supply, fisheries, wetland edge gardening and grazing.

2. Sustainable use of wetlands approach

The sustainable use of wetland is understood as utilization which ensures that the products or services derived from that use are available in the same proportions for the future. For example, yields from fishing or harvesting of papyrus, should be set at a level that can be maintained for the foreseeable future. To achieve this, wetlands need to be utilized in such a way that they do not lose traditional benefits and one's decision to use wetlands must con sider the requirements of other users in the community.

3. **Protection of vital wetlands approach**

Wetlands are important habitats for a variety of biological resources, some of which depend entirely on wetlands for their survival. Their conservation would preserve indigenous species of plants and an animal is essential for the future biodiversity. Many attributes of wetlands remain to be discovered earning them ecological importance. For many of the Nile Basin countries, internationally recognized wetlands have been established. Other important wetlands outside those that are internationally recognized also need to be protected. For that to happen, fully "protected wetland areas" of important biological diversity, should be established. Also, some wetlands may be partially exploited and used for research. Protected wet lands should be left in their natural state without or very little disturbance from humans.
Any wetland serving as a source of water supply or receiving effluent as part of a designated service to any human settlement should be declared a fully protected wetland from encroachment, drainage or modification.

4. **Watershed management approach**

A watershed approach recognizes the inter-connectedness of water, land, and wetlands resources and results in more complete solutions that address more of the factors causing wetland degradation. The focus is on the protection and proper management of the wetland watershed. It involves the participation of various stakeholders including the central government, the local administrative leaders, the community, extension staff, CBOs and NGO's.

5. **Coordinated or Collaborative Approach -** Coordination and collaborative management involves multiple stakeholders focusing on priority natural re source issues that benefit the different stakeholders while maintaining the chemical and biological integrity of the wetland, diversity, and environmental health within the ecosystem.

5.3.5 Tools for ensuring effective wetlands management

1. **Environmental Impact Assessment (EIA) and Monitoring**

Development activities in general tend to impact upon natural resources and environment in various ways. Assessment and evaluation of such impacts helps to minimize the economic and social costs preventing damage before occurrence as compared to restoring a degraded wetland. In view of this, all planned new wetland development of a certain magnitude should be subjected to an EIA process to determine the required environmental controls and be monitored regularly there after to asses their impact.

2. **Developing Public Education and Awareness**
Very often wetlands are degraded because the public does not appreciate the diversity of values and functions of wetlands. Public awareness is therefore essential in creating a commitment and positive attitude towards conservation and sustainable utilization of wetland resources. Public awareness campaigns on wetlands resources in co – operation with other natural resources sectors should be carried out at local and national levels. Such media as leaflets, posters, radio, and television could be employed and all should give guidelines for wetlands developers.

3. **Ensuring that land tenure systems do not affect management**
Wetlands in the Nile basin region belong to the public because they keep the water which replenish the Nile. Governments should therefore control their conservation requirements. Their use should be guided by wise use principles and well set guidelines.

4. **Government policies and guidelines**
Governments has to set guidelines and policies to protect the wetlands

ACTIVITY 5.2

Design A Poster
Design a poster/s to sensitize your school or local community on the values and functions of wetlands. Or write a poem on a particular aspect of wetlands that you want your community to learn and read it at assembly or have it published in the school journal.

Think of other ways:
Think of other ways or procedures that need to be put in place to ensure effective management of wetlands in your area or country

5.4 ROLE OF VARIOUS STAKE HOLDERS

Recently, partnerships to manage wetlands have developed among the central government, the district, local administrative leaders, the community, extension staff and NGO's. Let us now look briefly at the role played by each partner. Wetlands conservation and management is a shared responsibility for all citizens, however, the Central Government has a leading role to play. The central government formulates policies on wetlands which are passed by the parliament into laws. These laws empower technical staff to handle wetland related issues. Central government identifies its resources, allocates annual budgets to the wetland sector and enters into agreement with donors. The Government provides legal framework for wetland management by establishing a monitoring and evaluation mechanism used to verify policy implementation by local authorities.

Photograph 13. Children are leaning to make papyrus mats from their elders

The physical management of wetlands is the mandate of either the central or local governments. Political support at this level is crucial to ensure that the administrative units carry out the wetland policy correctly. The administrative units play an important role in formulating and passing legislation that relates to the wetlands in their area. The administrative unit also protects and promotes wetland services and attitudes. They also encourage NGO's to take up active roles in promoting and building the capacity of those institutions. The local government finances activities related to wetland management. The local governments also look for donors interested in wetland management.

In the case of Uganda, according to local government act it is considered of great importance that management of wetlands is further devolved to local councils. The local authorities have the mandate to formulate bye – laws that are even more specific to there area than the district bye – laws and because sub – counties are small administrative units it is easier to monitor the enforcement of the laws. Wetland activities are incorporated into the main sub–county development plans. The local authorities also encourage NGO's to take up active role in promoting and building capacity of institutions at this level. The local authorities have an important role in the financing of activities related to wetland management. Like the districts, sub-counties also write proposals and present them to potential donors interested in wetland conservation and management.

Technical staff implement the wetland policies and carry out management functions decided nationally and locally. The roles of technical staff may include: carrying out wetland inventories, drawing up wetland management plans, assisting the district environment officers to carryout Environmental Impact Assessment, conducting

sensitization and awareness activities on wetland to the communities to enrich their knowledge on the importance of wetlands, build capacity of members of the local community through training on proper use of their wetlands, establish community – based wetland management structures and monitor and evaluate wetland related activities

For their part, the local communities should promote wise practices in all wetland activities. They ensure that what is being enjoyed today is left for future generations to enjoy. For this reason, the community: maps the wetland boundaries, provides information about the size, characteristics and inherent features and guides on prioritizing of wetland activities. The local community helps in identifying wetlands that require urgent attention within their locations, Observes and identifies wetlands that are threatened by both human and natural activity and report to local authority.

Community associations organize and guide the community on how to use and share wetlands for water, animal grazing and fishing and ensure participatory and transparent management of wetland resources. They can influence local governments to formulate bye – laws and support or participate in enacting the laws at local level while promoting equitable participation.
The NGOs contributing towards wetland sustainability must clearly have defined roles which do not crush with other institutions mandates. The assistance should be transitory in nature, seeking to transfer their knowledge to the communities and enable them to become independent from external assistance and take up all functions in wetland management. Their role is therefore summarized in the following: draw up management plans of wetlands, financing reputable organizations and firms to carry out wetland conservation and management activities, raise awareness and train the local communities, provide wetland management materials for the communities, support the establishment of wetland management structures, monitor and evaluate projects on sustainable use and management of wetlands.

