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Wetland fragmentation and key drivers: A case of Murewa District of Zimbabwe

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Abstract: *There is still a dearth of knowledge regarding the nature, management and response of wetland biological integrity to agriculturally related activities and other land uses in Zimbabwe. There is need for an effective monitoring system that reflects the past and current conditions of wetlands in which is essential for ascertaining levels and trends in the degradation of these wetlands. The research aimed at assessing the impacts of land use practices on wetland health inthe Murewa District of Zimbabwe. Field visits and interviews were done in the study area with key informants.The research also analysed SPOT satellite imagery in order to have deeper understanding of the impacts of landuse change on wetland performance and integrity. In order to express wetland fragmentation over time, the research also made use of the class level landscape metrics. Results showed that sand extraction on wetland margins resulted in loss in vegetation and in some cases veldfires increased whereas wetland area decreased and they became more fragmented. Anthropogenic activities especially increase of agricultural land use in the form of cultivation and grazing were the main factors influencing wetland fragmentation. The research also noted that protected wetlands managed by communities remained the least fragmented hencethe government should thrive to protect wetlands through co-management with local communities.*

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I. Introduction

Wetlands remain a critical part of our environment be it natural or manmade and provide a range of ecological, socio-economic goods and services which are criticalfor a sound environment as well as human life. Accordingly the utilisation of these wetlands wetland resources for human development has received equal and opposing submissions given the increased trends in human poverty, wetland degradation as aspirations to develop overlap environmental protection aspirations. Under an ever changing climatic environment the human –wetland interface for survival cannot be ignored. Though humans have been modifying land to obtain food and other essentials for thousands of years, currents rates, extents and intensities of land use changes are far greater than ever in history deriving unprecedented changes in ecosystems and environmental processes at local global and regional scales (Erle and Pontius, 2007). The expansion of growth points and service centres towards rural hinterlands where sponges and marshes were once preserved has also been revealed in this research paper as some of the key drivers leading to wetland extinction. The research results thus are critical for Governments and Development Partners to consider with due diligence this critical development pillar which determines the future and health of human population globally.

The remaining wetlands whose status is not known in Africa, with Zimbabwe not being an exception are being encroached by development and agriculture. In Tanzania, almost the entire local population of Kilombero relies on wetland cultivation for their livelihoods (Bullock and McCartney, 1995). In Zimbabwe, wetlands popularly known as "matoro" or "dambos", cover over 1.28 million hectares (Whitlow, 2003), accordingly Svotwa et al., (2008) noted that most of communal farmers in Mashonaland East province of Zimbabwe derive their livelihoods from wetland use. Thus management agencies certainly need to constantly identify threats to existing wetlands and find ways to monitor changes so as to develop sustainable restoration efforts.

In Zimbabwe, previous inventory and mapping of wetlands was done in Mashonaland East Province by the Integrated Research Information System (IRIS) Unit in the Research and Technical Branch of the then Department of Natural Resources (now the Environmental Management Agency-EMA) (Mukwada, 2003). In the inventorying and mapping exercise, aerial photographs were the main data sources used to depict wetlands. EMA also carried out inventorying and mapping exercises for wetlands in Mashonaland provinces and soon spread covering the whole country by 2014.The Agency used the direct observation method where wetland boundary coordinates were mapped using GPS receivers. The identification and location of wetlands in the field was done with help of local community members but nonetheless after this base line survey was done no data is available tracing the impacts of land use changes on wetland ecosystems in these areas. Nonetheless it is therefore essential to note that future planning and ancillary Agronomic practices should consider the critical role wetlands play in the hydrological cycle, flood management ,biodiversity preservation lest no biodiversity, no future.

The Problem Statement

The body of literature on the ecological and hydrological impacts predicted to result from climaticand land cover changes has grown tremendously over the past decade (Ferrati et al., 2005). However, still limited is research on the state of wetlands in Zimbabwe especially those focusing on the impacts of land use changes on these ecosystems and assessment of drivers to such changes (Moyo, 2014). The survey data on wetlands only produced resource distribution maps and lack finer detail in terms of sizes of area under wetland utilisation hence no trends have been monitored in terms of landuse changes and impacts realised. Any wetland management practices crafted from such limited knowledge are likely to yield limited results hence the need for research to determine how the impacts of landuse changes on wetland ecosystems in rural communities can best be managed, in light of global fresh water demand which has tripled since 1950 and is projected to double again in 2035 and also a decline in its availability Posel, (2001).

