INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 20, No. 1, p. 141-153, 2022
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Sustainable natural resources management and utilization: Role of forest woodlands and wetlands for sustainable community livelihood and development

Douglas Marowa*

Amrita School for Sustainable Development, Amritapuri, Amrita Vishwa Vidyapeetham, India

Article published on January 12, 2022

Key words: Forest woodlands, Wetlands, Agriculture, Food security, Sustainable forest management, Anthropogenic

Abstract

Forest and wetlands are fragile communities, when human activities precede uncontrolled their roles are lost. Objective was to investigate the role of forest and wetlands as water catchment areas in Zimbabwe. Christmas Pass forest woodland and wetland in Mutare was the study site. Sample of 196 people, selected through stratified random sampling and simple random sampling, then purposive sampling for 20 key informants. In-depth interview, key informant interviews, focus group discussion, and observation was conducted. Study revealed that both forest and wetlands are important in the hydrological cycle. Noted that there are several adverse impacts brought by anthropogenic activities. Observed that water was an essential factor in sustainable forest management, and forests are crucial for regulating the water cycle. Forest woodlands and wetlands are under a huge threat for extinction, as anthropogenic activities continue to impact negatively on these areas. Forest woodlands and wetlands are a major water catchment area and there is need for catchment basin management plan for as to rejuvenate the river flow downstream. Recommended the need for best management practices (BMPs) as they are proactive and often voluntary practical methods or practices used during forest management to achieve goals related to water quality, silviculture, wildlife and biodiversity, aesthetics, and/or recreation. Noted that the sustainable management of the forest woodlands requires participatory approach of all stakeholders through capacity building and empowerment. Above all, there was need for the catchment basin to balance its role of provision of human needs and the ecosystem services.

***Corresponding Author:** Douglas Marowa ✉ briddids20003@am.students.amrita.edu

Introduction

The deforestation involves conversion of forest land to agriculture land, or residential resettlement. Worldwide the most concentrated deforestation occurs in tropical rainforests. About 31% of Earth's land surface is covered by forests. Between 15 million to 18 million hectares of forest, an area the size of Belgium, are destroyed every year, on average 2,400 trees are cut down each minute (IUFRO, 2007). FAO (2013) indicated that only 4 billion hectares of forest are left. The world has lost one-third of its forest, an area twice the size of the United States. This is despite the fact that forest and wetland are major catchment area for water, which need to be used by the human beings.

Plate 1. Deforestation in the Christmas Pass woodland in Mutare.

The above degradation of the wetland and forest has significantly affected the hydrological cycle. FAO (2013) suggested that water is a scarce commodity as it availability, accessibility, adequate and safety heavily depends on climate conditions, weather and sustainable management of the water catchment basins. The first and key step in providing safe water is the selection of the best available sources of water. The best sources of safe water is found in well protected catchment area that includes forest woodlands and wetlands. In general ground water is better protected water that the surface water, the ground water is usually found in the forest or wetlands as springs (Bonan, 2008).Catchment protection is the second step in providing safe water and where, for whatever reason, source choice is limited it presents a key opportunity to minimise pathogen contamination. A catchment is an area where water is collected by the natural landscape. Imagine cupping a person's hands in a downpour of rain and collecting water in them (FAO, 2013). The forest woodlands and wetlands are a very important water catchment basin. In most parts of Zimbabwe, it is being evident that the management of water catchment basin depends largely on the institutional setting as well as policy orientation of different communities.

Plate 2. Forest loss and land degradation fuel climate crisis.

Naturally, human beings, animals, birds and forests depend largely on each other and without proper management systems human beings will overrule the natural communities. This naturally creates tension between natural resources, including woodlands, wetlands, animals and birds since the demand and the need for these natural resources will increase (FAO, 2013). This has led to degradation of the forest woodlands and the wetlands. Wetlands and forest woodlands are fragile communities and when human activities precede uncontrolled, function and roles of the wetland and forest woodland as a water catchment source and species richness will be lost. According to Bredemeier (2002), anthropogenic activities affect the health of our water catchments this is through deforestation of the forest woodlands, and settlement and farming in the wetlands just to mention a few.

