Tool and Guideline # 3

Practical Tools on Restoration and Conservation of Protected Wetlands

Rwanda Environment Management Authority
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PREFACE

In 2010, REMA prepared 11 practical technical tools intended to strengthen environmental management capacities of districts, sectors and towns. Although not intended to provide an exhaustive account of approaches and situations, these tools are part of REMA's objective to address capacity-building needs of officers by providing practical guidelines and tools for an array of investments initiatives.

Tools and Guidelines in this series are as follows:

#	*TOOLS AND GUIDELINES*
1	Practical Tools for Sectoral Environmental Planning : A - Building Constructions B - Rural Roads C - Water Supply D - Sanitation Systems E - Forestry F - Crop Production G - Animal Husbandry H - Irrigation I - Fish Farming J - Solid Waste Management
2	Practical Tools on Land Management - GPS, Mapping and GIS
3	Practical Tools on Restoration and Conservation of Protected Wetlands
4	Practical Tools on Sustainable Agriculture
5	Practical Tools on Soil and Water Conservation Measures
6	Practical Tools on Agroforestry
7	Practical Tools of Irrigated Agriculture on Non-Protected Wetlands
8	Practical Tools on Soil Productivity and Crop Production
9	Practical Technical Information on Low-cost Technologies: Composting Latrines & Rainwater Harvesting Infrastructure
10	Practical Tools on Water Monitoring Methods and Instrumentation
11	11.1 Practical Tools on Solid Waste Management of Imidugudu, Small Towns and Cities : Landfill and Composting Facilities
	11.2 Practical Tools on Small-scale Incinerators for Biomedical Waste Management

These tools are based on the compilation of relevant subject literature, observations, experience, and advice of colleagues in REMA and other institutions. Mainstreaming gender and social issues has been addressed as cross-cutting issues under the relevant themes during the development of these tools.

The Tool and Guideline # 2 provides practical tools and methods on how to restore and conserve protected wetlands in Rwanda.

These tools could not have been produced without the dedication and cooperation of the REMA editorial staff. Their work is gratefully acknowledged.

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1. INTRODUCTION

1.1 Overview

Lakes and wetlands (including marshlands and swamps) sustain Rwanda's extensive hydrological network. A recent inventory recorded 101 lakes and 860 wetlands, covering a total surface area of 1,495 km² and 2,785 km², respectively. This is equivalent to 16 percent of the country's land area. Wetlands are amongst the most productive ecosystems in Rwanda in terms of plant matter, fisheries and supporting freshwater biodiversity. They provide critical services, they feed lakes and rivers, trap and filter sediments and nutrients, absorb floodwaters, buffer croplands and settlements from strong run-off, and replenish rivers and streams during the dry season.

Impacts on wetlands can be caused both by human activities within them and, because of the interconnectedness of the hydrological cycle, by activities that take place within the wider catchment.

Human modification of the hydrological regime, by removing water (including groundwater) or altering fluxes, can have detrimental consequences for the integrity of wetland ecosystems. Insufficient water reaching wetlands, due to abstractions, storage and diversion of water for public supply, agriculture, industry and hydropower, is a major cause of wetland loss and degradation. A key requirement for wetland conservation and wise use is to ensure that adequate water of the right quality is allocated to wetlands at the right time.

1.2 Purpose

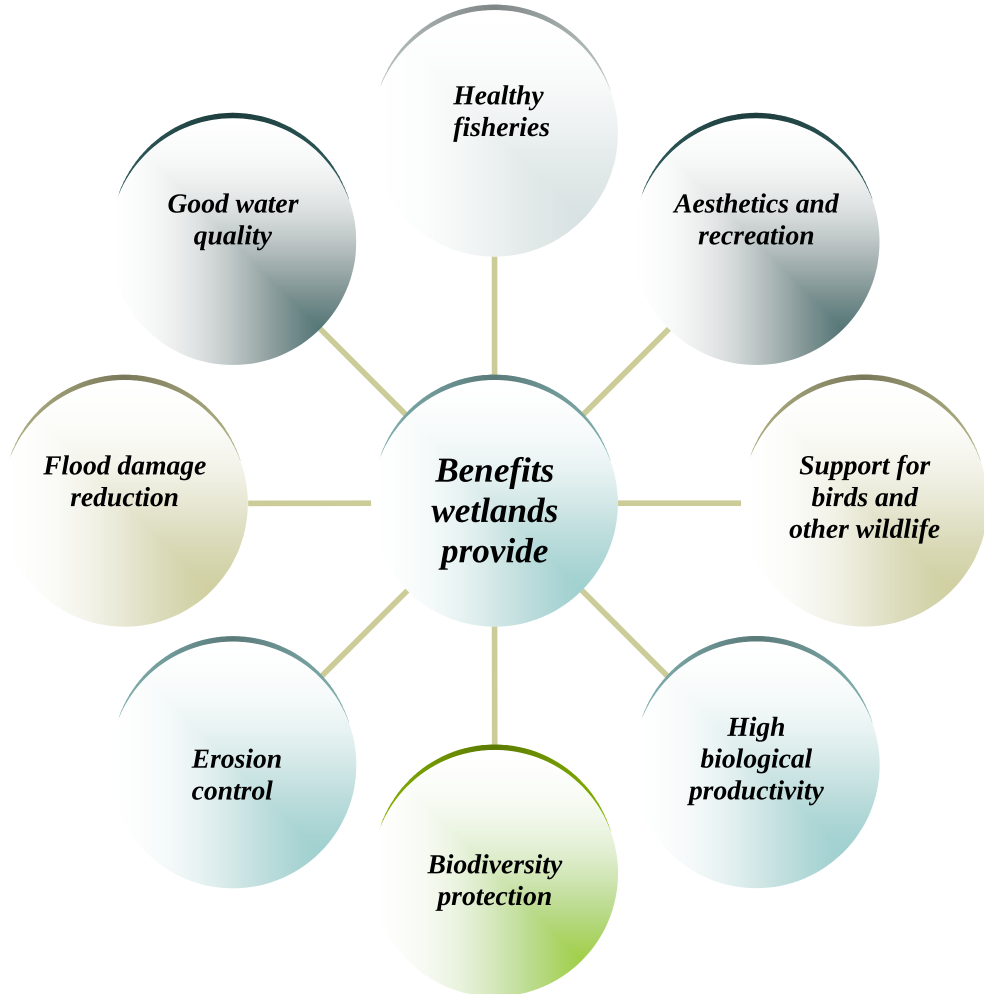
The objective of this tool and guideline is to propose practical methods on how to restore and conserve protected wetlands in Rwanda.

Although not intended to provide an exhaustive account of approaches and situations, this tool is intended to address capacity-building needs of officers by providing information on the restoration and conservation of protected wetlands in Rwanda.

This document was produced to address REMA's proposed policy action to strengthen the resource capacity of environmental and related institutions at national and district level for environmental assessment, policy analysis, monitoring, and enforcement.