Objectives

The paper aims at investigating the impacts of landuse changes on wetland ecosystems in rural communities of Murewa district.Specifically the paper explores the key drivers contributing to loss of wetland ecosystem services and to determine the changes in the area covered by specific wetlands in the district

II. Methodology

Study Area

The study was carried out in Murewa district of Zimbabwe and focussed specifically on Songore wetland in ward 14, Gutu wetland in ward 8, Njedza in ward 3, Bute in ward 30.Murewa was chosen as a study area because it is endowed with vast wetland ecosystems which are being used by the rural communities. This therefore provides the researcher with adequate scope in wetlands not limited to a single scenario. According to C.S.O (2012) Murewa district has 93 367 males and 101 718 women inhabitants with the major economic activity supporting rural livelihoods being agriculture. The common vegetation is Branchystegia savannah woodland also known as miombo woodland. The district is divided into 30 administrative wards with the bulk of these being communal wards and only 5 are resettlement areas (MRDC, 2017).

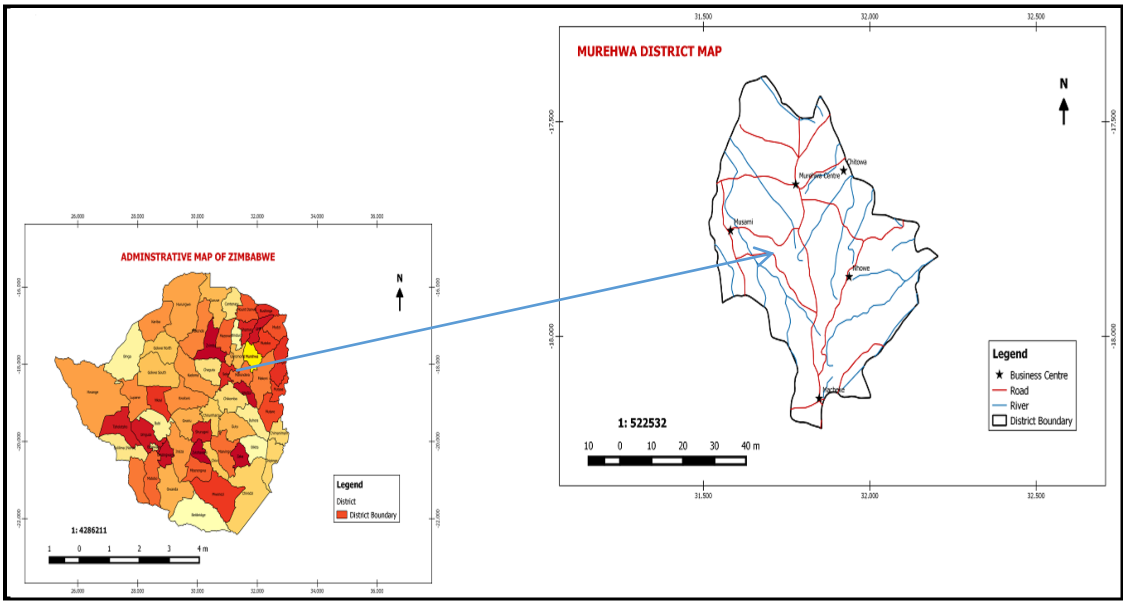

Figure 1: Study Area- Murewa

Agritex (2010) notes that the district falls under Zimbabwe's natural agro-ecological region 2B which is typified by rainfall amounts of 700mm and temperatures of 28 degrees Celsius. The bulk of the rainfall falls between November-March. Winters are generally chilly with limited ground frost experienced in Macheke. Some moderate showers are also experienced in Macheke area during winter periods. The soils vary from one area to another but predominantly sandy loamy soils occupy much of the area with spots of red clay soils and random self-ploughing black clays along rivers/water bodies and wetlands. Murewa district falls under Mazowe catchment and the catchment has several sub catchments including Nyadire and Inyagui.

III. Data collection instruments

Spatial Distribution of Wetlands

The distribution of wetlands in the district was arrived at through the use of secondary inventory data collected by the Environmental Management Agency. Precise areas of studies were visited and data pertaining to wetlands collected as well as mapping. Selected wetlands were thenidentifiedin satellite imagery for several years using the false colour composite for years the 2006, 2010, 2011, and 2014. The wetlands were then delineated and their surface area calculated for each specific year.