Humans often equate forest and wetlands with wasteland, a place to be drained, filled in, burnt off and re-purposed. In fact, FAO (2013) studies show that 64% of the world's wetlands have disappeared since 1900. Measured against 1700, an estimated 87% have been lost. There has been serious deforestation, clearance, clearcutting, or clearing is the removal of a forest or stand of trees the Christmas Pass forest woodland and wetland that is then converted to non-forest use.

Water has become a scarce commodity in the study area as the water catchment areas are drying up. FAO (2013) indicated that the forest woodlands and wetlands are being cleared for the purpose of timber harvesting, resettlement and farming. Therefore the study area is not spared, this has led to woodlands and wetlands around the study area losing their original status of being a water catchment basin, loss of flora and fauna species used to be seen in the forest and wetland area as there is no water to drinking. The rivers network are dried up and no water is flowing downstream. This then means that Zimbabwe has not been spared, from the adverse impacts of land degradation desertification, and drought. FAO (2013) indicated that it is estimated that 10% of land' soils are under high risk of erosion due to the nature of soils, which are sodic. The soils break into fine particles and tunnel subsequently collapsing and forming gullies (FAO, 2013). Some of the reason for land degradation especially taking the form of desertification, deforestation, overgrazing, salinization, or soil erosion, land degradation can be caused by unsustainable land management practices, such as deforestation, soil nutrient mining and biophysical factors, such as the natural topography of an area or its rainfall, wind, and temperature.

Plate 3. Unsustainable land management practices in Christmas Pass woodland – deforestation.

The main objective was to investigate the role of forest and wetlands as water catchment areas in Zimbabwe. This was done to recommend the sustainable management of forest woodland and wetlands so that the communities would built climate change resilience as they full utilise the function of the forest and wetland as a source where water is collected. The study recommended sustainable water catchment management strategies as climate adaptation and mitigation measures in the communities.

Research methodology

Research questions

i. What are the functions of both the forest woodlands and wetlands as water catchment areas for provision for safe water?
ii. What is the impact of anthropogenic activities on forest and wetlands as water catchment areas?
iii. What are the possible strategies to management forest woodlands and wetlands to address the impacts cause by anthropogenic activities?

Specific objectives of the study

i. To identify the function of both the forest woodlands and wetlands as water catchment areas for provision for safe water.
ii. To assess the impact of anthropogenic activities on forest and wetlands as water catchment areas.
iii. To bring out possible strategies to management forest woodlands and wetlands to address the impacts cause by anthropogenic activities.

Theoretical perspective

The theoretical framework used in the study was the social-ecological theory of forest macro-systems for improved ecosystem management (William *et al*., 2018). The theory suggested that the implications of cumulative land-use decisions and shifting climate on forests and wetlands, require humans to integrate their understanding of ecosystems, markets, policy, and resource management into a social-ecological system. Humans play a central role in macro-system dynamics, which complicates ecological theories that do not explicitly include human interactions. McGuire *et al*. (2001) suggested that these dynamics also impact ecological services and related markets, which challenges economic theory. A forest woodland is a habitat where trees are the dominant plant form. The individual tree canopies generally overlap and interlink, often forming a more or less continuous canopy which shades the ground to varying degrees. A wetland is an area of land that is either covered by water or saturated with water.

The water is often groundwater, seeping up from an aquifer or spring. Humans often equate wetlands with wasteland; a place to be drained, filled in, burnt off and re-purposed. Many pollutants are washed by rainfall from urban and agricultural lands and are carried overland to water bodies. Pollutants include soil particles, fertilizers, pesticides, grease and oil from cars and trucks, and road salts. Wetlands can improve water quality by removing pollutants from surface waters. Three pollutant removal processes provided by wetlands are particularly important which are sediment trapping, nutrient removal and chemical detoxification (Verdonschot, 2000). The role of forest woodlands and wetlands as was catchment areas would entail the need for social ecological contribution so as to improve the sustainable management of these areas. Without the social (human) aspect, the management of the ecology (forest and wetlands) will not be successfully as the social needs will over utilize or exploit the needs of the ecology. It is against this background that the research employed the social ecology theory of forest macro-system for improved ecosystem management during the study on forest woodlands and wetlands as water catchment and river network downstream.

Study Area

The study was carried out in Christmas Pass forest woodland and wetland that is found in Mutare. The neighbouring communities of Christmas Pass woodland and wetland include the high density suburbs of Mutare city at the southern area and the rural communities to the northern side. The Christmas Pass woodland has an estimate area of 2100 hectares covered with miombo vegetation and several other flora and fauna.