1.3 Why restore and conserve wetlands?

While preservation of habitat is a key to environmental health, there is a growing awareness that restoration and enhancement of wetlands are essential to recover ecosystems that have been degraded or destroyed. Wetlands have been altered and or drained to support agricultural uses. Indirect impacts from agriculture pollutants can degrade and destroy wetlands. The loss and degradation of wetlands can result in a decline in the important benefits that wetlands provide to society. Some of the benefits wetlands provide include:



- *Healthy fisheries:* Fish are dependent on lakes, rivers and their wetlands.

- *Support for birds and other wildlife:* Wetlands are probably best known for their value to waterfowl. In addition to birds, other wildlife makes its home in wetlands. Reptiles and amphibians are common wetland residents.

- *High biological productivity:* Many wetlands are highly productive ecosystems in large part because they are rich in organic matter and nutrients. These nutrients support organisms within the marsh, but in many instances the nutrients are also transferred to nearby aquatic systems (lakes and rivers), enhancing the productivity of these systems and supporting human uses such as fisheries.

- *Biodiversity protection:* Wetlands support a great diversity of species and many of the species are unique and rare.

- *Erosion control:* Wetland vegetation buffers the adjacent upland from erosion.

- *Flood damage reduction:* Wetlands intercept runoff thereby changing rapid and high peak flows to slower and smaller discharges over longer periods of time. Because it is usually the peak flows that cause flood damage, the effect of wetlands is to reduce the danger of flooding.

- *Good water quality:* Wetlands are known for their ability to capture sediments and filter pollutants, which improves water quality. For example, floods often carry very turbid water which, if not for the filtering that occurs in downstream wetlands, could deposit sediment that would smother plants and fish eggs.

- *Aesthetics and recreation:* Many recreational activities take place in and around lakes and wetlands.

What is restoration and enhancement of wetlands?

The terms “restoration” and “enhancement” have been defined a variety of ways. The following commonly-accepted definitions for these terms will be used in this document:

- *Restoration:* Returning a degraded wetland or former wetland to a pre-existing condition or as close to that condition as is possible.

- *Enhancement:* Increasing one or more of the functions performed by an existing wetland beyond what currently or previously existed in the wetland. There is often an accompanying decrease in other functions.

Restoration and enhancement projects may be difficult to distinguish from each other, because both can encompass activities in existing degraded wetlands. Restoration entails returning a wetland to a former state (e.g., filling a ditch so that a drained wetland becomes flooded again), while enhancement means changing the wetland so that one or more functions are increased beyond their original state. Enhancing a wetland in one way often degrades it in another way. For example, adding more water to a wetland may create better habitat for fish, but it will decrease the ability of the wetland to hold flood waters. This trade-off is particularly true for enhancement in relatively unaltered wetlands. Some common examples of the trade-offs that can occur with wetland enhancement include loss of fish habitat when marshes are impounded to provide waterfowl habitat, decreased water storage when seasonal wetlands are flooded to increase aquatic habitat, and loss of bird habitat when mangroves are removed to provide shorebird habitat.

When wetland enhancement is undertaken, the project goals should include minimizing any decrease in existing wetland functions. The outcome of an enhancement project is often difficult to predict because these projects essentially try to produce a new ecosystem. With restoration projects, outcomes are more predictable, although there may still be uncertainty depending on the type of wetland, extent of degradation, and many other factors.

2. TECHNIQUES AND METHODS FOR THE RESTORATION AND ENHANCEMENT OF WETLANDS

2.1 Guiding Principles

Wetland ecosystems are adapted to the prevailing hydrological regime. The spatial and temporal variation in water depth, flow patterns and water quality, as well as the frequency and duration of inundation, are often the most important factors determining the ecological character of a wetland. To maintain the natural ecological character of a wetland, it is necessary to allocate water as closely as possible to the natural regime. The ecological character of many wetlands has adapted to past alterations of the water regime, yet they still provide important goods and services. A key step in any wetland conservation strategy is to define the desired ecological character of the most important wetlands. In any water allocation decision, it is then necessary to quantify the critical water needs of the wetlands, beyond which their ecological character will change in an unacceptable manner.

The following seven guiding principles should be followed:

- *Sustainability as a goal*: Adequate water has to be provided to wetlands to sustain the functioning of these ecosystems, respecting their natural dynamics for the benefit of future generations.

- *Clarity of process*: The process by which decisions are made on the allocation of water should be clear to all stakeholders.

- *Equity in participation and decision-making factors*: There should be equity for different stakeholders in their participation in water allocation decisions.

- *Credibility of science*; Scientific methods used to support water allocation decisions should be credible and supported by review from the scientific community. Science must be based on appropriate hydrological and ecological data, including adequate baseline ecosystem records.

- *Transparency in implementation*: Once procedures for water allocation decisions have been defined and agreed, it is important that they be seen to be implemented correctly.

- *Flexibility of management*: Like many ecosystems, wetlands are characterized by complexity, changing conditions, and uncertainty. It is essential that an adaptive management strategy be adopted, which requires plans that can be changed as new information or understanding comes to light.

- *Accountability for decisions*: Decision-makers should be accountable. If agreed procedures are not followed or subjective decisions can be shown to be contrary to the spirit of the above principles, decision-makers should provide a full explanation. Stakeholders should have recourse to an independent body if they feel that procedures have not been followed.

2.2 Common Wetland Problems and Corrective Methods

Wetlands are unique ecosystems that often occur at the edge of aquatic (fresh water) or terrestrial (upland) systems. They may be wet year-round, wet during certain seasons, or wet during part of the day. Wetlands generally include swamps, marshes, bogs, and similar areas.

Although wetland types are diverse, they all possess several ecological characteristics that distinguish them from upland or other aquatic ecosystems. Specifically, wetlands are characterized by unique hydrologic, soil (substrate), and biotic conditions.

The hydrological regime is determined by the duration, flow, amount, and frequency of water on a site. A site has wetland hydrology when it is wet enough to produce soils that can support hydrophytic vegetation (plants that are adapted to waterlogged environments). Wetland substrates are called hydric soils, meaning they are saturated with water for part or all of the year. Saturated soils become anaerobic (without oxygen) as water stimulates the growth of micro-organisms, which use up the oxygen in the spaces between soil particles. When soils become anaerobic, they change significantly in structure and chemistry. These factors all make wetland soils stressful to terrestrial plants.

As a result of waterlogged, anaerobic conditions, wetlands are dominated by hydrophytic plants that are specifically adapted to withstand these demanding conditions. The wide diversity of wetland plant species includes emergent plants, those with leaves that grow through the water column, submerged plants, and floating-leaved plants. Wetland plants also include trees, shrubs, moss, and many other vegetation types. Because they exist where land and water meet, wetlands are often used by animals from both wet and dry environments. A number of invertebrate, fish, reptile, and amphibian species depend on wetland water cycles to survive or complete their life-cycles.