Wetlands Change Detection

Rogan and Chen (2003) indicate that single date mapping provides a static view of the land cover condition hence the need for multi temporal datasets. The post classification images for 2006 and 2010, 2011 and 2014 were used to establish and characterise the spatial and temporal changes for wetlands in the study area using ArcView 3.2 GIS software. Change detection maps showing the location and extend of changes in wetland areas for the cluster region were produced by overlaying two date images (2006/2010 and 2011/2014). The analysis of these change detection maps provides indicators of the varying conditions in wetlands that are not evident at a single time observation (Ndirima, 2007). Besides the use of overlay function wetland area changes were also calculated through measuring wetland sizes over time and compare with previous years.

Data Analysis

Analysis of data was carried out for each of the single date post classification images (2006, 2010, 2011 and 2014) showing the spatial extent of wetlands in ArcView 3.2. The ArcView 3.2 software measures polygon areas in acres and hectares and presents those (areas) as tables (dbf files) which can be exported to excel. The wetland areas therefore for single date images were calculated and quantified (in excel) for each ward. The changes over time in the wetland areas were then calculated and expressed as a percentage. The following formula was used to determine spatial changes in wetland areas per ward:

$[(A-B)/A]*100$……………………………………….(1)

Where:

A – Previous wetland area

B - Recent wetland area

Land use change data analysis

In an effort to determine the fragmentation statistical conclusion in this research class level metrics were computed in Arch view GIS as well as utilisation of spatial analyst extension. This is supported by Pan et al (2004) who posited in a similar analysis that class level landscape metrics provides for spatial distribution of land use patterns particularly in agriculture. Besides Mcgarigal et al 2002 contends that class level metrics can be interpreted as fragmentation indices due to the fact that they quantify the amount as well as distribution of a land class. The writer thus for the four wetlands under investigation did utilise class level metrics to characterise wetland fragmentation under the four periods reviewed.

Sampling

In this research non-probability sampling specifically, purposive sampling was used. Purposive sampling was used during the research which is a non-probability sampling technique. This entails a deliberate selection or choice of participant due to qualities the participant possess. It is therefore a non-random technique which do not require under lying theories or a set of participants. To collect socio-economic data on the use of and ownership of wetlands, out of the 50 village heads in Murewa District, 16 were interviewed. Other key informants were drawn from Agritex, EMA to gather secondary data.Sample sizes for interviews of the 16 village heads were bases on the principle of data saturation. This involved obtaining a comprehensive understanding by continuing to sample until no new substantive information is acquired.

Semi structured interviews

Open ended nature of the interviews allows for interviewer and interviewee to define topic under investigation, gain more insight into the subject matter and permits use of clues in difficult questions. Interviewer has the freedom to probe and request for more detail thus was ideal when tracing historical timelines on wetland performance.

Use of interviews

Key informants from Agritex, EMA were interviewed to collect data on wetland use and status in the district. A total of 5 informants participated in the interviews. The other interviews were conducted with the Chief and village heads. This was aimed at gathering information on wetland use and ownership.

IV. Results

Wetland fragmentation

Figure 2a shows the spatial coverage of Bute wetland in 1996. As observed in figure 2a, the wetland was 19.63 hectares in extent, well forested with trees on the margins and some indicator species following very wet zones i.e. very dark Chroma.

Figure 2a: Bute wetland 2006

The wetland size in 2010 was 17.38ha and it was noted that the wetland shrunk in size by 11.69% over four years which translates to an average of 2.92% reduction annually. The result can be attributed to impacts from anthropogenic drivers noted through stakeholder interviews such as deforestation, open grazing, marginal cultivation and sand mining.Figure 2b shows the Bute wetland 2010.

Figure 2b: Bute wetland 2010

By 2014, the wetland was now 14.75 hectares and devoid of most trees. Sand mining became very prevalent and it was heavily grazed. When compared to the previous seasons, the wetland shrunk by 6.35% over 4 years. Figure 2c shows the Bute wetland in 2014.

Figure 2c: Bute wetland in 2014

Field visits and interviews conducted with key stakeholders to solicit their views on Bute wetland utilisation noted that sand mining 23%, deforestation 11% and communal grazing 66% as key drivers of the wetland fragmentation process. The result indicate that overgrazing and livestock concentration on the sponge contributed immensely to its fragmentation. Sand mining was also ranked as a key driver as stakeholders noted that Murewa Growth point was being built from pit sand deposits on the margins of the wetland resulting in loss of wetland vegetation, compaction and drying of the wetland.