Research design, population and sample

The researcher opted to use both positivist and interpretivist paradigm in this research, on positivist paradigm, reality was given from the community and was measurable (quantifiable) using instruments that were independent of the researcher. Observations and reasons were the best means to understand human behavior in the study area. On interpretivist paradigm, reality was perceived by people in the study area, each of whom views it through the lens of his/her prior experience and knowledge. The researcher had to use both descriptive research design, both quantitative and qualitative data was used in the research. The community people tried to make sense of the world they live in through interactions with other people and the material world they find around them using their own specific social, political, cultural and historical contexts. This means that reality or knowledge was socially constructed. Knowledge in this research study was shared meaning.

The researcher gathered deep information and perceptions through qualitative methods using as interviews and observations and representing this information and these perceptions from the perspective of the research participants. A sample of 196 people from a total targeted population of 1960 people were selected and participated in the research. Stratified random sampling and simple random sampling was used to select the participants, and purposive sampling was used to select the 20 key informants. Therefore the total sample was 216 respondents.

Data collection methods, instruments and analysis

Data collection methods was done through in-depth interview, key informant interviews, focus group discussion, and forest woodland and wetland visit observation was conducted. This research study used the mixed method research design, which was appropriate for the investigation of presently existing conditions. Analysis started by indexing or coding data according to the objectives of the study. The objectives of the study provided the units of analysis. Data organised according to the themes that emerged from the respondents, particularly the focus group discussions.

Results

Functions of both the forest woodlands and wetlands as water catchment areas

The study revealed that both forest and wetlands are important in the hydrological cycle. The participants agreed that in the Christmas Pass forest woodlands and wetlands, thus where the science that encompasses the occurrence, distribution, movement and properties of

the waters of the earth and their relationship with the environment within each phase of the hydrologic cycle. There is the continuous circulation of water in the earth-atmosphere system. Of the many processes involved in the water cycle, the participants revealed that the most important are evaporation, transpiration, condensation, precipitation, and runoff. The research revealed that although the total amount of water within the cycle remains essentially constant, its distribution among the various processes is continually changing, this was confirmed by the water received in the wetland ponds and the little amount of water flowing downstream.

The focus group discussion and the interviews revealed that forests are a critical cog in the global water cycle, trees pull water from the ground and release it into the atmosphere as vapor through pores in their leaves in a process called transpiration, which can drive temperatures and rainfall across the globe. It was agreed that the forest canopy regulates the rate at which moisture and energy are returned to the atmosphere at a local scale, which can in turn influence water retention and the makeup of forest ecosystems. The interviews revealed that when both the forest woodland and wetland are properly managed and not disturbed the rain water and springs would automatically flow to form streams which will eventually turn in to rivers feeding into dams, dams overflow in and the rivers will continue flowing downstream into sea and oceans.

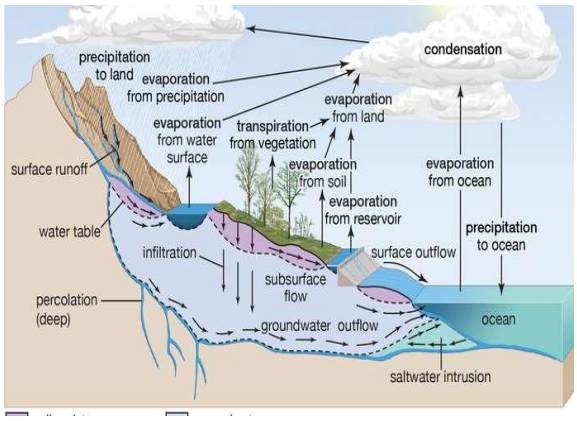

Plate 4. Foest woodlands and wetland contibutes to the hydrological cycle.

The study finding from the in-depth interviews, focus group discussion, key informant interviews and observations were as follows:

Functions of the forest woodlands as water catchment areas

- Water is an essential factor in sustainable forest management, and forests are crucial for regulating the water cycle. One of the challenges for forest managers is to maximize forest benefits while conserving water resources.
- Forests need water, and forests provide and regulate water
- Forest buffer extreme weather
- Flood protection as forest soils act as sponges and retain water longer than soils under other land uses.
- Soil protection as forests are effective in minimizing surface erosion for a range of reasons; for example, their canopies, undergrowth, leaf litter and other forest debris reduce the impact of rain drops on bare soils, their porous soils help infiltration thus reducing surface water flows and their root systems help hold soil particles together.