Study Questions:

1. How does the management of wetland sites and use of resources take into consideration local needs?
2. How do formal institutions influence the management of wetlands in your area?
3. What have been the major roles of NGOs and CBOs in wetlands management?

ACTIVITY 5.3

Information Sources

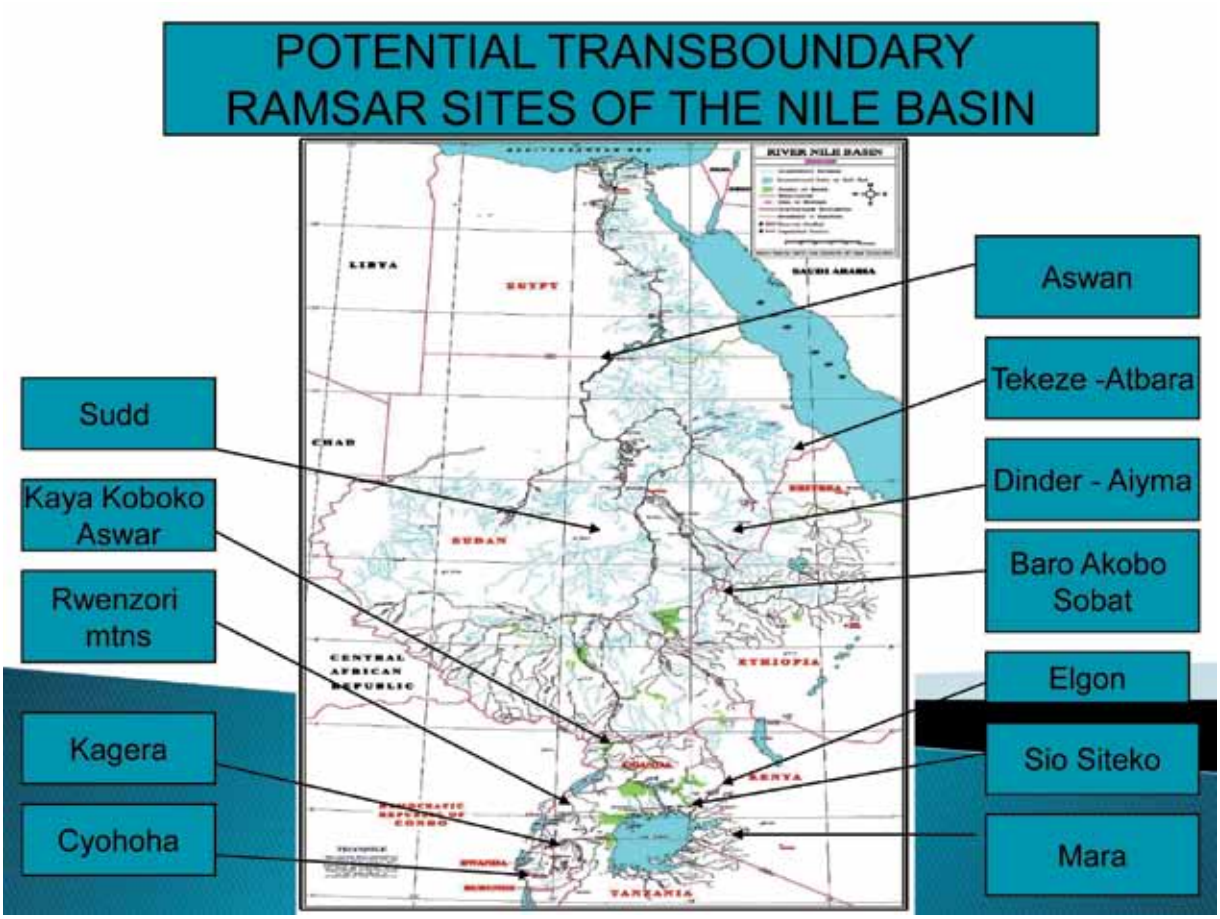
Find five or six people in your class and discuss the following questions

- What are the sources of information from which people in your community derive on awareness of wetlands?
- How do variations in access to environmental knowledge affect the conservation of wetlands in your area?
- How do people establish and negotiate their 'entitlements of wetland resources'?

5.5 MANAGEMENT OF TRANS-BOUNDARY WETLANDS

5.5.1 What are Trans-boundary wetlands?

A trans-boundary wetland refers to one which is found across the boundaries of two or more administrative units or countries. Individual action by states may be insufficient for the conservation and management of wetlands because many wetlands and watercourses cross national boundaries; many wetland species are migratory; coherent management of wetlands often requires collaboration and exchange of experiences between countries; and development assistance is often required for wetland conservation actions in developing countries.



Many protected areas share national or provincial boundaries and adjoin other protected areas across the boundary. It is obvious that poor planning can result in incompatible activities in areas on either side of the boundary. For example, the zoning of a wilderness area on one side of a boundary could be compromised by infrastructure development on the other. Coordinated planning can reduce this risk, and ensure that the partners develop an appreciation of their relative biophysical, political, social and economic contexts. Therefore, co-operation between neighboring administrations in such situations is crucial.

5.5.2 The need for coordinated planning

This is essential if the purposes of the protected areas involved are to be translated into effective programs for management and development. Integrated planning ensures that all interests in neighboring countries or provinces should be involved and that the consequences of decisions for sectoral programs are fully evaluated. The process of planning, if handled in a participatory manner, can promote commitment and empowerment among stakeholders on both sides of the boundary, as well as capacity building where there would otherwise be unequal experience or skill.

5.5.3 Examples of trans-boundary in the Nile Basin wetlands

1. The Nile River (Congo, Rwanda, Burundi, Ethiopia, Eritrea, Uganda, Kenya, Tanzania, Sudan, Egypt)
2. Siwo-Malaba River (Uganda and Kenya)
3. Kagera (Tanzania, Uganda and Rwanda)
4. Sobat-Baro-Akobo system (Ethiopia-Sudan)
5. And others as in the map on previous page

Recent examples of international cooperation over shared wetlands and water systems in relation to Ramsar sites and the Ramsar Convention include the efforts of the member States of both the Lake Chad Basin Commission (LCBC) and the Niger Basin Authority (NBA), with assistance from WWF International and financial support from the Global Environment Facility, to designate each of their parts of these large catchments as Wetlands of International Importance and work toward their collaborative management, especially in the framework of memoranda of cooperation signed between the Ramsar Secretariat and both the LCBC and the NBA in November 2002.