The Gutu wetland was noted to be 23.4 hectares in extent in 2007.The wetland was well vegetated and looked stable. Cultivation was evident but confined to the margins leaving a vast well preserved core. Figure 3a shows the Gutu wetland in 2007.

Figure 3a: Gutu wetland in 2007

In 2010 the wetland was now 23.01hectares thus 0.39 hectares less which translates 1.67% fragmentation over 3 years. The wetland thus indicated some form of stability and community preservation was evident on site. The reduction in size can be attributed to cultivation and climate variability. Figure 3b shows the Gutu wetland in the year 2010.

Figure 3b: Gutu wetland 2010

In 2014 the wetland was still at 23.01 hectares thus no change was recorded over 4 years. Field interviews with local farmers using the wetland provided answers to wetland stability after 2010 as the community got funding and training from a local NGO and fenced off the wetland, whereas delineation of the wetland was done. They noted that water discharge downstream had improved once drying in August before protection but discharging throughout the year over the 4 year period.

Figure 3c: Gutu wetland 2014

The Njedza wetland measured 34.8 hectares in 2006, with vegetation along the core of the wetland but was being cultivated thus the image show that 50% of the wetland area was being cultivated and the rest was being used for grazing. The edge of the wetland had evidence of degradation. Figure 4a shows the Njedza wetland in 2006.

Figure 4a: Njedza wetland in 2006

In 2011 the wetland shrunk drastically and upon measurement it was 30.94 hectares in extent thus 3.86 hectares of the wetland dried corresponding to 11.09% of the original area lost in 5years. This can be attributed to intensive cultivation and open grazing as well as the impacts of the noted low rainfall received in the area during this period. Figure 4b shows the Njedza wetland 2011.

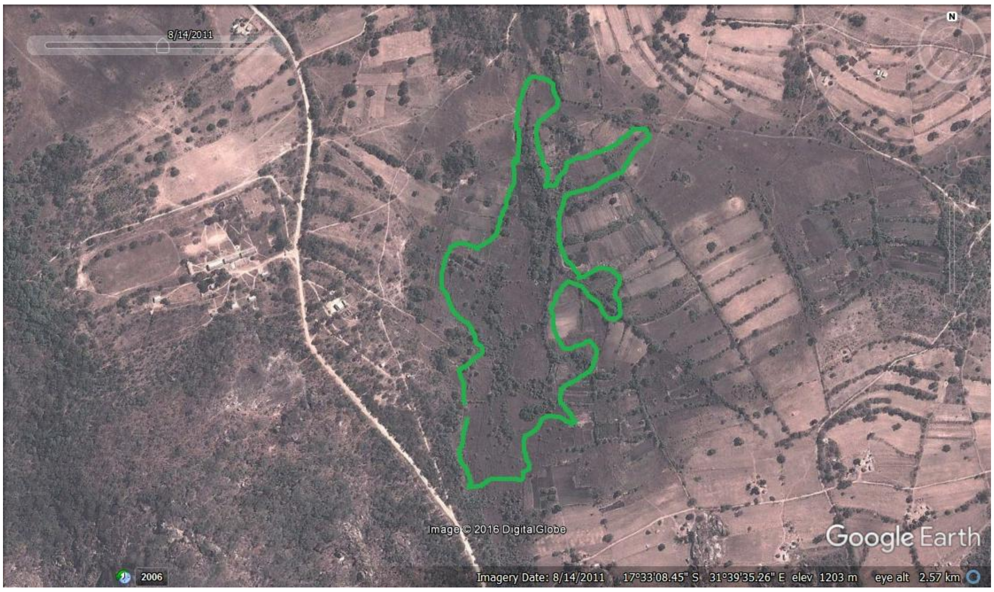

Figure 4b: Njedza wetland in 2011

In 2014 merely 3 years later, the wetland was 27.85 hectares thus 0.45 hectares was further lost which translates to a loss of 1.6%. Informants revealed that the wetland was protected by government in late 2013 which might have attributed to stabilisation as communal grazing was no longer allowed. Key drivers raised and noted were deforestation, agriculture, grazing and settlements on the edges of the wetland. Poor rainfall distribution also noted to have contributed. Figure 4c shows Njedza wetland in 2014.