Plate 5. Forest woodlands as water catchment areas and biodiversity habitat.

- Mountain forests have a close association with freshwater: they gather water not only through normal vertical precipitation.
- Swamp forests are environmentally sensitive areas in which the maintenance of hydrological integrity should be a management priority. Swamp forests are important sources of aquatic foods, timber and firewood, and they play a fundamental role in maintaining water quality and quantity.

- Riparian buffer zones**,** Trees on the shores of lakes and along streambeds have important water-protection functions.
- Forests on saline-susceptible soils, deforestation should be avoided in forested areas with saline subsoils or groundwater. Through their use of rainwater and groundwater, forests and trees help prevent water tables from rising by balancing recharge (the movement of water down through a soil profile to a water table) and discharge (the loss of water from a water table).

Functions of the wetlands as water catchment areas

- Wetlands ensure fresh water for the people and provide water flora and fauna in the study area
- Wetlands purify and filter harmful waste from water and wetlands are nature's shock absorbers

Plate 6. As climate shock absorbers, remaining wetland in Chrsitmass Pass Forest woodland.

- Wetlands guarantee our food supply through fishing and water for irrigation
- Wetlands store carbon, hence becomes a very excellent carbon sink through sequestration
- Wetlands are critical for biodiversity
- Wetlands create sustainable products and livelihoods

The impact of anthropogenic activities on forest and wetlands as water catchment areas

In the study area humans have converted forest woodlands and the wetlands to agricultural and residential settlement, exploited species, fragmented wildlands, changed the demographic structure of forests, altered habitat, degraded the environment with atmospheric and soil pollutants, introduced exotic pests and competitors, and domesticated favored species. There has been overpopulation, pollution, burning fossil fuels, deforestation, fetching the water from the wetland and woodland of domestic use as they are molding bricks around the wetland and woodland areas. The changes on land use of the forest woodland and the wetland as a water catchment area have triggered climate change, soil erosion, poor air quality, and poor water quality and quantity downstream. This have impacted heavily on the stream flow leading to the drying up of the river network downstream. Communities below the forest woodlands and the wetland are running short of domestic water for farming and for their livestock.

Plate 7. Fire damaging the forest woodland.

The research revealed that human influences have caused significant changes in the function and quality of many wetlands as there is increased accumulation of sediment. In study area, human activities going on in the study area which have lasting effects on wetland ecosystems include stream channelization, dam construction, discharge of industrial wastes and municipal sewage (point source pollution) and runoff urban and agricultural areas (non-point source pollution). These activities contribute to changes in the flood regime of wetlands and the input and cycling of nutrients. Below is a residential stand where a house is being constructed in the wetland areas.

In the study area, it was revealed that wetlands have been traditionally used for hunting, trapping, fishing, berry and timber harvest, bird watching and livestock grazing. It was noted that most traditional uses of wetlands do not impose permanent impacts, with the exception of livestock grazing and timber harvest which can affect the functions such as water quality

and habitat. However, human uses of wetlands, such as drainage for agriculture and filling for industrial or residential development, can impose irreversible impacts to wetlands. In the past, the societal and ecological values of wetlands were not widely recognized and many wetlands were destroyed. Besides filling them in or damming them, the people in the study area have also damaged or destroyed wetlands by planting invasive alien species around them, draining them by piping the water out to sea, or directing filthy storm water from cities towards them.

Pate 8. Settlement in the wetland and drying up of forest woodlands.

The possible strategies to management forest woodlands and wetlands

As well manage is always attractive to flora and fauna such that the forest woodland will be also a centre of attraction to tourist. Therefore, forest woodlands are actively managed for a number of reasons and these include maximizing the yield of economically important products such as timber and game, as well as for conservation and biodiversity. Recreational access is also becoming increasingly important. The research then revealed that there was need for a forest woodland management plan and this was very essential. At its most basic, a forest woodland management plan will be a working document, which provides a central point to keep all of the paperwork associated with the management of a woodland, with information about the boundaries, features and woodland character.