The loss and degradation of wetlands in Rwanda has resulted in a decline in the important benefits that wetlands provide to society. These benefits or functions usually link to goods and services important to society. Some of the benefits wetlands provide include support for birds, wildlife and fisheries, high biological productivity, biodiversity protection, erosion control, flood damage reduction and good water quality controls.

The primary goal of wetland restoration is to preserve and restore wetland benefits by re-establishing natural ecological processes. Restoration practitioners typically implement only the actions necessary to re-establish natural wetland processes on a site. The first method to consider for renewing functions is to *remove the factors causing wetland degradation or loss* and let nature do the work of restoration. This method is often called the *passive approach*. For example, if wetland vegetation and water quality are degraded primarily as a result of cattle grazing, then removing the cows may be the only activity needed to restore the wetland system.

Passive methods allow natural regeneration of wetland plant communities, natural re-colonization by animals, and re-establishment of wetland hydrology and soils. Passive approaches are most appropriate when the degraded site still retains basic wetland characteristics and the source of the degradation is an action that can be stopped. The success of passive methods usually depends on an accessible source of water, the close proximity of wetland plants and animals, and a mechanism for bringing species to the restoration site. The benefits of passive methods include low cost and a high degree of certainty that the resulting wetland will be compatible with the surrounding landscape.

For many sites, passive methods are not enough to restore the natural system and an *active approach* is necessary. Active approaches involve physical intervention in which humans directly control site processes to restore, create, or enhance wetland systems. The active approach is most appropriate when a *wetland is severely degraded* or when goals cannot be achieved in any other way, as is the case with wetland enhancements. Active methods include re-contouring a site to the desired topography, changing the water flow with water control structures (i.e., weirs or culverts), intensive planting and seeding, intensive non-native species control, and bringing soils to the site to provide the proper substrate for native species. The design, engineering, construction, and costs for such work can be significant.

The next Table contains some of the most common and obvious examples of wetland damage and typical corrective measures. The table also lists some cautions. If the damage is severe or has been present for a long time, reversing the damage may not be as simple as it initially seemed. Some of these corrective measures are also applicable to implementing enhancement projects.

Table 1 : Common Wetland Problems and Corrective Methods

Wetland Damage	***Reason for Damage Suggested***	***Correction***	***Considerations***
Hydrology			
Water Quality Impairment	Excess sediment or nutrients in runoff from adjacent area	Work to change local land use practices; Install vegetated buffers; Install sediment traps.	Sediment traps will need periodic cleaning; An expert may be needed to design buffers.
Water Quality Impairment	Excess sediments from eroding slopes	Stabilize slopes with vegetation or soil and water conservation measures	Many corrective methods exist; look for most sustainable and effective methods[1].
Altered Hydrology (drained)	Ditching	Fill or plug ditches	Organic soil may have decomposed so that the elevation of the site is lower than it used to be.
Altered Hydrology (constrained)	Road crossing with undersized culvert	Replace with properly sized culvert	Hydrologic/engineering expert needed to correct this.
Altered Hydrology (drained)	Former wetland diked off from its water sources	Remove/breach dikes or install water control structures	Substrate elevation may not be correct for vegetation; add soil or control water level with low maintenance structures
Soils			
Raised Elevation	Soil dumping or fill	Remove material	Fill may have compressed soil to lower than initial elevation; take steps to avoid erosion.
Subsidence	Soil removal; oxidation of organics; groundwater removal	Add fill; allow natural sedimentation	Fill must support target wetland; test fill for toxic compounds.
Toxic Soils	By-product of on-site or off-site industrial process; dumping; leaching and concentration of natural compounds	Treatment systems or methods appropriate to the soil /pollutants; remove material; cover with appropriate soil.	Work with experts to choose treatment methods that cause least amount of indirect damage; choose a different site to avoid serious toxin problems.
Biota			
Loss of Biodiversity	Change in original habitat	Restore native plant and animal community using natural processes.	Allow species to colonize naturally; import species as appropriate.
Loss of Native Plant Species	Invasive and/or non-native plants; change in hydrology; change in land use	Remove invasive, non-native plants (allow native plants to re-colonize); try to reverse changes in hydrology.	Pick lowest impact removal method; repeat removal as non-natives reinvade; alter conditions to discourage non-native species.

[1] Refer to Tool and Guideline # 5 – Practical Tools on Soil and Water Conservation Measures.

2.3 Planning

Good planning is a critical, but often overlooked, stage of the restoration and enhancement process. Inadequate planning is often cited as a major reason projects fail to result in self-sustaining, naturally-functioning systems. Here are just a few reasons thoughtful planning is so important:

- Planning requires collecting information about the local area, potential restoration or enhancement sites.
- Planning will help you choose the best site to achieve your goals.
- Planning will help you establish clear and feasible objectives given the factors that may constrain the project.
- Planning identifies the materials, labour, and activities that will be needed to achieve the project's goals.
- Objectives and target criteria established during planning direct the type of monitoring that will be needed.
- Clear goals and objectives will help you explain to other people, including potential funders, partners, and the local community, what you are trying to accomplish.

Below is a list of questions to keep in mind as you plan your wetland project. Don't be alarmed if the answer to many of these questions is "*we don't know precisely and finding out would be too costly*." Many of these questions do not have simple answers, but even partial answers can help you in your planning.

Hydrology

- Where can baseline hydrologic data, including typical and extreme flood events and their potential, be found?
- What are the current hydrologic characteristics of the project site?
- What parameters should be measured at the project site?
- What has caused changes to the hydrologic characteristics of the site (what removed the water or prevents it from entering your site)?
- Are there potential effects on downstream areas of changing the hydrologic characteristics of your site?
- What is the relationship between the elevation of the land surface and primary water sources (surface and ground water) for the wetland?
- What changes might restore hydrology and the correct relationship between soil and water levels?
- What design elements should be included to restore or create the typical hydrological regime and allow for extreme events?
- What bioengineering or soft engineering implementation methods are available?
- What factors might constrain restoring or creating full hydrological functioning?
- What are likely reasons that the site might fail to reach its hydrological goals?
- What potential remediation or correction measures are available?
- Are the project goals reasonable, feasible, and likely to result in establishing the maximum ecological functioning possible for the site?
- What parameters should be monitored? How often should they be monitored and for how long?

Water Quality

- Are there indications of pollution? What are the likely sources?
- What water quality tests are necessary?
- What are the best methods for testing water quality (field kits, lab testing)?
- What methods are available for fixing pollution problems?
- Are the project goals reasonable, feasible, and likely to result in establishing the maximum ecological functioning possible for the site?
- What parameters should be monitored? How often should they be monitored and for how long?