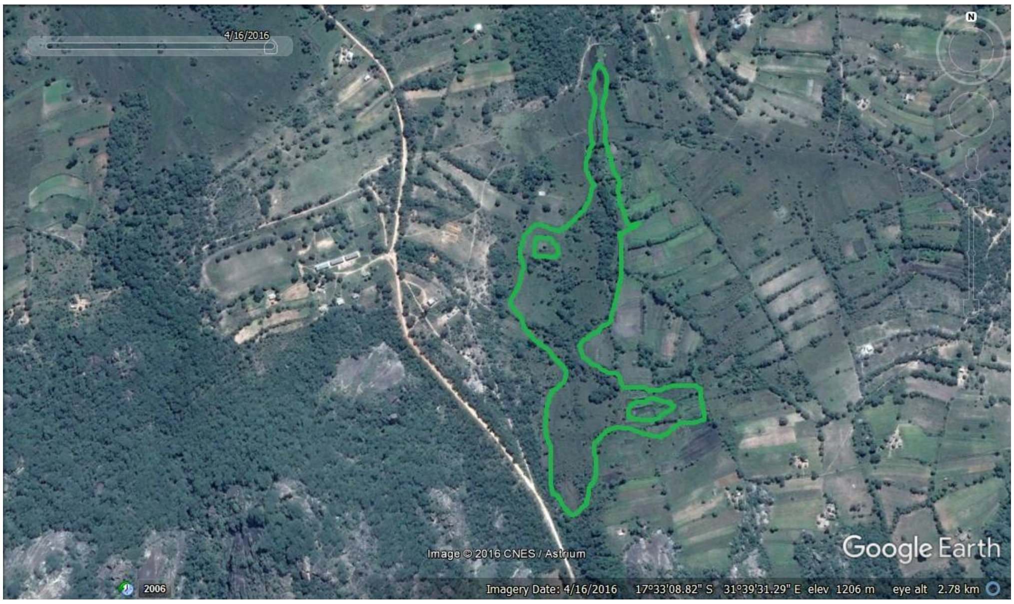

Figure 4c: Njedza wetland 2014.

The Songore wetland was 26.5 hectares in spatial extend in the year 2006. It had open grassland with few trees. The wetland was being cultivated on the margins and evidence from key informants and satellite imagery show that the wetland was still stable.Figure 5a shows the Songore wetland in 2006.

Figure 5a: Songore wetland 2005

In 2010 the wetland size shrunk to 22.3ha which translates to 15.8% reduction in size of the original area. The reduction can be attributed to cultivation, open grazing, draining by farmers in search of water for watering their gardens. Figure 5b shows the Songore wetland in 2010.

Figure 5b: Songore wetland in 2010

In 2016 the wetland was 19.3 ha thus 27.2% reduction in size over a 10 year period. Continued agricultural invasion and draining were noted to be the key driver to continued wetland loss as shown by the figure 5c.

Figure 5c: Songore wetland in 2016

Figure 6 show the changes in wetlands in Murewa over time. It shows that most wetlands in the area have declined in spatial extent and only one shows signs of stabilisation over time.