This means that the management and utilisation of the forest would minimize erosion and protect waterways, avoid the use of chemical pesticides, properly dispose of waste, conserve native tree species and maintain genetic diversity on their land and set aside part of their properties as protected areas where logging will be prohibited.

Plate 9. Sustainable managed forest woodlands provide protection to water catchment basin.

It was noted that the community around Christmas Pass forest woodland and wetland should support in the achievement of UN's sustainable development goal 15. This goal aims to "protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss. However, the key informant were quick to note and revealed that the goal encourage sustainable forest management concept.

The participants agreed that the aim of sustainable forest management for Christmas Pass woodland will be is to ensure that forests supply goods and services to meet both present-day and future needs and contribute to the sustainable development of communities. The research revealed that the goal of forest management was to protect existing undeveloped forests and greenspaces from further development. Enhance the health, condition and function of existing tree and forest fragments to provide such things as air quality and temperature regulation, hydrologic function and habitat. The study revealed that there was need for best management practices (BMPs) to be applied as they are proactive and often voluntary practical methods or practices used during forest management to achieve goals related to water quality, silviculture, wildlife and biodiversity, aesthetics, and/or recreation.

Table 1. Forest and wetland management activities associated with each category of BMP.

Category	Common goal
Water quality	reduce or eliminate non-point source pollution; maintain water clarity, quality, and quantity for human consumption and fish and wildlife habitat
Silviculture	maintain the desired stand characteristics, including adequate regeneration of suitable species
Wildlife and biodiversity	provide habitat, food, and cover for a variety of wildlife species; optimize diversity of native plant and animal species among stands (landscape approach)
Soil quality	maintain soil characteristics to ensure the potential of the site to continue productivity at current and historic levels
Aesthetics	create or maintain forest conditions that are aesthetically pleasing (entirely subjective and owner specific)
Recreation	provide opportunities for land owners and/or the public to pursue desired, often multiple-use, recreational activities

The suggested best management practices strategies on the forest woodlands for water quality and quantity were:

➢ Timber harvesting systems and skid trail layout through avoiding erosion associated with harvesting typically results from poorly designed skid and haul roads.

➢ Landings through locating landings on gentle slopes with drainage, or slope land to provide drainage.

➢ Stream crossings through avoiding stream crossings whenever possible.

➢ Wetlands, streams or rivers as these aquatic areas provide many important ecological services, and require extra precautions.

➢ Site stabilization, closure, and revegetation through grading roads and landings to fill ruts and removing temporary stream crossing devices.

➢ Season of harvesting through minimizing or avoiding wet season logging except on very well drained soils.

The research revealed that use of best management practices for wetlands, the humans and the woodlands can enjoy all the no-cost services that wetlands provide. Hence the study revealed that protection of wetlands can be through:

- Avoiding construction of roads and landings in wetlands.
- Avoiding intense forest management activities in wetlands and their buffers. When activities are unavoidable, they should be limited to when the ground is frozen.
- Do not dispose of slash in wetlands.
- Do not use pesticides and other toxic chemicals in wetlands.
- Create buffer zones around wetlands to protect them from management activities.

Plate 10. The low part Christmas Pass forest woodlands where the wetlands is less degraded.

The participants highlighted the following factors as the root causes of degradation of the forest and wetlands (overexploiting) the water catchment basin (forest woodlands and wetland) in Christmas Pass; unreliable climate, resettlement, food insecurity and fishing, timber harvesting, farming and hunting, and poverty and brick molding. Below is a linkage diagram, based on scoring and ranking, of the main causes.

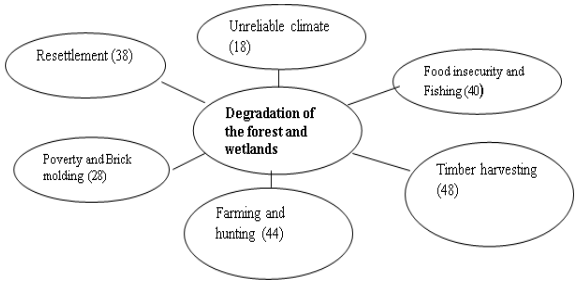

Fig. 1. Main causes of degradation of the forest and wetlands.