The others are the Lake Victoria Environmental Management Project, The Horn of African Initiative.

5.6 INSTITUTIONS MANAGING WETLANDS

5.6.1 Local institutions

Local institutions overseeing wetland management exist in all countries either as independent organizations or agencies, or as part of the line ministry concerned with water, environment, agriculture, forestry and natural resources. In countries such as

Uganda, there is the Wetlands Management department in the Ministry of Lands, Water and Environment. Agencies such as the National Environment Management Authority (NEMA) in Kenya and Uganda; the Rwanda Environment Management Authority (REMA) in Rwanda; and the Environment Protection Agency (EPA) of Ethiopian also oversee wetland conservation issues. Other lead institutions are in eacu of the countries of the Nile Basin.

5.6.2 Regional institutions: The Nile Basin Initiative (Organization)

The Nile is the longest river in the world, combining the Blue Nile that rises in the highlands of Ethiopia, and the White Nile, which rises in the Equatorial Great Lakes region of East and Central Africa. The 3.2 million sq kilometers of the river basin contains all or part of the territory of ten countries - Burundi, Democratic Republic of Congo, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, Tanzania and Uganda, totaling at least 140 million people. Countries upstream are well watered while many of those downstream remain arid and heavily dependent on the Nile, a situation which has led to conflict over centuries. Accords signed by Britain and Italy in 1929 and 1959, respectively, awarded control of the Nile Waters to Egypt alone, creating conflict with countries which insist on being involved in the management of the waters of the Nile. In 1992, the Council of Ministers from the Nile Basin countries began an initiative to promote co-operation and development.

The Nile Basin Initiative was established in February 1999 to bring together governments of the ten riparian states in order to prepare coordinated development projects to benefit the poor, involving water, energy and agriculture. IUCN, WWF and World Bank hosted a workshop to investigate the establishment of an International Discourse on the Nile, held at the IUCN Headquarters in Gland, Switzerland. The idea was to involve civil society in planning and development in order to ensure that the developments coincide with the wishes of the Nile Basin peoples. Subsequent meetings underscored the need for the international discourse to continue for several years.

International Discourse on the Nile River Basin is designed to promote broad based dialogue, and sharing of views on development in the Nile River Basin. This occurs mainly through the Nile Basin Initiative with a wide ranged of national, regional and international levels. The discourse covers a broad range of themes including poverty alleviation, conflict resolution, the environment and development.

5.7 THE RAMSAR CONVENTION

5.7.1 What is Ramsar Convention?

The Convention on Wetlands of International importance especially as Waterfowl Habitats was adopted at Ramsar, a city on the Iranian shores of the Caspian in 1971. The Convention was astonishingly far-sighted for its time, recognizing several important principles which are now widely accepted: the interdependence of Humankind and the environment; the fundamental ecological functions of wetlands

as regulators of water regimes; and the value of wetlands in economic, cultural, scientific, and recreational terms. This concern with the functioning of wetlands, and how it affects humankind and the cultural and economic well-being, has become more and more relevant over the first 25 years of Ramsar and will undoubtedly be a major issue for the 21st century, when water supply will become even more crucial.

Although the Convention's original focus was on wetlands as a habitat for waterfowls, Ramsar has developed into an international instrument dealing with wetlands from a broader point of view. Ramsar remains the only international convention that concentrates on a particular type of ecosystem - wetlands - rather than on species or other issues. Such an approach is natural, given the widely held view that wetlands and forests are two of the most threatened ecosystems in world terms. Ramsar establishes, for the first time in an international convention, two basic concepts:
The first concept is the List of Wetlands of International Importance which is a list of important sites proposed by member governments, who formally accept an obligation to maintain the ecological character of these sites. The second concept is the principle of wise use of all the wetlands in the territory of a Contracting Party. Wise use of wetlands is considered as synonymous with sustainable use, a term which has recently gained general currency.
Like any other convention, Ramsar is a living, evolving instrument. The emphasis in the early years was on listed sites, the flagship concept which attracted immediate attention and publicity.

5.7.2 Ramsar and Wetlands of International Importance?

In recent years, the broader concept of wise use has become increasingly important, with the growing realization that listed sites cannot be conserved in a vacuum but are affected by decisions taken outside their boundaries; the crucial need is to integrate conservation and wise use of wetlands into national land use and water management strategies. While the Ramsar text sets out basic concepts, guidance is needed on how to put them into practice and how to adapt them to changing world perceptions. In its first 25 years, Ramsar member states have, at their Conference of the Parties (normally held every three years), approved numerous interpretations of the text and mechanisms to make sure that the basic concepts of the Convention are effectively applied.

Ramsar definition of wetlands: An important feature of Ramsar is its approach to the once unfamiliar term 'wetlands'. The definition of wetlands in the first article of the Convention has been widely accepted: '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 metres.' This definition encompasses coastal and shallow marine areas (including coral reefs), as well as river courses and temporary lakes or depressions in semi-arid zones.

The Ramsar 'Guidelines on wise use' provide a concise account, for both decision-makers and the general public, of the benefits and values of wetlands which may be felt within the wetland itself or some way away from it (for example in the case of wetlands which absorb floods). The Guidelines summarize the benefits as follows: sediment and erosion control; flood control; maintenance of water quality and abatement of pollution; maintenance of surface and underground water supply; support for fisheries, grazing and agriculture; outdoor recreation and education for human society; provision of habitat for wildlife, especially waterfowl; Contribution to climatic stability.

ACTIVITY 5.3

World's Wetlands day 2nd February

- Plan to celebrate the World Wetlands Day in your school. The world wetlands day is celebrated on 2nd February every year, but you can celebrate it on another day depending on your school calendar. Choose a theme for the day and plan the activities you and other members would do to create awareness on the wetlands.
- These are some other activities you might find interesting to try: Form a wetland club for your school/community, conduct a nature walk in the wetlands, make an inventory of rare plants and animals, visit in a local stream/river, collect favourite flowers or plants from the wetlands and press them under newspapers to use later in your wetland journal. Make some crafts like basket from reeds and pots from clay and others.
- Read more about The Ramsar Convention
- Design a game to play with your friends to summarize the Ramsar guidelines on wetland management.
- Write a report on your activities

5.8 INTERNATIONAL AND REGIONAL POLICES AND LAWS ON WETLANDS

5.8.1 Overview of the Policies

A policy is a plan or course of action, or business, intended to influence and determine decisions, actions, and other matters. It is the policy of the governments in the Nile basin region should be to promote the conservation, sustainable management and wise use of wetlands by all stakeholders for the benefit of present and future generations. Adoption of the Wetlands Policy means that the governments, in their decision-making will give explicit consideration to the biophysical requirements of wetlands with the goal of ensuring their sustainable management.