Wetland Soils and Substrate

- Where can baseline information about local soils be found?
- What are the typical characteristics of substrates in the wetland of interest? Levels of organic matter, nutrients, soil moisture? Particle sizes and soil structure?
- Are there impervious soil layers contributing to the wetland dynamics?
- What soil parameters should be sampled to characterize the site?
- What are typical substrate elevations and micro topographic features of this wetland type (including channels, islands, and mounding)?
- What methods are available to bring the soil conditions and substrate elevation in line with observations from relatively unaltered wetlands?
- What bioengineering or soft engineering implementation methods are available?
- Are the project goals reasonable, feasible, and likely to result in establishing the maximum ecological functioning possible for the site?
- What soil and elevation parameters should be monitored? How often should they be monitored and for how long?

Wetland Plant Communities

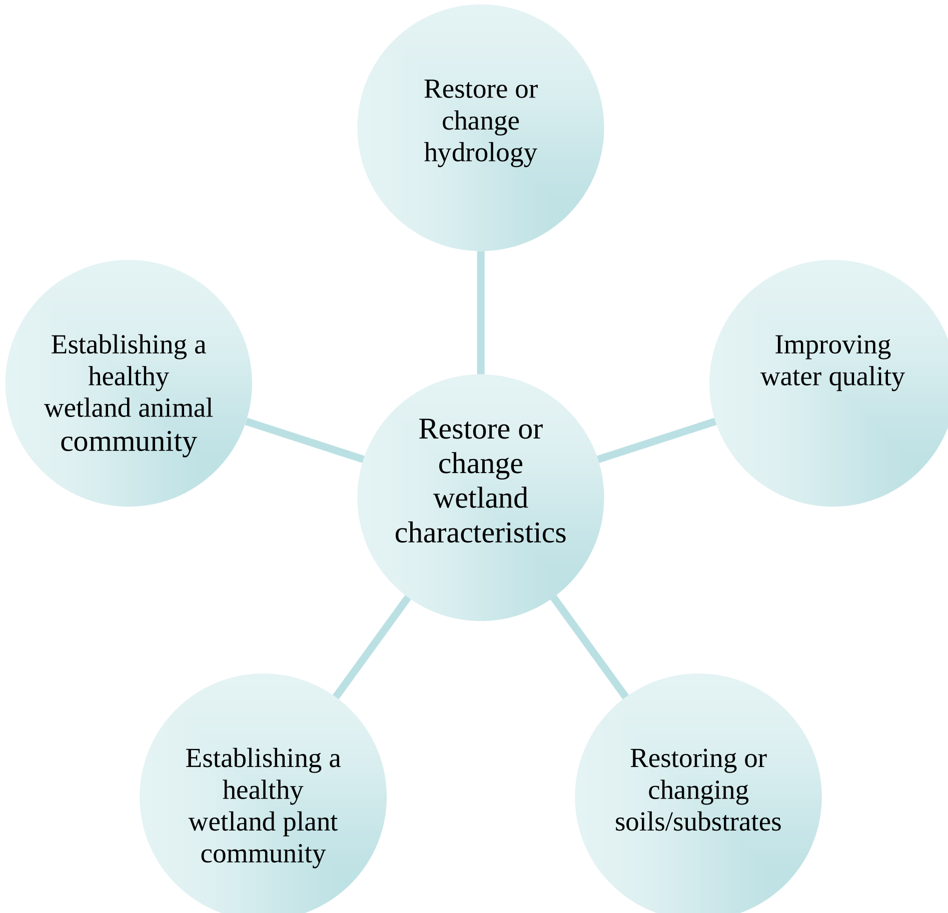
- What native plant species are found in pioneer and mature stages of the target wetland type?
- What are the dominant and rare species?
- On the potential project site, what plant species are present, including special status and listed species, non-native invasive, and species native to the target wetland?
- What natural disturbances are typical of this wetland type?
- What soil and hydrological conditions on the potential site would constrain establishing the native community? How should these conditions be changed?
- How should the site be prepared (adding soil amendments, removing non-natives, etc.) for establishing native plants?
- What methods are available for eliminating the most damaging non-native species?
- Is it likely that native species will colonize the site quickly? If not, what methods should be used to establish native plants?
- What are the threats to newly established plants (herbivores, flooding, intense sun, etc.) and how should they be combated?
- Are the project goals reasonable, feasible, and likely to result in establishing the maximum ecological functioning possible for the site?
- What plant and plant community parameters should be monitored? How often should they be monitored and for how long?

Wetland Animal Communities

- What native animal species are found in pioneer and mature stages of the target wetland type? What are the dominant and rare species?
- On the potential site, what animal species are present, including special status and listed species, non-native invasive, and species native to the target wetland?
- What natural disturbances affect animal species in this wetland type?
- What soil, hydrological and plant community conditions on the potential site would constrain establishing the native community? How should these conditions be changed?
- What habitat conditions will attract the typical animal species and what specific habitat features can be added to attract specific valuable and/or rare species?
- What methods are available for eliminating the damaging non-native species?
- Is it likely that native species will colonize the site quickly? If not, what can be done?
- What are the threats to newly established animal populations on the site (predators, flooding, pollution, human impacts, etc.) and how should they be managed?
- Are the project goals reasonable, feasible, and likely to result in establishing the maximum ecological functioning possible for the site?
- What parameters should be monitored? How often should they be monitored and for how long?

2.4 Activities to Restore or Change Wetland Characteristics

The next section contains typical measures for restoring, creating, or enhancing wetlands.



Activities used to restore or change hydrology

- Try to reverse the actions that caused the loss or alteration of a wetland's hydrologic characteristics. Measures may include:
    - Remove dams or other water control structures.
    - Fill or plug ditches or drains.
    - Remove fill that has elevated the land surface.

- Bring additional water to the site if the current water supply is inadequate. Methods include:
    - Dig channels to bring water to additional areas.

- Control water levels by installing water control structures[2]. Some structures include:
    - Open culverts.
    - Culverts with manual or automatic gates.
    - Weirs.
    - Check dams.

- Use the lowest maintenance water control structures possible. Seek structures that allow flexibility in use and are able to withstand extreme hydrological and climactic events (major floods).

- Reinstate proper substrate to water level elevations. Some methods include:
    - If the substrate elevation is too low, allow natural sedimentation to build up the elevation (a passive method).
    - If the substrate elevation is too low, import appropriate sediment/soils (an active method).
    - Soils may come from upland sites, dredged sites (dredged material), or other wetlands.
    - If the substrate elevation is too high, excavate to the required level.
    - Shape and contour your site to re-establish the right relationship between the hydrology of the site and its topography.
    - If the primary water source is groundwater, you may need very precise grading because deviations of only inches can alter the habitat for plants.

Approaches to improving water quality

- If contaminants are found in the water at the restoration site, check uses and inputs upstream or adjacent to the site i.e. agricultural fields.

- If you find a potential source of pollution, government authorities should help to determine whether it is the source of the contaminants and whether it can be cleaned up. If a site contains contaminants in amounts that are toxic to wildlife or humans, have the toxic materials removed or remediated by professionals.