Below is a linkage diagram, based on scoring and ranking, showing factors considered most important for a sustainable land management system in water catchment to the local communities.

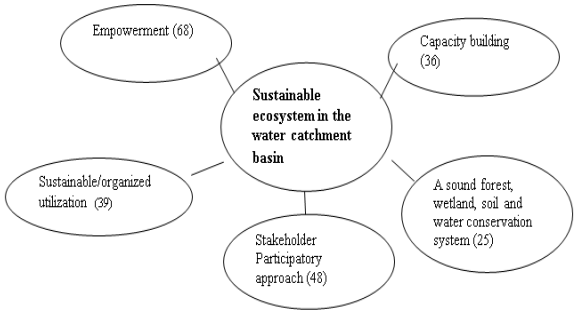

Fig. 2. Factors considered important for a sustainable water catchment ecosystem system management.

Plate 11. Wetland settlement at the downstream of Christmas Pass woodland in Muatre.

Human settlement in the wetlands has led to the anthropogenic activities threaten wetlands in several different ways. These settlements has resulted in the deposition of fill material, draining, dredging and channelization, diking and damming, diversion of flow and addition of impervious surfaces in the watershed, which increases water and pollutant runoff into wetlands.

Discussion

Functions of the forest woodland and wetland as water catchment area

The noted functions of the forest woodlands and wetlands were, the study revealed that very little fresh water from the Christmas Pass catchment basin was being used for domestic use around the communities. This concurred with FAO (2013), which reflected that less than 3% of the world's water is fresh, and most of that is frozen. Yet every human requires 20-50 litres of water a day for basic drinking, cooking and cleaning. Wetlands provide our water needs and help replenish the groundwater aquifers that are an important source of fresh water for humanity (FAO, 2013). The study concluded that wetlands guarantee food supply through fishing and water for irrigation, as the people around were fishing in the middle of the wetland pond at Christmas Pass as indicated by Bredemeier (2002) that humans consume 19 kg of fish each year on average. Most commercial fish depend on coastal wetlands for part of their life cycle. Rice, grown in wetland paddies, is the staple diet of nearly three billion people, and accounts for 20% of the world's nutritional intake (FAO, 2013). Wetlands also purify and filter harmful waste from water, some of the pollutants from pesticides, industry and mining, including heavy metals and toxins are absorbed by wetland sediments, plants and marine life. Almost two billion people in Asia and 380 million Europeans depend on groundwater aquifers for their water supply (IUFRO, 2007).

Wetlands are nature's shock absorbers, peatlands and wet grasslands in river basins act as natural sponges, absorbing rainfall, creating wide surface pools and reducing floods in streams and rivers. This storage capacity also helps safeguard against drought. Mangroves, saltmarshes and coral reefs all reduce the speed and height of storm surges. Their roots bind the shoreline, resist erosion by wind and waves, and increase resilience against climate change. Wetlands store carbon, hence becomes a very excellent carbon sink through sequestration. Peatlands alone cover an estimated 3% of the world's land area, but they hold 30% of all carbon stored on land.

This is twice the amount stored in all the world's forests. But when they are burned or drained for agriculture, they go from being a carbon sink to a carbon source (IUFRO, 2007). Carbon dioxide emissions from peatland fires, drainage and extraction equate to 10% of all annual fossil fuel emissions. The wetlands are critical for biodiversity, are home to more than 100,000 known freshwater species alone, and this number is growing all the time. From 1999 to 2009, some 257 new species of freshwater fish were discovered in the Amazon (FAO, 2013). Wetlands are essential for many amphibians and reptiles, as well as for bird breeding and migration. Individual wetlands often hold endemic species; forms of life that are unique to one particular site such as Lake Baikal in Russia or the Rift Valley lakes of East Africa (McGuire *et al*., 2001). Wetlands create sustainable products and livelihoods as 61.8 million people earn their living directly from fishing and aquaculture. Including their families, more than 660 million people depend on these sectors (IUFRO, 2007). Sustainably managed wetlands provide timber for building, vegetable oil, medicinal plants, stems and leaves for weaving and fodder for animals.