5.8.2 Goal of the Policies

Policies should assist in the protection of wetlands in good condition, rehabilitate degraded wetlands where feasible, and support appreciation of wetlands by:

- Protecting wetland biodiversity, functions and services;
- Protecting social and economic benefits of wetlands;
- Providing flow regimes that mimic natural conditions, where possible;
- Providing wetlands with water of appropriate volume and quality;
- Limiting further fragmentation and reconnecting wetland systems;
- Preventing or limiting catchment activities that impact upon wetlands;
- Protecting the cultural heritage and spiritual significance of wetlands;
- Rewarding wetland managers who improve the condition of wetlands; and Promoting the importance of wetlands to the community.

5.8.3 Principles governing the Policies

The governments should achieve these goals by adopting the following principles:

- Wetlands are valued as significant parts of landscapes; their conservation and management are most appropriately considered at the catchment scale.
- Appropriate water regimes and water quality needed to maintain or restore the ecological sustainability of wetlands will be provided through the implementation of water management plans.
- Wetlands of international, national, state and regional significance will be identified and conserved.
- Land use and management practices will maintain or rehabilitate wet land habitats, processes and cultural values.
- Degraded wetlands and their habitats will be rehabilitated and their eco-logical processes restored as far as is practicable.
- The potential impacts of climate change will be considered in long term strategies for water resources and land use.
- Continued research into wetland ecology will be encouraged to better support water and land use planning and management.
- Natural wetlands should not be destroyed or degraded. When social or economic imperatives in the public interest result in a wetland being degraded or destroyed, the rehabilitation or construction of a compensatory wetland that supports similar biodiversity and ecological functions will be required.
- Purpose-built wetlands will not be constructed on the site of viable natural wetlands.
- Cooperation and incentives among land managers, government authorities, catchment management authorities, non-government organizations and the general community is essential for effective wetland management, and will be encouraged.

5.9 EXAMPLES OF BEST PRACTICES AND WHAT YOU CAN DO TO CONSERVE WETLANDS

A story of Reid, the wetland conservation hero:

1. Below is a story of a wetland conservation hero in South Africa. Read the story carefully.
2. What lessons do you get from the story?
3. Design your own plan of how you can similarly make yourself a hero that could be recognized internationally just like Reid. Your teacher will help you do implement your plan.

EARTH KEEPER HERO: WORLDWIDE WETLAND CONSERVATION

Below is a story of a a school girl from South Africa recognized internationally for working to preserve and protect wetlands.

Claire Reid, a student from Johannesburg, South Africa, captured the attention of the scientific community with her unique ideas on water conservation and agricultural development. The Ministry of Water Affairs and Forestry hosted a competition for schoolchildren to create "an awareness of the importance of water and promote water conservation," and Reid's project was selected. Honored in Sweden for her idea, her "real gardening" concept requires less water than normal gardening and helps people grow vegetables even in dry and dusty arid lands. Wetlands in South Africa

"I came up with the idea to help people, especially in less advantaged communities, grow their own food while at the same time saving water and saving money on fertilizers," Reid said.

Her idea could revolutionize agriculture for the arid regions of her home nation, and of the world. She sealed pre-fertilized seeds into long, narrow strips of newspaper. The newspaper allowed the seeds to stay moist, therefore utilizing less water in their planting process. "My method means that the seeds need less water, while the fertilizer and carbon from the paper make sure the seeds grow faster," Reid added. The seed strips are placed into the ground, covered with soil and watered. The strips make gardening nearly flawless even for the most amateur of gardeners, as each seed is at the appropriate distance from one another, and the strips ensure they are planted at the appropriate depth.

Reid's project is being implemented by local charities in needy parts of the country. Claire Reid's work is living proof that water conservation and environmental protection - as well as the consideration of, and assistance for, needier communities - is very feasible, regardless of age, clout or stature.

What you can do?

While regulation, economic incentives and acquisition programmes are important, they alone cannot protect the majority of our remaining wetlands. Education of the public and efforts in conjunction with local governments, and private citizens are helping to protect wetlands and to increase appreciation of the functions and values of wetlands. As wetlands are lost, the remaining wetlands become even more valuable. We must now take positive steps to protect wetlands to ensure that the functions and related values they provide will be preserved for the present and future generations. You can play a part in protecting these national treasures and below are some suggestions of how you can be involved.

- Find out where the wetlands are in your community. Learn more about wet lands by contacting your local parks department, state wildlife or natural resource agency. Become a member if there is an opening.
- Visit a local wetland and take part in a bird watch, nature hike, canoe trip, or other activity.
- Volunteer with a local group (or start a wetland and conservation club if none exist in your area) to protect, restore, and monitor a local wetland.
- Plant native vegetation in your school yard or garden at home and limit use of fertilizers and pesticides.
- Encourage neighbours, developers, and state and local governments to protect the function and value of wetlands in your watershed.
- Familiarize yourself with the principles for the sustainable management of wetlands given.
- Use water wisely so that more will be available for wetlands.
- Avoid pouring down cooking oil or paint the drain to protect the water quality of your wetland.
- Throw your rubbish in the bin or recycle it move away from throwing it into your local wetland.
- Purchase government stamps that have wetland animals and plants from your local post office to support wetland acquisition.
- In future, select upland rather than wetlands sites for development projects and avoid wetland alteration or degradation during project construction.

Journal entry:

- Read the Journal entry below on "Creating Wild Words"
- What is the main focus of the Journal entry
- You can enter interesting bits of information on wetlands and the activities that either you or your classmates have carried out.

It could be activities carried out during the International Wetlands Day (2nd February). Make the entry interesting and educative.

- Share your Journal entry with other students and the teacher
- You can have bits of it published in the school year book, or share with local wildlife or natural resource agency.

Creating wild words

Naturalists study nature, especially plants, animals and their habitats. They record what they see by writing about it, drawing or sketching it, or sometimes they write creatively poems, prose and essays. You too can be a wetland naturalist! You just have to enjoy being in a wetland, quietly watching birds, animals, insects and plants. Besides a love of the outdoors you need a journal to record your observations, poetry, ideas and to draw sketches. You can create your own journal on the wetlands!