- If the source of the pollution can’t be removed, lessen its impact by:
    - Implementing “Best Management Practices” to reduce pollution adjacent to the site i.e. settling basins.
    - Planting vegetated upland buffers to reduce the amount of contaminants, excess nutrients, or sediment coming into your site from adjacent or upstream areas.
    - Selecting plant species that can tolerate the existing conditions.
    - Routing the water through pools or other structures constructed to allow excess nutrients, sediments, or contaminants to settle out or become absorbed or converted to a less harmful form by natural processes.
    - Educating neighbours about pollutant effects on wetlands and asking them to reduce their use of fertilizers and pesticides.

Activities for restoring or changing soils/substrates

- If soils are degraded or are lacking nutrients, organic matter or other soil component:
    - Do nothing, and see what plants grow at the site.
    - Amend the soil with materials designed to address the soil nutrient deficiency. There are many amendment approaches[3].

[2] Refer to Tool and Guideline # 5 - Practical Tools on Soil and Water Conservation Measures.
[3] Refer to Tool and Guideline # 8 - Practical Tools on Soil Productivity and Crop Protection.

- Cover the site with wetland soils.

- If you need to raise the elevation of compacted or eroded sites:
  - Let natural sedimentation build up the elevation, if the process is fast enough.
  - Use dredged materials to build up the elevation.

- Provide controls against erosion and sedimentation during construction in or near the wetland or aquatic areas. Common erosion prevention techniques include cover vegetation (temporary plantings or seeding). Once construction is completed, you may want to delay flooding the site until the exposed soils have been stabilized with vegetation.

- Protect site against long-term erosion. Many methods exist to achieve this goal[4].

Activities for establishing a healthy wetland plant community

- To establish native species for the target habitat type, after establishing hydrology and soil conditions:
  - Wait a season or two and see what comes in naturally (assuming wetland hydrology has been established).
  - Plant wetland vegetation, using local plants or seeds from local nurseries.
  - Salvage plants that would otherwise have been destroyed from local land development, road building, or logging operations, and plant them at your site.

- Follow plant lifecycle needs, including:
  - Plant early in the species' growing season.
  - Control water, if possible, to help vegetation establish.
  - Provide irrigation until young plants are established.

- Control erosion, add nutrients, and establish cover quickly with a fast-growing "cover species" while slower-growing plants become established. Use a leguminous species to boost soil nitrogen, if needed. Never use an invasive or competitive native or non-native species.

- Remove non-native species. The wide range of methods falls into three categories:
  - Mechanical–pull by hand, burn, or graze, etc.
  - Biological–use a bio-control species, host-specific to the non-native exotic plant.

- Protect new plants from herbivores. Many methods exist, depending on the herbivore, including:
  - Fencing the planted area.
  - Putting wire cages around planted seeds, roots, and shoots.
  - Put up perching posts to attract birds of prey that feed on animals, such as gophers, which feed heavily on new plants.

Activities for establishing a healthy wetland animal community

- Plant upland species around the wetland to enhance the habitat diversity and act as a buffer. Help with choosing species for wildlife cover and food, erosion control, etc.

- Create a variety of habitats - different water depths, different vegetation types - to appeal to a variety of animals.

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[4] Refer to Tool and Guideline # 5 - Practical Tools on Soil and Water Conservation Measures.

- Tailor nesting and foraging habitats to particular native species, especially rare species, based on information from wildlife specialists and reference wetlands. Typical structures include:
    - Nest boxes or nesting platforms,
    - Perches,
    - Logs and brush,
    - Islands,
    - Specific food sources.

- Create a variety of gentle slopes of 3:1 to 20:1 (3:1 means three feet of length for every one foot of rise) similar to those in the reference wetlands.

- Establish connections to other habitats (i.e. channels connecting to larger water bodies, forested corridors connecting to wildlife refuges) unless those areas contain invasive species or other threats.

2.5 Technical Approaches

The design of restoration or enhancement projects can be highly technical and may require hydrologists, ecologists, geotechnical experts, and/or engineers. Construction documents are usually prepared by engineers for use by contractors in the field for constructing a project. If construction documents are necessary, find local engineering and construction firms or NGOs that are flexible and willing to undertake non-traditional designs and soft engineering methods. Try to find NGOs and firms that have done wetland restoration work in the past. Be sure your ecological advisors work with the engineers to produce plans that accurately reflect the methods you want used for the project. During construction, have the work inspected by your ecological experts to be sure that the plans are being followed accurately.

These are some technical approaches that can be used in wetland restoration:

Small dams

Small dams can be constructed in all wetland type, in limited circumstances. Dams have been widely and correctly condemned for their negative influence on the environment. However, small dams built specifically to restore or create wetland habitat have been used successfully in a number of circumstances. Where wetlands have been drained, drainage ditches can be plugged with small dams. Where natural drainage ways exist, dams can be installed to hold water in place and create small wetlands. Small dams can be used to re-establish or create wetland hydrology. Small earthen dams can be built at very low costs. Even dams intended for wetland restoration can have negative impacts. Potential impacts to downstream areas and to areas that might be flooded should be carefully considered. Also, dams will require maintenance and in general should not be thought of as permanent structures.

Canals

Canals are dredged through wetlands to allow proper hydrological regime. Dredged material removed from canals is usually piled along the edge of canals in spoil banks. Vegetated habitat in the canal itself is replaced by open water habitat, while vegetated habitat along the edge of the canal is buried under spoil banks. Canals can lead to at least partial restoration of wetlands.

Dredged Material

Dredging is often required to construct or maintain canals or flood control channels. Dredged material can be used to create or restore wetlands on shallow, un-vegetated low areas.

Excavation

Upland areas can be excavated to create wetlands. Excavation lowers elevation to intercept groundwater may be used to create a receiving basin or to otherwise establish wetland hydrology. In some cases, sediment that has been deposited in a wetland can be removed to restore the wetland. This allows the creation of wetlands at a number of locations; however, cost of excavation and removal of excavated material can be high. In some circumstances, it is also difficult to predict appropriate excavation depths. Excavation to subsoil leaves poor substrate for plant growth. Excavation to create a wetland displaces other habitat (i.e., upland habitat may be lost).

Increase of effective flooding across floodplains

Temporary floodplain wetlands may receive less effective flooding due to blockages in floodplain flow paths. Development on floodplains includes many features that create barriers to flow in floodplain flow paths. These include flood levees, roads, fences, and earth banks. By modifying or removing these barriers in floodplain creeks, floods can be directed more effectively across the floodplain to fill temporary wetlands and have the maximum effect similar to natural conditions. When water flows across the floodplain, natural regeneration processes are triggered by the simulated flood pulse. Rehabilitation projects can identify opportunities to remove or modify barriers to allow flows to reach the floodplain more effectively when natural flow peaks occur in the river system.