The impact of anthropogenic activities on forest and wetlands as water catchment areas

The impacts on forest woodland and wetlands from anthropogenic activities noted were, humans have converted forest woodlands and the wetlands to agricultural and residential settlement, exploited species, fragmented wildlands, changed the demographic structure of forests, altered habitat, degraded the environment with atmospheric and soil pollutants, introduced exotic pests and competitors, and domesticated favored species. This concurred with FAO (2013), as it suggested that the humans impacted the physical environment of the forest woodlands and wetland through overpopulation, pollution, burning fossil fuels, deforestation, fetching the water from the wetland and woodland of domestic use as they are molding bricks around the wetland and woodland areas. The changes on land use of the forest woodland and the wetland as a water catchment area have triggered climate change, soil erosion, poor air quality, and poor water quality and quantity downstream. This have impacted heavily on the stream flow leading to the drying up of the river network downstream. Communities below the forest woodlands and the wetland are running short of domestic water for farming and for their livestock.

Human influences have caused significant changes in the function and quality of many wetlands. These changes have resulted from alteration of the physical, chemical and biological components of wetland ecosystems. Widespread land development and clearing have caused increased erosion in uplands areas leading to increased sedimentation in lowland wetlands. This increased accumulation of sediment can alter the chemical and hydrologic regime of the wetlands in a relatively short time. Other human activities which can have lasting effects on wetland ecosystems include stream channelization, dam construction, discharge of industrial wastes and municipal sewage (point source pollution) and runoff urban and agricultural areas (non-point source pollution). Bredemeier (2002) highlighted that these activities contribute to changes in the flood regime of wetlands and the input and cycling of nutrients. Sources of pollution have local and regional effects on the chemistry and quality of water flowing through wetlands. Point sources, such as municipal industrial sites, and non-point sources, such as agricultural lands and urban runoff, add materials to ground water and surface water that upset the balance of wetland water chemistry and the biogeochemical cycling of materials in wetland ecosystems (Bredemeier, 2002).

The research revealed that the Christmas Pass forest woodlands and wetlands have been traditionally used for hunting, trapping, fishing, berry and timber harvest, bird watching and livestock grazing. It was noted that most traditional uses of wetlands do not impose permanent impacts, with the exception of livestock grazing and timber harvest which can affect the functions such as water quality and habitat. However, human uses of wetlands, such as drainage for agriculture and filling for industrial or residential

development, can impose irreversible impacts to wetlands. IUFRO (2007) indicated in the past, the societal and ecological value of wetlands were not widely recognized and many wetlands were destroyed. Besides filling them in or damming them, humans have also damaged or destroyed wetlands by planting invasive alien species around them, draining them by piping the water out to sea, or directing filthy stormwater from cities towards them.

The possible strategies to management forest woodlands and wetlands

The possible strategies to management forest woodlands and wetlands noted during the research were, the study revealed that there was need for best management practices (BMPs) as they are proactive and often voluntary practical methods or practices used during forest management to achieve goals related to water quality, silviculture, wildlife and biodiversity, aesthetics, and/or recreation. As suggested in Verdonschot (2000), the research also revealed that it can be is applied on harvesting, silviculture, and road design as tools to attain certain goals, but necessitate specific practices to ensure the continued quality and sustainable productivity of the forest. BMPs should be used, as warranted, under specific conditions and at appropriate times and sites. The suggested best management practices strategies on the forest woodlands for water quality and quantity were:

Timber harvesting systems and skid trail layout

- erosion associated with harvesting typically results from poorly designed skid and haul roads
- reduce costs by using the least amount of road to complete the job safely and effectively
- use existing roads when possible
- locate roads away from poorly drained sites and soils
- maintain protective buffers between roads and streams
- forwarders cause less rutting and skid trail disturbance than either tracked or rubber tire skidders
- trees should be winched to the skidder rather than driving skidder to each tree

Landings

- locate landings on gentle slopes with drainage, or slope land to provide drainage
- do not locate landings on poorly drained soils
- locate landings 60 metre away from streams, or use sediment and erosion control devices
- install diversion ditches on the uphill side of landings
- properly store and dispose of petroleum products and containers

Stream crossings

- avoid stream crossings whenever possible
- bridges and culverts can be used for stream crossings to prevent erosion
- fords can be used where stream banks are hard and the stream channel contains rock or gravel

Wetlands, streams and rivers

- aquatic areas provide many important ecological services, and require extra precautions
- maintain buffer strips around wetlands, streams, and river
- avoid crossing nonforested wetlands, cross only if frozen or dry enough to prevent rutting
- do not add or remove woody debris to streams