For your wetland journal, you'll need: A small notebook crayons, pens, markers (to take into the field), and natural inspiration. A wetland is a quiet natural place to sit back and gather inspiration. Close your eyes and hear the wind in the trees. Feel sunlight on your face, and the cool ground under you. Open your eyes, but don't focus on any object in particular. Try to see the whole scene. Write about what you see, what you feel, what you smell. Sketch trees, grasses and animals, too. If you have your identification books with you, try to identify what you're seeing and drawing. If you can, visit the same place through the year and see how its different inhabitants change.

If you'd like, you can also press flowers and put those into your journal, too. Falling leaves are also good to press. Fallen, dry leaves, though, aren't good for journals. They turn into dust. Try picking some colorful leaves that are still attached to a live tree and are flexible, not brittle. These will press well and be flat for your journal.

5.10 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
- Relate what has been achieved by individuals on wetlands management else where in the world to our own situation in the Nile Basin region.

5.11 FURTHER READING

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http://www.ramsar.org/mtg/mtg_reg_europe2001_5paulsen_e.doc
http://www.wetland.org/education_writeon_challenge.htm
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http://www.myhero.com/myhero/hero.asp?hero=Wetland_Conservation

APPENDIX 1

STREAM QUALITY MONITORING: INVESTIGATION OF KIKENYI STREAM AT WANYAMA VILLAGE IN BUGEMBE-JINJA DISTRICT IN UGANDA

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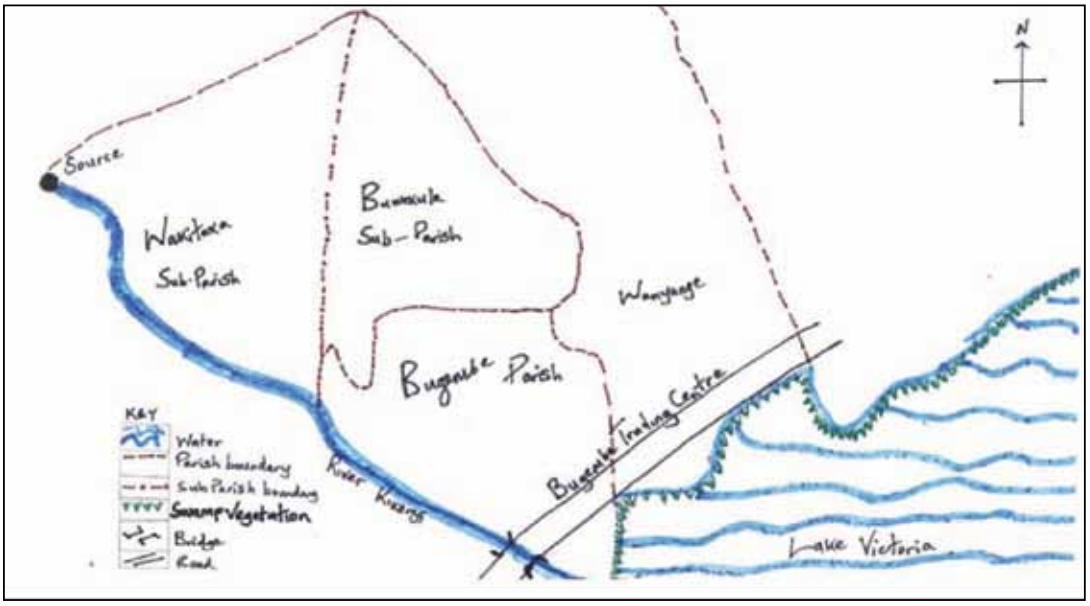
Environment Committee and Wildlife Club, Wanyange Girls' Secondary School

Introduction

Following the call worldwide on environment alert, we the undersigned group has decided to take a case study on the courses/sources of water pollution on river Kikenyi so as to determine water quality. As we are all aware water is life, millions



of people have died because of lack of safe drinking water. Many people can't afford clean water. Uganda in particular is affected. Environmentalists, in their programmes have tried their best to protect and conserve the water so as to ensure continuity of clean water both in rural and urban localities. It is on this basis that the environmental club of Wanyange Girl's Secondary School under took this research so that the findings can be used in the future to guide the policy makers in controlling water pollution.

Description of the area under study

- Date of study: From May to July 2003
- Frequency After every two weeks
- Name of town: Jinja
- Name of river: Kikenyi
- Location: Bugembe Parish- 5 Kms along Jinja-Tororo road
- Weather condition: Rainy/dry
- Depth of water: Varies from 0.8m to 1 3/4 m
- Rate of water flow per minute: Varies from 12m – 26m per minute

Target group

The group involved includes: Residents of the village, members of the local community and Religious leaders.

Point 1 is upstream, near the source; point 2 is downstream, before its mouth

Location

The stream under study is located along the border of: Wanyama, Namulesa, Kikenyi, Masese and Budumbuli stream. It stretches from Buwekula hills through Wanyama across Jinja -Tororo highway and drains into Lake Victoria's Napoleon gulf. It is in Bugembe parish, Mafubira sub-county and Butembe county- see the attached map. The catchment area covers Wanyange hill, tributaries from Buwekula, and Wanyama.

RESULTS THE STATE OF KIKENYI STREAM

The group carried out on spot investigations on many occasions on the state of river kikenyi and the findings were that Kikenyi stream is polluted seasonally. Evidence of this is seen in a change in water colour, oil scum floating on the water surface, polythene bags accumulated on the riverside, shallowness in-depth [an indicator of siltation] human and animal excreta etc basing on the background, we categorized the pollution on the river as follows; chemical, biological, physical pollution.

Chemical pollutants

There are evidences of:

- Residues from waragi distilleries. These are Buwekula, Wanyama and Budumbuli villages along which the river passes. Over 15 distilleries are located on the river banks and all the waste is discharged into the s tream.
- Used oil, chemicals from steel rolling mill and agro chemical fertilizers applied by the local market farmers. Traces of oil and agrochemical containers were observed floating on top of the water in the stream. These can be classified under industrial hazardous waste.

Biological pollutants

The following were observed as indicators of biological pollution

1. Green algae seen growing on water
2. Decomposing organic matter
3. Animal excreta from cattle, pigs poultry, ducks and chicken
4. Farming activities along the river e.g. growing of sugarcane, yams, potatoes, tomatoes, cassava, maize etc. These loosen the soil, exposing it to erosive agents who wash it into the river causing siltation and contamination. Eucalyptus trees are planted too near the water. Their roots cause seepage which results into contamination.

Activities carried out around the stream.

