School of Geography, Archaeology and Environmental Sciences

Human utilisation and environmental quality of wetlands: the case of Harare, Zimbabwe

Dissertation submitted to Faculty of Science, University of the Witwatersrand, in fulfilment of the requirements for the degree of Masters of Science by research.

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Declaration

I declare that this dissertation is my own, unaided original work. It is being submitted for Masters degree at the University of Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other university. I have acknowledged within the text and references list any work taken from other authors.

Signature: _________________ Date: _________________

Abstract

Most wetlands in urban environments, especially metropolitan cities in developing countries like Zimbabwe, are being threatened by human activities. This study investigates human understanding and perceptions on wetlands and assessing environmental effects of human utilisation of the wetlands as a means of evaluating their sustainability. A mixed methods approach which entails both quantitative and qualitative methods was used to collect data from human and physical environments of two wetlands in Harare, Zimbabwe. Convenience and snowball sampling were used to select participants for questionnaires, interviews and focus groups. The study used two sets of similar questionnaires to collect data from 40 Borrowdale and 39 Belvedere wetland users and residents. Interviews were also administered to 10 Borrowdale and 12 Belvedere wetland users. Two focus group discussions were administered for Borrowdale and one was administered for Belvedere. Wetland delineation and land use mapping were done using a hand-held GPS. Sediment samples were collected from the utilised and unutilised parts of the two wetlands and were tested for sediment grain size and organic carbon content. Results showed an increase in urban wetland utilisation driven by complex economic, social and political issues. The majority of respondents showed that they were aware of the economic and socials benefits of wetland and environmental effects of different land uses on wetlands. Some respondents were sceptical about some of the environmental benefits of wetlands. Respondents were also aware of negative changes of wetland properties (soil, water, vegetation, birds and animals) due to different land uses on wetlands. Low percentages of organic carbon content in sediments from utilised parts of both wetlands reflected deterioration in soil fertility. There is poor dissemination of knowledge about wetlands to the general public, and existing wetland legislation is not effectively implemented. The study recommends that the government of Zimbabwe should: change its wetland management strategies, review the Environmental Management Act, enact a national wetland policy which involve decisions from all stakeholders, investigate institutions that facilitate wetland laws implementation, and change strategies used and people involved in educating and disseminating information about wetlands.

Keywords**:** *vleis, human perceptions, land uses, wetland ecosystems, soil grain size, organic carbon content, wetland elements, wetland values and benefits*

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Acronyms

AREX: Agricultural Extension

AVHRR: Advanced Very High Resolution Radiometer

AVIRIS: Airborne Visible/Infrared Imaging Spectrometer

CSO: Central Statistics office

EMA: Environmental Management Act

ESAP: Economic Structural Adjustment Programme

FAO: Food and Agriculture Organisation

GIS: Geographical Information Systems

GPS: Geographical Positioning System

IPCC: Intergovernmental Panel on Climate Change

ITCZ: Inter-tropical Convergence Zone

MNF: minimum noise fraction

MODIS: Moderate-resolution Imaging Spectroradiometer

MSS: Multi-Spectral Scanner

NDVI: Normalized Difference Vegetation Index

SPOT: Satellite for observation of Earth

UNEP: United Nations Environment Programme

Chapter 1: Introduction

1.1 Background

The natural environment is a critical component for all aspect of human activities. The health of the natural environment is crucial for people's prosperity and sustainable development (Chiras, 2001). In the environment, wetlands are the most productive and fragile ecosystems with a rich biodiversity but are amongst the most endangered ecosystems (Okruszko *et al*., 2005; Keddy, 2010). Extensive loss of wetlands globally has been linked to rapid population growth (Teles *et al*., 2007). In California, New Zealand and Australia, it is estimated that human activities such as building different infrastructure on wetlands have degraded more than 90% of the wetlands (Chiras, 2001). Africa is also thought to have lost about 30% of these ecosystems (Chenje and Johnson, 1999). In Harare (Zimbabwe) over 30 wetlands are under threat due to different uses such as housing, waste dumping, infrastructural development and agriculture (Daily News, July 2014).