Site stabilization, closure, and revegetation

- grade roads and landings to fill ruts
- remove temporary stream crossing devices
- install water bars on permanent roads, prevent vehicular access as necessary
- grade roads and side ditches to ensure proper drainage
- loosen soil in heavily compacted areas before seeding
- seed and mulch disturbed areas to stabilize soils, use appropriate seed mixtures

Season of harvesting

- minimize or avoid wet season logging except on very well drained soils

- summer logging may scarify soils necessary for establishment of some species
- bark "slips" more easily when bumped during the Spring season

Plate 12. Demonstration of Vetiver grass plant (*V. zizanioides L.*) terracing at the grass nursery.

Cpmmunities could do proper site stabilization, closure, and revegetation through planting Vetiver grass (*V. zizanioides L.*), grading roads and filling skid trails and removing temporary stream crossing devices. Wetlands serve many important functions in the woodland ecosystem, providing everything from wildlife habitat and water quality to flood protection. According to Verdonschot (2000), there are many different types of wetlands, many different sizes and shapes supporting unique communities of plants and animals, but they all adhere to one general definition of a piece of land where water levels are near or at the surface for consistent periods of time. Verdonschot (2000) further indicated that one factor defines this unique landscape feature and ensures that it can play these special roles in the woodland:

- A wildlife haven. Birds, insects, fish, amphibians and many more wild species depend on wetlands for food, nesting sites and protection from predators.
- Flood protection. Wetlands can store excessive amounts of water from storms and snowmelt. Research has shown a single acre of wetlands can store up to 1.5 million gallons of floodwater.
- Water quality protection. Wetlands act as a filter for runoff, pulling out pollutants and providing the same services for free that a multi-million dollar wastewater treatment plant provides.
- Erosion prevention. Like riparian areas, wetlands can stabilize lake shorelines and stream banks and prevent erosion by waves, currents and runoff.

The research suggested that application of best management practices of the wetlands would lead to the humans and forest woodlands benefit from all the no-cost services that wetlands provide to the communities around Christmas Pass. Hence there is need to protect the wetlands by:

- Avoiding construction of roads and landings in wetlands.
- Avoiding intense forest management activities in wetlands and their buffers. When activities are unavoidable, they should be limited to when the ground is frozen.
- Do not dispose of slash in wetlands.
- Do not use pesticides and other toxic chemicals in wetlands.
- Create buffer zones around wetlands to protect them from management activities.

Conclusion

The researcher concluded that forest woodlands and wetlands in the study area are under a huge threat for extinction, as anthropogenic activities continue to impact negatively on these areas. Human activities affect the health of our water catchments. The researcher also concluded that, in the study it was very clear that forest woodlands and wetlands are a major water catchment area and there is need for catchment basin management plan for as to rejuvenate the river flow downstream. These areas significantly contribute to the hydrological cycle as they provide the much needed carbon sink through sequestration, fresh water, purify and filter harmful waste from water and are nature's shock absorbers. The researcher recommended the need for best management practices (BMPs) as they are proactive and often voluntary practical methods or practices used during forest management to achieve goals related to water quality, silviculture, wildlife and biodiversity, aesthetics, and/or recreation. Water quality and quantity, through the BMPs, the common goal will be to reduce or eliminate non-point source pollution; maintain water clarity, quality, and quantity for human consumption and fish and wildlife habitat. The researcher also concluded that it was very important that the sustainable management of

the forest woodlands requires participatory approach of all stakeholders through stakeholder capacity building and empowerment. Above all there is need for the catchment basin to balance its role of provision of human needs and the ecosystem services.

Acknowledgements

I would like to thank the Almighty God for guiding me throughout the entire study. Many thanks go to participants for their cooperation and time during data collection. I would also want to acknowledge the government department, non-governmental organizations like Community In Need Africa, Forestry Commission, Environmental Management Agency, community members and all stakeholders around the Christmas Pass woodland who were involved in one way in this study.

Funding

Acknowledgement to Amrita Vishwa Vidyapeetham.
This article has been funded by the E4LIFE International PhD Fellowship Program offered by Amrita Vishwa Vidyapeetham. I extend my gratitude to the Amrita Live-in-Labs® academic program for providing all the support.

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