Increase of flood frequency in droughted floodplain wetlands

Temporary floodplain wetlands droughted by reduced flood volumes and frequency are due to river regulation and upstream storages. Upstream storages and regulation of river systems with variable flows have ensured water supply for domestic, irrigation, and electricity production. The changed water regime has greatly reduced flood frequency, volume, and duration, causing a major reduction in natural flood pulses which act as cues for breeding and regeneration of aquatic and riparian species. By lowering the threshold-to-flow for floodplain creeks, smaller floods can be directed onto the floodplain to fill temporary wetlands and have the same effect as a larger flood under natural conditions. When water flows onto the floodplain, natural regeneration processes are triggered by the simulated flood pulse.

Prescribed flooding

River floodplain wetlands have been degraded by the construction of upstream dams and water diversions. Floodplain wetlands can be severely degraded by changes in the magnitude, timing, duration, and frequency of flooding events resulting from the management of upstream dams and water diversions. Re-establishing the physical and biological connections between the river channel and associated floodplain wetlands is essential to the rehabilitation of river-floodplain systems. Artificial flood releases below dams is a means of wetland management and sustainable development.

Prescribed flood releases may be the only way to reintroduce the natural timing, duration, magnitude, and frequency of floodwaters in flood-dependent wetland systems, using natural processes to restore wetland diversity and heterogeneity; numerous studies suggest that the economic benefits of improved flood management may outweigh the costs in terms of other potential water uses; efforts may benefit both human and ecological communities. However, this may involve an often complex process to gain local and institutional support for flood releases from among competing demands for water among river basin stakeholders, particularly in larger river-floodplain systems; flood releases may not solve other problems associated with dams and diversions such as reduced floodplain siltation or poor water quality; some of the changes in wetlands systems caused by water regulation may not be readily reversed by mimicking former hydrological conditions, requiring other complementary restoration practices; some dams may not be designed to enable planned flood releases.

Planting

Planting can be used as part of the overall restoration methods or as the sole restoration activity. Different plant species require different methods of site preparation, planting, and care. In some situations, planting is necessary to introduce desired species to a site, but in other settings the desired plant species would probably become established on the site through natural colonization, which has prompted some restoration ecologists to suggest that planting is overused in wetland projects. Planting quickly establishes vegetation structure under some circumstances. For wetlands that are isolated from seed sources, planting can introduce species that would otherwise be permanently excluded from the site. Rapid establishment of plant cover can reduce problems with erosion. However, many planting efforts fail to establish desired plant communities because of improper handling of stock, poor weather conditions after planting, planting of species that are inappropriate to environmental conditions, inability of planted stock to compete with other species, and grazing by livestock, rodents, birds, and fish. Planting cannot replace establishment of appropriate hydrology and other restoration activities.

Reintroduction of the drying cycle in drowned temporary wetlands

Regulation of river systems with variable flows has produced stable higher water levels to ensure water supply for domestic, irrigation and industrial use. The changed water regime has lost variability and natural flood pulses which act as cues for breeding and regeneration of aquatic and riparian species. By installing a flow control structure on a drowned wetland, water can be excluded to allow evaporative drying to the point where the bed of the wetland dries out and cracks. When the wetland is re-filled, natural regeneration processes are triggered by the simulated flood pulse. Demonstration projects indicate a powerful positive response from the first drying cycle, which continues to expand with a second cycle. Wetting and drying cycles are managed to coincide with natural flow patterns in the river system. The method uses natural processes to restore wetland biodiversity; quick local response in wetland health is visible to community and funding bodies however, the ongoing management and monitoring needs are required.

Weed Control

In tropical freshwater wetlands, thousands of species of plants have been transported beyond their natural ranges, both intentionally and unintentionally. Many introduced species spread prolifically in environments where predation and competition are limited. Examples of plant species that have led to wetland degradation include *Eichornia crassipes* (water hyacinth) and the *Salvinia molesta* (salvinia, a water fern). Plants can sometimes be controlled manually with biological control agents (grazers or pathogens intentionally introduced to control nuisance species), through hydrological manipulation, or by some combination of these methods. Weed control can allow re-establishment of native plant communities.

Once introduced plant populations become well established, complete removal is difficult or impossible. Biological controls that are effective on dense populations become less effective as populations decrease in size and become patchy in distribution. Manual and mechanical control is prohibitively expensive. Control using pesticides is not appropriate in all circumstances, either because chemical pesticides may not be appropriate for the restoration site or because available pesticides may impact desirable native species. Hydrological manipulation is not always possible. In all cases, scattered individuals or seed-banks remaining after restoration efforts can lead to renewed infestation of sites.

3. MANAGEMENT APPROACHES

3.1 Implementation

After determining what site changes are necessary, prepare to implement the changes by developing project designs such as field protocols or construction plans and specifications. Protocols are written guidelines for field crews on how to undertake the work. They should be as specific as possible. Most projects will need some level of documentation to direct implementation; more complex projects will probably need construction plans. Good designs include at least these elements:

- Specifications/diagrams for all installation/construction features;
- Descriptions of site preparation needed;
- Descriptions of how to install features, such as plants, etc.;
- Plans to prevent construction impacts, such as erosion;
- Lists of plant species, numbers of each to be planted, and planting locations; plans for site maintenance; and monitoring features, such as groundwater wells and gauges.

3.2 Monitoring

Monitoring is systematic data collection that provides information on changes that can indicate problems and/or progress towards target criteria or performance standards which, when met, indicate that established ecological goals have been reached. Thus, monitoring provides data on whether a site is developing in a way that will achieve the project goals.

A common misconception about wetland restoration is that once a project is implemented, nature will just do the rest. In reality, many wetland projects need mid-course corrective actions such as re-planting seedlings that were washed away by a storm, digging more channels to get water to remote parts of the site, or plugging ditches missed during the initial site survey. Monitoring provides the information for this adaptive management. Monitoring can also give information on routine maintenance that may be necessary to keep the site functioning well.

Steps in the Monitoring Process include:

- Select the parameters you will monitor based on the target criteria established in the planning stage. Include observations to assist in site maintenance.

- Develop procedures for qualitative and quantitative monitoring methods.

- Collect data at intervals that will provide information necessary to monitor the progress of the site relative to the target criteria.

- If monitoring shows that site conditions are not meeting target criteria, use an adaptive process to identify corrective measures.

- Continue long-term monitoring and maintenance to ensure that the site continues to provide the maximum ecological value.

- Provide your monitoring data and results to local communities and publish in newsletters.

Two basic approaches to monitoring are to collect qualitative (observational and general) information and to collect quantitative (numerical and specific) data. Qualitative methods can be used in conjunction with quantitative measures. Qualitative methods typically do not provide enough information to accurately determine how close the site conditions are to target criteria, but they do give a general view of whether change is occurring. Some typical methods for gathering qualitative information include:

- Aerial photographs to show general hydrology, evidence of channelization and general substrate levels, and the extent of the site covered by plants;

- Ground-level photographs for identification of some plant species, general level of plant growth,

- General substrate levels, general water levels; and

- General observations such as water clarity, presence of trash, evidence of human use, bird species present, vegetation condition (stressed, blooming, healthy), presence of invasive plants, evidence or erosion, and the integrity of structures.