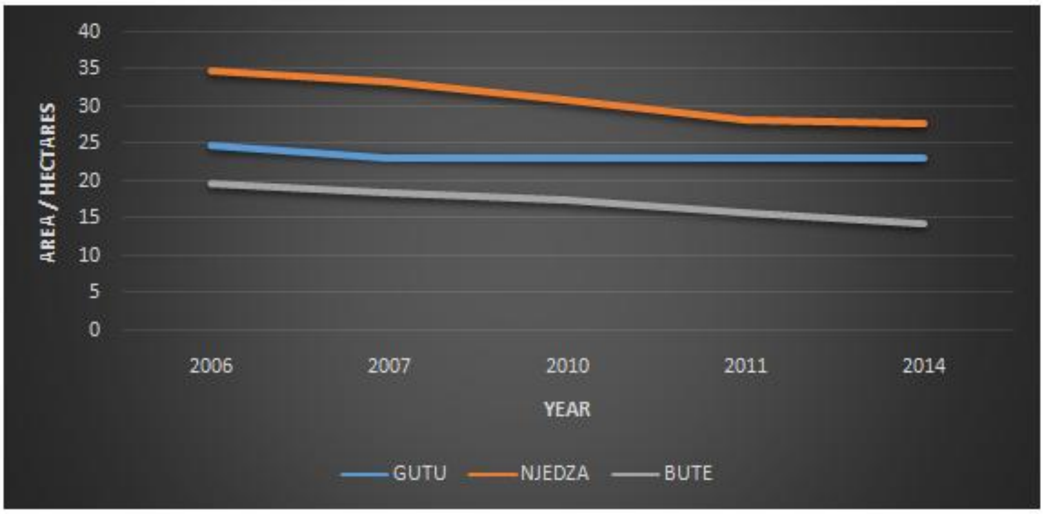

Figure 6: Change in studied wetlands over time.

Key drivers of wetland fragmentation
Rainfall patterns

It was observed that there were slight increases in total seasonal rainfall activity at all the research sites.Rainfall pattern trends analysis as a key driver to wetland fragmentation remain critical due to the fact that ground water recharge is a function of participation received within a given area, soil type and condition, vegetation, slope among others. The ground water availability greatly influence the nature and function of wetlands. However its distribution within and between seasons was noted to be uneven. Figure 7 shows rainfall received at the study sites from 2006 to 2016 from measurements taken from rain gauge data Dandara, Musami and Murewa centre.

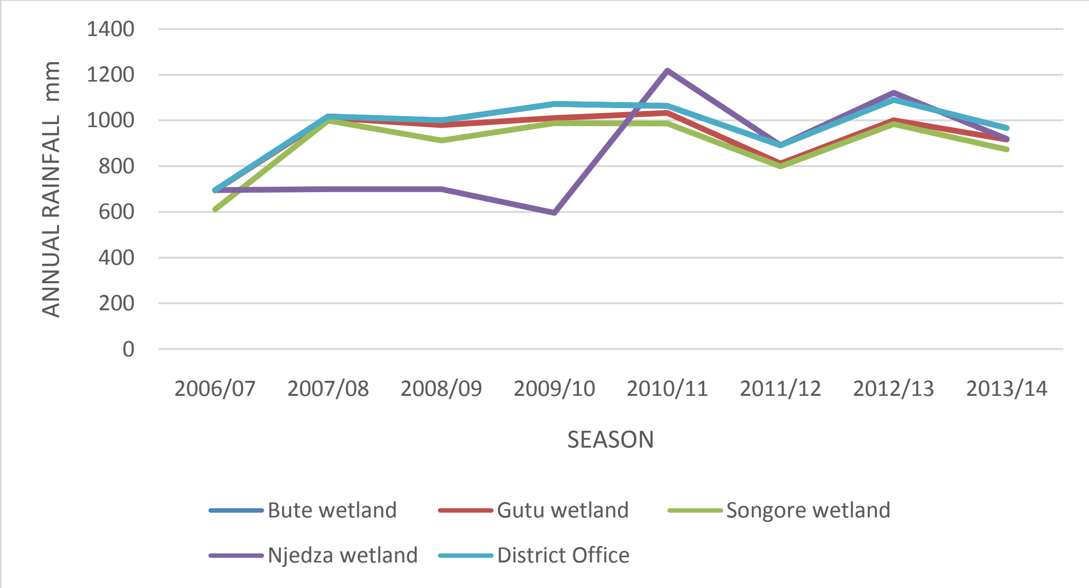

Figure 7: Rainfall scenarios for the observed wetlands

The rainfall recorded in the research sites indicate that the season 2006/7 received the least rainfall amount that was poorly distributed. Bute Gutu and Njedza which fall under region 2b received improved amounts in the following season. It is important to note that the rainfall trends which are characterised by rises and falls from season to season point to climate variability which might affect both the rate of wetland recharge and their utilisation. The above rainfall trends were confirmed through key informants who observe that although the Murewa district receives relatively normal rainfall, the distribution was poor and characterised by early onset and early cessation coupled by intermittent mid-season droughts. The analysis of rainfall patterns as a key driver to wetland changes is an important process because wetlands are highly dependent on groundwater levels, hence changes in climatic conditions that affect groundwater availability will highly influence the nature and function of specific wetlands, including the type of plant and animal species within them (Mitsch and Gosselink, 2000).