- Construction of houses (building & settlement along the river) at the river bank
- Brick making along the river bank
- Throwing polythene papers into water. These are seen floating on top of water
- Disposal of human faecal matter into the water due to lack of pit latrine
- Chewing and throwing the cane remains into the stream
- Runoff water from drainages/channels that carry soil, wastes and sediments into the river
- Roads construction at Wanyama that exposes soil leaving it to be washed in river
- Dumping of wastes and decomposing oil products from silos, located north of the river
- Erosive activities and deposition of soil into water from the river bank. This is seen around Buwekula.
- Wastes from abattoir [slaughter house] in Bugembe central market, channels in to a main drainage which originates right from Bugembe cathedral draining into the stream
- Wastes from Bugembe market channels through the same drainage and finds its destination into the stream.
- Wastes from local brew [malwa] at Wanyama trading centre are either poured into the main drainage which connects to the river or disposed off directly into the river.
- Intensive farming along the river bank loosens the soil and causes collapse of the river bank into the water causing siltation. Agro-chemicals applied to crops are eventually washed by heavy rain into the water. Organic matter(manure used in farming finds its way into the river
- Pieces of metal from steel are also evident in the stream
- Washing of clothes, kitchen utensils, equipments from small scale distilleries along the river drums saucepans, plastic mugs and mineral -water containers are also major cause of water pollution in the river

Others sources of pollution include:

- Burnt old tyres around the river, the residues are washed into the stream by running water
- Swimming and bathing in the stream leaves impurities in the water and at times urine a major source of bilharziasis
- Mining of river sand leaves impurities in the water
- Fishing in small scale leaves the water dirty

Young boys polluting the stream by washing their feet in it

Investigation 3

Table 1 Measurements (results) May-July

Date of test	Temp(average	Ph	Speed of water(m/min)	Depth of water	Colour of water
May					
1st week	26^{0}c	8.30	18	0.8m	Brown[dirty]
2nd week	27^{0}c	8.00	14	0.8m	Brown[dirty]
3rd week	29^{0}c	8.20	12	0.8m	Brown[dirty]
June					
1st week	19^{0}c	8.11	20	1m	Clear
2nd week	16^{0}c	8.00	23	1 1/4m	Clear
3rd week	12^{0}c	8.22	23	1 1/2m	Clear
July					
1st week	14^{0}c	8.10	26	1 3/4m	Clear
2nd week	17^{0}c	8.30	26	1m	Clear
3rd week	21^{0}c	8.20	24	1m	Brownish

Further Investigation: Investigation 4 will be on mineral content of the water

a. b.

Notice the difference in water quality between (a) upstream and (b) downstream.

APPENDIX 2

ENVIRONMENTAL IMPACT OF THE FLOWER GROWING INDUSTRY: A case study of Victoria Flowers Limited

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ENTEBBE SENIOR SECONDARY SCHOOL

Victoria Flowers Limited, Entebbe

Introduction

Floriculture is becoming a major economic activity around the shores of Lake Victoria. Some of the flower growing companies located along Kampala-Entebbe road are: Expression, Rosebud, Victoria Flowers Uganda Limited, Wagagai. All the farms are constructed near wetlands. Entebbe Secondary School Environment Club has carried out a case study at one of the flower farms in Entebbe that is Victoria Flowers Uganda Limited. The focus of the study was on the emrging impact of the flower farm on the other components of the environment in the locality.

Background

Victoria Flowers Uganda Limited is situated in Entebbe – Busambaga Zone 1½km off Entebbe-Kampala road. It was started by a Ugandan Businessman Mr. Gordon Wavamuno and his French Counterpart Mr. Rene Bartoli in 1995. It started with 2½ hectares but presently it convers 8 hectares and so far has 15 green houses.
Further expansion is still going on. The farm employs approximately 200 workers both skilled and unskilled of whom 80% are women and 20% are men. Some of the rose species grown on the farm: Red calypso, Lambadda, Vanilla, Sun beam and Eskimo.

Objectives of the study

- Investigate if there is pollution taking place
- Find out the impact of flower growing on subsistence farming
- Find out the effect of flower growing on Lake Victoria
- Identify the effect of flower growing on the environment
- Find out the different methods being used to grow flowers

Limitation/problems

- **Language Barrier:**
  Some of the workers did not know English and some of the students did not know Luganda and so communication was difficult.
- **False Information:**
  Some workers gave false information about pollution caused by the chemicals. Some said that there was an effect and others said there was no effect yet the waste chemicals are being poured into Lake Victoria.
- We had limited time for interviewing the workers.
- Some workers were impolite and rude and so they could not give us all the necessary information.
- Some workers could shy away and so we found it difficult to get information from them.

Talking to workers doing Packaging

- Some students who interviewed some workers from the rooms where chemicals are mixed complained of an irritating smell.

Methods of study

- Questionnaire
- Interviews
- Field visits
- Observations
- Sampling
- Documentation

A student interviewing some workers outside the Greenhouse

Four visits in all have been made with 3 of them in Victoria Flowers Limited and one to Rosebud. Both students and teachers participated in the formulation of the questions, administering the questionnaires and making
evaluation.

Observing the packaging process

Two types of questions were administered. One was to the workers mainly to find out the effect of flower growing on subsistence farming and the occupational hazard of the worker (see questionnaire 1).

FINDINGS

(a) The findings of the visits to Victoria Flowers are summarized so far as below:

TABLE 1: WORKERS AT VICTORIA FLOWER FARM

Number of People interviewed	: 32
Gender	: Female 53% : Male: 47%
Age Range	: 20 – 50years
Working hours	: 10- 11 hours per working day
Meals given to workers	: Break : Porridge : Lunch : Posho and Beans
Previous employment before joining the farm	: Unemployed, former students, : Waitress, Drivers, Statisticians
Other jobs they do after their work	: Baking bread, housewives, further : Baking bread, housewives, further
	: studies, kiosk business
Training for their job	: On joining and some trained before joining the farm

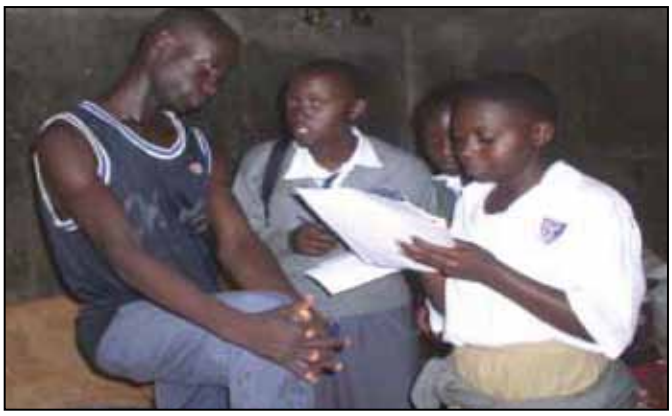
(b) Method of Rose Growing: Budding

Advantages

- Grow faster
- Reduced costs
- Easy to carry out
- Many buds can be established on one stem