Quantitative methods are used to provide detailed information about how the wetland is developing with respect to target criteria and can also provide information important to long-term wetland research. A wide range of methods exist for collecting numerical data. With your technical advisors, develop the most appropriate methods for your project. Examples of some quantitative methods include:

- Measuring water level changes with an automatic water level gauge;

- Collecting and testing water samples periodically to evaluate changes in water quality;

- Collecting a representative sample of sediment cores to test for organic matter and other soil characteristics;

- Surveying surface elevations at permanent transects once a year;

- Recording plant species and cover by species along randomly established transects across the site; and

- Setting traps for small mammals at randomized locations to determine species diversity and abundance;

- Quantitative monitoring is often carried out by experts in hydrology, soils, or biota.

Monitoring consists of measuring a number of wetland attributes or parameters at regular intervals to record the changes in the wetland. The parameters to be measured at any particular site are based on the project objectives and target criteria. Monitoring efforts should be directly linked to the target criteria. An array of parameters is usually measured to assess hydrology, soils, and biological conditions on the site. After the project is completed, initial site conditions (including as-built conditions) should be documented to provide baseline information against which changes to the site can be evaluated.

Typical parameters measured to evaluate wetland functions are listed in Table 2.

Table 2 : Wetland Parameters and Monitoring Methods

Characteristic being monitored	***As-built***	***Qualitative method***	***Quantitative method***
GENERAL			
Mapping	Location use existing map or create map with property boundaries, scale, north arrow, district and provinces		
Wetland Type	As per REMA wetland type (2009 State of the Environment)	classify actual type(s)	classify actual type(s)
Drainage area	identify hydrologic unit from maps or watershed unit		map using GIS and appropriate base maps
Surrounding land use	estimate % surrounding land use	estimate % surrounding land use	estimate % surrounding land use
Wetland area	determine wetland boundary and use basic survey techniques to create a map of the site		delineate wetland boundary and use basic survey techniques to create a map of the site
Slope	measure slope at intervals along a transect		survey elevations
HYDROLOGY			
Water depth	above ground: use gauge, below ground: use shallow well	above ground: use staff gauge, below ground: use shallow well and read on site	
Flow patterns	direct observation to indicate major pathways and channels on map	direct observation to indicate major pathways and channels on map	regular direct observation or aerial photography to indicate major pathways/channels on map
Flow rates	measure inflow or outflow (if present)	estimate flow based on rates typical for the area and estimated wetland size	measure inflow or outflow (if present)
Indirect observations	record observations of high-water marks, drift lines, etc.	record observations of high-water marks, drift lines, etc.	
SOIL (sample using soil auger or pit)			
Soil depth	dig to compacted soil or at least 18 inches, observe changes in soil color and structure	dig to compacted soil or at least 18 inches, observe changes in soil color and structure	take soil core to at least 18 inches deep and have soil expert analyze the soil horizons and their composition
Soil color	use color chart to determine color of matrix (the dominant color) and any mottles or streaks		use color chart to determine color of matrix (the dominant color) and any mottles or streaks
Soil texture	use soil texture triangle to classify based on feel	use soil texture triangle to classify based on feel	take a soil core to soils lab for particle size analysis of the different soil horizons
Organic matter	lab analysis for percent organic matter in top layer; include soil moisture measurement		lab analysis for percent organic matter in top layer; include soil moisture measurement
Sedimentation	survey base elevations of completed project	read changes in sediment depth from a staff gauge	survey topography or bathymetry on a yearly basis; or, take sediment cores on a yearly basis for analysis by soils experts

Characteristic being monitored	***As-built***	***Qualitative method***	***Quantitative method***
VEGETATION			
Species	diversity identify species, document planting locations	identify common species and note number of unidentified species	identify all species, native and non-native
Coverage	estimate coverage to 10%, map plant communities	estimate coverage to 10%, map plant communities	collect plot data along transects, calculate coverage, map plant communities
Survivorship	count plants and determine % of plants alive	visually determine % of plants alive	count plants and determine % of plants alive
Height		measure heights of particular plants on a regular basis	measure heights of randomly chosen plants for a valid statistical comparison
Structure		count stems and branching of particular plants on a regular basis	count stems and branching of randomly chosen plants for a valid statistical comparison
Reproduction		of particular plants, determine the number blooming and setting seed each year	determine percentage of randomly chosen plants blooming and setting seed each year; count new seedlings in randomly chosen plots

In addition to providing data on whether a site is developing in a way that will achieve the project goals, monitoring is essential for the long-term management of wetland projects. A wetland is an ecosystem that evolves and changes in response to the surrounding environment. It is not realistic to expect that when the implementation stage is complete, the work is done. Long-term management is often required to keep the site functioning as it was designed to function and to keep human impacts to a minimum.

For example, long-term management is often needed to:

- Maintain existing structures such as water control structures, or levees;
- Maintain a specific desirable plant community by burning, mowing, or otherwise managing the vegetation on a periodic basis;
- Address problems such as invasive species or excessive sediment deposition; or
- Address unexpected events such as structural failure.

4. GENDER AND SOCIAL ISSUES

The different roles and responsibilities of women and men in water resources use and management are closely linked to environmental change and well-being. This is true both for how women and men affect the environment through their economic and household activities and how the resulting environmental changes affect people’s well-being. Understanding these gender and social differences is an essential part of developing policies aimed at both better environmental outcomes and improved health and well-being.

Women play a critical role in the field of environment, especially in the management of plants and animals in forests, arid areas and wetlands. Rural women in particular maintain an intimate interaction with natural resources, the collection and production of food products, fuel biomass, traditional medicine and raw materials. Poor women and children especially may collect grasshoppers, larvae, eggs and birds' nests to sustain their families.

Wetlands are fundamental ecosystems for the maintenance of life in Rwanda. For centuries people have depended on wetlands for services such as food, water, natural resources and transport. For women, wetland ecosystems and the goods they yield sustain rural livelihoods. The main economic activities undertaken by woman in wetland areas are:

- *Wild resources* provide materials for utensils and construction, and contribute to improved diets and health, food security, income generation and genetic experimentation.

- *Fishing* is done throughout the year using different equipment for different seasons. The flooding of the wetland due to dams, diversions and climate change reduces fishing revenues.

- *Agriculture* includes dry-land farming, seasonally flooded rice farming, flood-retreat farming and irrigated farming. Rice is the most important crop grown in seasonally flooded areas.

- *Dry season grazing* of sheep, goats and cattle occurs when pastoralists move into the area during the dry season.