Wetland hydrology, precipitation and climate

Wetland recharge as well as stability is greatly influenced by precipitation regimes as well as land use systems. Thus to determine the characteristic of terrestrial ecosystems for instance one heavily influenced by water/ moisture patterns and availability as they shape wetland status. Although precipitation in the area of study had a fair cumulative figure not deviating from traditional annual figure for the region, wetlands with open access and less protection continued to fragment instead of expanding. This can be attributed to poor rainfall distribution which did not promote effective infiltration hence poor recharge of wetlands.

Literature reviews conducted tend to point at most research concentrating on water balance and precipitation being a very critical in changes in stream flow and wetland status. Similarly, vegetation cover types also play the critical role in vegetation of water balance. Thus removal of pioneer vegetation species on wetland areas as well as altering species composition have a great influence on rain water interception, retention and moisture loss. Invasive alien lantana camara have invaded most of Murewa wetlands, thus contribute to wetland fragmentation

The replacement of wetland vegetation by invasive weeds resulted in the wetland ecosystem losing its primary ecological function and associated services. Field visits done during the research revealed that more than two thirds of wetland vegetation was removed basing on the baseline data collected by EMA in 2013 for Bute wetland. Three veld fire cases have been recorded affecting the same wetland thus killing surviving saplings of pioneer species hence lash of lantana weeds. It is against such observation that the researcher notes that besides notable influence of climate change on wetland health, fragmentation of wetlands can result from mismanagement.

Socio-economic factors

The socio-economic practices impacting on wetland fragmentation in the research were noted to be agriculture expansion and intensification (20%), sand mining on the margins of spring sites (12%), deforestation on the spring sites and its recharge zones (15%), and communal grazing(25%), settlement construction (10%) other factors 8%. The majority of the respondents therefore observe communal grazing

(25%) to be the main practice influencing fragmentation of wetlands in Murewa district. This means wetlands which are open to communal grazing are likely to dry or vanish than those which are solely being used for gardening and protected. Cattle tracks and overgrazing on these wetlands were observed to result in severe gullying and drying of sponges. Figure 8 shows the composite socio-economic drivers of wetland fragmentation at all the study sites.