Disadvantages

- Time consuming
- Wilting
- Persons are exposed to thorn pricks
- Needs skilled labour



Occupational hazards

The workers reported:

- Irritating smell of chemicals used for spraying
- Skin rash
- Chest pain
- Back pain

Extremes of temperature both hot and cold (in the cold room and green houses respectively)

Interviewing a worker

- Exposure to chemical irritants (sometimes workers are forced to undress in green houses when it is hot).
- Blindness: A worker is reported to have become blind when chemically treated soil particles entered his eye.
- Lung damage: A worker is reported to have developed holes in his lungs and he was retired
- Headaches probably due to too much sun shine or exhaustion
- Finger nail pricked by thorns infected because of pesticides

(c) Water Pollution

Cut flowers require a lot of water (60,000 litres/hectare per day). See impact of flower industry in Uganda by P. Asea and D. Kaija). Victoria Flowers pumps water from the lake which later finds its way back to the lake. Mitigation measures against pollution include using a soak pit with a stone medium and charcoal. Some samples of water have been taken for laboratory test by S.6 science students. When asked about pollution, 30 people said yes and 2 said there was no pollution.

FERTILISERS USED IN THE FARM

Fertiliser and chemical used	Use	Effect to the Environment
Sulphur dust	To kill invading insects such as bees, caterpillars, butterflies etc.	- Causes air pollution Irritating smell Reduces/kills biodiversity
Ammonia nitrates	To lower soil Ph from 7.5 to 6.8	It does not favour survival of extreme pH needing micro organisms in the soil
Poly feed	To increase root hair growth	
Manganese	Serves as a micro nutri-ent element	
Urea	To provide nitrogen to the soil	
Mono potassium phosphate		
Potassium nitrate	Provide potassium ions and nitrates	
Calcium nitrate	To provide nitrogen	
Magnesium sulphate	To provide for sulphur and magnesium	
Iodine	For micro nutrient	
Zinc nitrate	To provide nitrogen	

(d) Displacement Of People

Most of the local people around Victoria Flowers are Kibanja holders (squatters). They lost their land rights when the land-owners sold out to Victoria flowers. Some had lived here for as long as 35 years. They have not been resettled and they complain of terms of resettlement. They are expected to vacate anytime.

NEGATIVE IMPACT ON THE LOCATION AND WETLAND SUBSISTENCE FARMING

- Fruit trees (jack fruit, mangoes, avocadoes), banana plants, empafu, are no longer yielding as they used to.
- At least 12 goats miscarried in 2003 at New Life Education Centre which is close to the farm. Another goat this year had premature delivery.
- The free-range chickens which stray into the farm end up dying.
- They were hardly any flying insects in homesteads in the vicinity of

the farm. A very distinct smell of chemicals can be smelt outside the fence around the flower garden.

- All the above is said to be due to the close proximity of homestead around the flower farm.

Test on water effluents from the farm

Test	Observation
PH	
Colour	Pale green
Ca 2+	Yet to be done
Mg 2+	Yet to be done
Suspended particles	Many
Smell	

(e) Wetland encroachment and degradation:

Victoria flowers and Rosebud II (formerly Equator Flowers) are located at the edge of a wetland;

- Crocodiles, hippos and monkeys used to frequent this wetland, but are no longer there.
- We fear that the wetland might be reclaimed at Lutembe Bay (Rosebud).

Recommendations:

- Encourage resettlement of people to other areas; away from the farm.
- Flower farms should be established in areas with scarce settlement.
- Improve on the treatment of waste water.
- Improve on the use of protective gear for persons working on the farm.
- Proper incinerators should be used in burning waste
- Put in place waste management measures.

APPENDIX 3

4.5.2 WATER QUALITY PARAMETERS

The quality of water for any intended use is determined by both physical and chemical parameters (characteristics). The physical parameters 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:

1. 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 (º C) or degrees Fahrenheit (º F).

2. pH

PH represents the effective concentration (activity) of hydrogen ions (H+) in water. The pH of water can be measured with a pH meter, which is an electronic device with a probe which is dipped into water. pH can also be measured with pH paper or by adding a reagent (universal indicator solution) to the water sample and recording the change in colour. Sometimes gases such as CO2, SO2, H2S get into the water forming acids.

Carbon dioxide (CO2) 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 CO2 forms a weak acid. Natural, unpolluted rainwater can be as acidic as pH 5.6, because it absorbs CO2 as it falls through the air. Because plants take in CO2 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 (NO2, NO3) and sulfur dioxide (SO2)) which can react in the atmosphere to form nitric acid (HNO3) and sulfuric acid (H2SO4). 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.

3. 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 through the photosynthetic processes of aquatic plants and algae. 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 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 therefore "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.

Some factors that affect DO include;

- Velocity and volume of water: 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.

4. 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. Buffering materials such as bicarbonate (HCO3-) and carbonate (CO32-) ions help neutralize acids as they are added to the water.

Waters with low alkalinity are likely to be affected by changes in pH. Waters with high alkalinity are able to resist major changes 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 reduced. 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).

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

Common Forms of Nitrogen in Water

- Nitrates
- Nitrites
- Ammonia

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 your teacher will explain to you.

- Total ammonia (ammonium ion ($NH4^+$) plus unionized ammonia gas ($NH3$) is often measured in a laboratory by titration. Again your teacher should be able to explain to you how this can be done.

Factors Affecting Nitrate Nitrite Concentrations

a) Wastewater and Septic System Effluents

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 in these forms, the nitrogen goes down the drains in our houses and businesses, and can enter streams from wastewater treatment plant effluent, illegal sanitary sewer connections, and poorly functioning septic systems.

b) Fertilizer Runoff

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 places into storm drains and nearby streams, or seeps into groundwater.

c) 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, piggeries and dairies.

d) 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 concentration in clean waters is generally very low. However, phosphorus is used extensively in fertilizers and other chemicals, so it can be found in higher concentrations in areas of human activity.

Phosphorus in natural waters is usually found in the form of phosphates (PO4-3). 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 in a process called eutrophication. Dissolved oxygen concentrations can drop too low for fish to breathe, leading to death of fish. 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 such as in dissolved or particulate form using a colorimetric method. Your teacher will explain how this can be done.

Water hardness

Hardness is measure of cations in water. Hardness generally represents the concentration of calcium (Ca2+) and magnesium (Mg2+) ions, because these are the most common cations. 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 and is generally expressed in units of milligrams per liter (mg/l) or parts per million (ppm) of CaCO3 (calcium carbonate).