- *In the urban centres*, the women process fish products, particularly the steaming of fish and oyster breeding. Recently several women's organisations have been getting involved in urban agriculture (market gardens).

As their knowledge is transmitted through generations, girls and women often acquire a thorough understanding of their environment, and more specifically of its biodiversity. Their experience gives them valuable skills required for the management of the environment. Women have an important role to play in preserving the environment and in managing natural resources to achieve ecologically sustainable production. Despite women's assumed special relations to nature it should be stressed that all people depend on the environment and all should share the responsibility for sustainable use of water and other natural resources.

<u>Challenges</u>

- *Environment vulnerability:* The impacts of the degradation of the environment on people's everyday lives are not the same for men and women. When the environment is degraded, women's day-to-day activities, such as fuel and water collection, require more time, leaving less time for productive activities. When water becomes scarce, women and children in rural areas must walk longer distances to find water, and in urban areas are required to wait in line for long hours at communal water points. Despite their efforts, women living in arid areas tend to be categorised among the poorest of the poor, and have absolutely no means to influence real change. They are often excluded from participating in land development and conservation projects, agricultural extension activities, and policies directly affecting their subsistence. Men make most decisions related to cattle and livestock, and even in households headed by women, men still intervene in the decision-making process through members of the extended family. However, because of the important contribution of women, the fight against the degradation of arid areas requires a gender-inclusive approach.

- *Access To and Control over Resources:* Land tenure influences how different groups use natural resources. Women, the poor, and other marginalised groups are less likely to invest time and resources or adopt environmentally sustainable farming practices on land they do not own. Women's food crops are relegated to rented, steeply sloped land with eroding soils. Because tenure is not secure, women have little incentive to invest in soil conservation measures. These restrictions on women's land rights hinders their ability to access other resources and information.

Towards the Integration of Gender and Social Issues

Women's status in conserving biodiversity may be enhanced through the following types of actions to integrate gender and social concerns into environmental planning:

- Improve data collection on women's and men's resource use, knowledge of, access to and control over resources. Collecting sex-disaggregated information is a first step toward developing gender-responsive policies and programmes.

- Train staff and management on the relevance of gender and social issues to water resources and environmental outcomes.

- Establish procedures for incorporating a gender and social perspective in planning, monitoring, and evaluating environmental projects.

- Ensure opportunities for women to participate in decisions about environmental policies and programmes at all levels, including as designers, planners, implementers, and evaluators. Women need official channels to voice their environmental concerns and contribute to policy decisions.

Women and men around the world play distinct roles in managing plants and animals, in use of forests, drylands, wetlands and agriculture. Moreover, gender roles are differentiated in collecting water, fuel, and fodder for domestic use, and in generating income. Due to their distinctive engagements with the natural environment, women's experience and knowledge are critical for environmental management. Using a gender perspective and enabling the integration of women's knowledge of the environment will increase the chances of environmental sustainability.

Annex 1: Definitions

"lake" means a relatively large body of slow-moving or standing water that occupies an inland basin.

"Wetland" means any low-lying area which is intermittently or periodically waterlogged.

"Wetlands (agricultural lands)" means land that has a predominance of hydric soils and is inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and under normal circumstances does support, a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions. "Normal circumstances" refers to the soil and hydrologic conditions that are normally present, without regard to whether the vegetation has been removed. All three wetland criteria, hydric soils, hydrophytic vegetation, and wetland hydrology, normally must be met for an area to be identified as wetland.

"swamp" means freshwater wetland ecosystem characterized by poorly drained mineral soils and plant life dominated by trees. Swamps have a sufficient water supply to keep the ground waterlogged, and the water has a high-enough mineral content to stimulate decay of organisms and to prevent the accumulation of organic materials.

"Deepwater habitat" means that habitats that are permanently flooded lands lying below the deepwater boundary of wetlands. The boundary between wetland and deepwater habitat in tidal areas is the elevation of the extreme low water of spring tides. The boundary between wetlands and the deepwater habitats of lakes and rivers lies at a depth of 2 meters (6.6 feet) below low water. If emergent, shrubs, or trees grow beyond this depth at any time, their deepwater edge is the boundary.

"hydrophytic vegetation" means plants that are adapted to waterlogged environments

"Establishment" means the manipulation of the physical, chemical, or biological characteristics present to develop a wetland on an upland site that did not previously exist. Establishment results in a gain in wetland acres.

"Restoration" means the manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural/historic functions to a former or degraded wetland. For the purpose of tracking net gains in wetland acres, restoration is divided into:

- Re-establishment: the manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural/historic functions to former wetland. Re-establishment results in rebuilding a former wetland and results in a gain in wetland acres.
- Rehabilitation: the manipulation of the physical, chemical, or biological characteristics of a site with the goal of repairing natural/historic functions of degraded wetland. Rehabilitation results in a gain in wetland function but does not result in a gain in wetland acres.

"Enhancement" means the manipulation of the physical, chemical, or biological characteristics of a wetland (undisturbed or degraded) site to heighten, intensify, or improve specific function(s) or to change the growth stage or composition of the vegetation present. Enhancement is undertaken for a purpose such as water quality improvement, flood water retention or wildlife habitat. Enhancement results in a change in wetland function(s), and can lead to a decline in other wetland functions, but does not result in a gain in wetland acres.

This term includes activities commonly associated with the terms enhancement, management, manipulation, directed alteration.

"Protection/Maintenance" means the removal of a threat to, or preventing decline of, wetland conditions by an action in or near a wetland. This includes purchase of land or easements, repairing water control structures or fences, or structural protection such as repairing a barrier island. This term also includes activities commonly associated with the term preservation. Protection/Maintenance does not result in a gain of wetland acres or function.

"Wetlands (non-agricultural lands)" means those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

Annex 2: References and Useful Resources

- REMA (2009): Rwanda State of Environment and Outlook Report, Rwanda Environment Management Authority, P.O. Box 7436 Kigali, Rwanda http://www.rema.gov.rw/soe/
- CIDA, Environmental Handbook for Community Development Initiatives (2002), Second Edition of the *Handbook on Environmental Assessment of Non-Governmental Organizations and Institutions Programs and Projects (1997)* http://www.acdi-cida.gc.ca/acdi-cida/ACDI-CIDA.nsf/eng/JUD-47134825-NVT
- USAID, Environmental Guidelines for Small-Scale Activities in Africa: Environmentally Sound Design for Planning and Implementing Development Activities, U.S. Agency for International Development, Office of Sustainable Development, Draft Version, January 2005, www.encapafrica.org.
- The Ramsar Convention on Wetlands: (http://www.ramsar.org/cda/en/ramsar-home/main/ramsar/1%5e7715_4000_0__)
- The Ramsar 'Toolkit', third edition (2007): (http://www.ramsar.org/cda/en/ramsar-pubs-handbooks-ramsar-toolkit-21323/main/ramsar/1-30-33%5E21323_4000_0__)