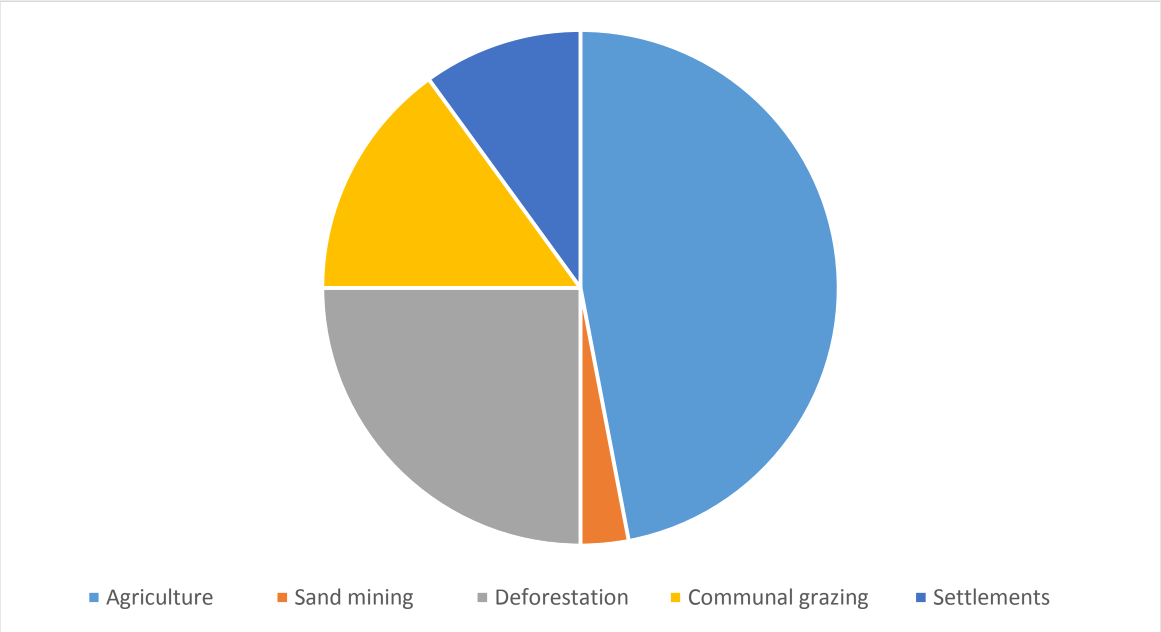

Figure 8: Socio-economic drivers to wetland fragmentation

V. Discussion

The largest decrease in wetland size was noted for Bute wetland. This wetland was used by communal farmers for grazing and agriculture that has been in use since the 1970s. Hence, agriculture and open grazing are likely to have contributed to the shrinkage of the Bute wetland. The wetland was also a burrow site for pit sand extraction on it margins. The change might also have been due to intensive water abstraction and the movement of heavy machinery which may have compacted the soil leading to drying up of the wetland. Commercial agriculture using flood irrigation may cause the biggest impact on the wetland's rate of drying. In Namibia for example, water abstraction and transfer is the most important issue threatening wetlands (Breen et al., 1997).

In a study done by the Wetland Research Unit (1987) to evaluate the impact of increase in wetland cultivation and irrigation on the water balance of wetlands in the Chizengeni wetland in Chihota communal area of Zimbabwe, the drop of groundwater levels was noted to vary with the irrigated wetland area as a percentage of the total catchment area and with changes in the crop coefficient. The research recommended a safe limit on the extent of irrigated cultivation on a wetland of 10% of the catchment area or 30% of the wetland area which ever was smaller. Considering this assessment the wetland cultivation in the study at Njedza was beyond sustainable levels with a decrease of approximately 19.97 % between the period 2006 to 2014. The decline can be attributed to agriculture and open grazing. The result thus confirms the results of a similar research conducted by Faulkner and Lambert, (1991).

The main crops grown in the Njedza wetland were maize and sweet potatoes. Wetlands in countries such as Malawi, Zambia and Zimbabwe are mostly used for growing grain, tubers, vegetables and fruit (Scoones et al., 1996; Whitlow, 2003). For these to grow well the farmers create ridges to prevent water logging (FAO, 1998). Similar drainage systems were observed in the Songore and Njedza wetlands. These ridges encourage runoff thereby reducing seepage into the soil. Hence, over time, water levels in the wetland may go down causing wetland shrinkage. Estimates of the loss of wetland in industrialized regions indicated that up to 60% of these have been destroyed in the last 100 years due to drainage, conversion, infrastructure development and pollution (Mitsch and Gosselink, 2000). Research results thus confirm similar research outcome by, (FAO, 1998).

The Gutu wetland experienced the least reduction in wetland size. Using the 2006 as baseline, 72 % of the wetland area remained in 2008. Subsistence agricultural activities flourished only recently between the periods 2008 to 2014 after the wetland was fenced off and community trained by NGO. Therefore, it may be a reason why the wetland has declined at the slowest rate as compared to the other three wetlands (Bute, Njedza and Songore). Another crucial factor to which the minimal decrease in overall size of Gutu wetland may be attributed was that about 20% of the 2006 total wetland area was conserved by some local community with the aid of an NGO. Within the conserved area no agriculture or other forms of land conversion was allowed by the Gutu wetland committee. This therefore implies that conservation of an area by limiting human activity may be critical to the conservation of the wetlands and also wetland education is also key to their conservation (Dixon and Wood, 2007) . Therefore, the recent use of the Njedza and Bute wetland for agriculture and grazing present a threat to the existence of that wetland.

VI. Conclusion

The study revealed that wetland resources in Murewa are disapearing, fragmenting as well as degrading mainly due to open grazing, agricluture, sand mining and deforestation. Njedza wetland showed the highest rate of drying with 19.97% from 2006 to 2014 followed by Bute wetland with 11.69%.Open grazing, deforestation, agriculture are the key drivers to wetland loss in Murewa. Protected wetlands like Gutu and Songore showed some form of stabilisation whereas unprotected ones like Njedza was drying faster. It is recommended that wetland mapping and monitoring should be done by Government arms which deal with water resources so as to come up with sustainable management systems.Ownership and use of wetland resources should be resolved as current use point to diapperance of these resources as indicated by the rate of wetland loss in the case of Bute wetland.Protection of wetlands from encroachment should be promoted as this leads to wetland resource stabilisation.Clear lines should be drawn by Government on wetland ownership and use.Traditional leaders should consult technical departments of government before allocating land for agriculture. Indigenous knowledge systems should be use to protect wetland ecosystems and where possible it should be doccumented for the benefit of future generations and wetland sustainability.

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