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.

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 (some times called a nephelometer) is used. 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 105º 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

Fecal coliform bacteria, which belong to several genera of bacteria belonging to the family enterobacteriaceae, are present in large numbers in te feces and intestinal tracts of humans and other 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 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 and dysentery. 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. Your teacher may explain to you how these methods work.

GLOSSARY

Adaptation:
Evolutionary process by which an organism becomes better suited to live in particular environment. How a species changes over time to better live in a particular environment.

Anoxic:
Without oxygen.

Authority:
The power to enforce laws, exact obedience, command, determine, or judge
Aquifer: An underground layer of rock and sand that contains water

Biodiversity:
The number of different species in a defined ecosystem. Bog- A wetland ecosystem that is highly acidic and has an accumulation of decomposed plants known as peat.

Buffer zone:
The area of land next to a body of water, where activities such as, construction are restricted in order to protect the water.

Buttress:
Broadened bottom of a tree trunk that helps to stabilize a tree growing in wet soil or water.

Carnivore:
Any organism that eats other consumers (sometimes referred to as "meat eaters")

Conservation:
Preservation or restoration from loss, damage, or neglect.

Consumer:
Any organism that cannot produce its own food and must, therefore, get its energy by eaing, or consuming, other organisms

Decomposer:
Organisms such as fungi and bacteria that feed on dead material causing the chemical break down of the material

Detritus:
Decaying organic matter found in the top layer of soil or mixed with wetland waters; a food source for many
small wetland organisms.

Detritivore:
Any organism that consumes detritus

Dormant:
Period when a plant is not actively growing, but is still alive. For most wetland plants this happens in the winter

Endangered species:
Any species of plant or animal that is having trouble surviving and reproducing. This is often caused by loss of habitat, not enough food, or pollution. Endangered species are protected by the government sin an effort to keep them from becoming extinct.

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.

Ecosystem:
A network of plants and animals that live together and depend on each other for survival. It refers to an ecological community together with its environment, functioning as a unit.

Emergent:
oft stemmed plants that grow above the water level.

Endemic:
Native only to a particular area.

Environmental Impact Assessment (EIA):
A systematic examination conducted or procedure followed to determine whether or not a given project / development activity/land use in a wetland will have any adverse impact on the environment.

Erosion:
Process in which land is worn away by external forces, such as wind, water, or human activity.

Estuary:
An environment where terrestrial, freshwater, and seawater (saline) habitats overlap

Evergreen:
Any plant that keeps its leaves throughout the year.

Freshwater:
Water without salt in it such as like ponds and streams.

Global warming:
An increase of the earth's temperature by a few degrees resulting in an increase in the volume of water which contributes to sea-level rise

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.

Habitat:
The environment in which an organism lives.

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

Hydric soil:
Soil that is wet long enough for anoxic (oxygenless) conditions to develop. The water in the soil forces air out. This soil is found in wetlands.

Hydrophyte:
A plant that can, and often must live in water.

Management:
The act, manner, or practice of managing; handling, supervision, or control.

Mangrove forest:
Wetland in tropical areas, such as the coasts of Africa, Mexico, Australia, that has mangrove trees and either fresh or salt water.

Marsh:
An environment where terrestrial and aquatic habitats overlap; a wetland dominated by grasses

Natural resources:
Are naturally occurring substances that are considered valuable in their relatively unmodified natural form.

Nonpoint source pollution:
Indirect or scattered sources of pollution that enter a water system such as drainage or runoff from agricultural fields, airborne pollution from crop-dusting, runoff from urban areas (construction sites, etc.)

Omnivore:
Any organism that eats both plants and animals
Organic material- Anything that is living or was living; in soil it is usually made up of nuts, leaves, twigs, bark, etc.

Organism:
A living thing.

Pathogens:
Microorganisms (e.g., bacteria, viruses, or parasites) that can cause disease in humans, animals and plants.Also referred to as a disease causing organism or an infectious agent that causes illness to its host

Peat:
Organic material (leaves, bark, nuts) that has decayed partially. It is dark brown with identifiable plant parts, and can be found in peat lands and bogs.

Persistent emergent plant:
Species of plants whose stems show above the water and do not deteriorate when the plant goes dormant (e.g. cattails).

Policy:
A plan or course of action, or business, intended to influence and determine decisions, actions, and other matters.

Pollution:
Waste, often made by humans, that damages the water, the air, and the soil.

Precipitation:
Rain, sleet, hail, snow all of which are formed by condensation of moisture in the atmosphere and fall to the ground/earth's surface.

Predator:
An animal that lives by capturing other animals for food

Prey:
An animal that is killed and eaten by another animal

Producer:
Any organism that is capable of producing its own food, usually through photosynthesis

Ramsar Convention:
The Convention on Wetlands, signed in Ramsar, Iran, in 1971, is an intergovernmental treaty which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.

Rhizome:
A special underground part of the stem of a plant form which may grow new plants.

Runoff:
Rainwater that flows over the land and into streams and lakes; it often picks up soil particles along the way and brings them into the streams and lakes.

Salinity:
The amount of salt in water.

Salt Marsh:
Flat land that is flooded by salt water brought in by tides; it is found along rivers, bays, and oceans.

Saltwater:
Water with salt in it, such as in oceans.

Saltwater Intrusion:
The invasion of freshwater bodies by denser salt water

Saturation:
The condition in which soil has as much water in it as it can hold.

Scavenger:
An animal that eats the dead remains and wastes of other animals and plants
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. Silt- One of three main parts of soil (sand, silt, and clay); silt is small rock particles that are between .05 mm and .002 mm in diameter.

Submerged aquatic vegetation:
Plants that live entirely under water.

Subsidence:
A gradual sinking of land with respect to its previous level

Sustainable use:
Use of resources at a rate which will meet the needs of the present without impairing the ability of future generations to meet their needs

Swamp:
A wetland that has trees and shrubs.

Water Table:
The highest level of soil that is saturated by water.

Watershed:
All the water from precipitation (snow, rain, etc.) that drains into a particular body of water (stream, pond, river, bay, etc.). 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.

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.

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) It 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.

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 food borne disease through consumption of the same micro-organisms.A waterborne disease can be caused by protozoa, viruses, bacteria, and intestinal parasites. (Examples include; Diarrhoea, Dysentry, Cholera,Trachoma,Typhoid e.t.c)

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.

Wetland Abuse:
Any action that leads to loss or degradation of a wetland.

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