Wetlands are crucial ecosystems which have been used for various environmental, social and economic activities. Wetlands can be used for flood control, reducing urban runoff, removal of toxic elements and purification of wastewater due to their unique soils and variety of vegetation (Kadlec and Knight, 1996). It is important to take into consideration these values and functions especially when planning to utilise the wetlands (Silvius *et al*., 2000). Urban wetlands have not been used sustainably (Luan and Zhou, 2013). In South East Asia pollution of freshwater and loss of biodiversity have been a result of unsustainable agriculture on wetlands (Hillstrom and Hillstrom, 2003). Many environmental problems also emanate from the declining ecological qualities of these wetlands (Luan and Zhou, 2013), such as deforestation, peat oxidation and fires on degraded peat land areas which are indicators of unsustainable wetlands use and are responsible for greenhouse gas emissions. Identifying effects of wetland utilisation in this research is important in evaluating their sustainability.

In all Zimbabwean cities, municipal responses to urban agriculture have changed from making it illegal, to supportive programmes resulting in most domestic gardens on wetlands, and they are intensively being used for agriculture as a result (Drakakis-Smith and Kivel, 1990; Mbida, 1995). Rapid population growth has made people see wetlands as food security nets, readily available to the urban poor (Kotze, 2002; Keddy, 2010; Gaitan *et al*., 2011). However water quality, high productivity of wetlands and their ecological composition have been altered by uncontrolled utilisation (Keddy, 2010). In Harare, the Mukuvisi and Manyame rivers which feed into Harare's main water source Lake Chivero have been greatly affected by nutrients and sedimentation, mainly coming from degraded wetlands (Nhapi, 2008). There is also conflict between different land uses in urban areas, such as agriculture and conservation for cultural heritage and recreational activities. Urban sprawl also increases social tension because of the increased need for houses (Sebastia-Frasquet *et al*., 2014). Urbanisation and urban agriculture are the main human activities which have placed wetlands at risk, since they represent large open spaces within the urban environment (Kentula *et al*., 2004; Nhapi, 2008). Laws to control human activities on wetlands to ensure proper conservation have not been fully implemented (Kentula *et al*., 2004).

Despite objections from the Environmental Management Agency (EMA) in Zimbabwe and the fact that wetlands are valuable ecosystems that should be preserved, some wetlands in Harare have been allocated for developmental purposes (Herald, January 2014). These include the Borrowdale vlei covering 52 km^2 and the Belvedere North vlei covering 85 km^2 (see Figure 3.1). Although the Environmental Act (Chapter: 20:27) and Statutory Instrument 7 of 2007, the Environmental Management and Ecosystem Protection Regulation, govern wetland utilisation in Zimbabwe, most of these wetlands have been threatened (EMA Act, 2007). It is, therefore, the thrust of this research to investigate and analyse how human utilisation of these wetlands has altered their environmental quality such as soil and vegetation as a way of evaluating wetland sustainability. This research also aims at improving understanding of wetland functions in urban areas. Land scarcity in Harare as in most metropolitan cities of developing countries has caused the destruction and modification of wetlands, because they represent one of the few undeveloped areas remaining within the city. The population of Harare has drastically increased in recent decades, imposing pressure on natural resources, especially land and wetlands (Nhapi, 2008)

1.2 Problem statement

Overexploitation of urban wetlands has led to the destruction of these fragile ecosystems. Wetlands have become a sensitive issue in Harare due to conflicts among stakeholders on whether they should be used for developmental purposes. Most residents seem not to be aware of the importance of wetlands and the effects of different land uses on the ecological quality of wetlands. Modification of wetlands by human activities in Harare has affected their ability to perform ecological functions (McCartney *et al*., 2005). The government seems to lack commitment to protect these valuable ecosystems, and government knowledge and information failure have led to the unsustainable use of wetlands (Maclean *et al*., 2003). Knowledge about the extent of the damage caused by human activities is also inadequate (Maclean *et al*., 2003). This research investigates human understanding of the importance and values of wetlands and effects of different land uses on the ecological quality of wetlands. Human perceptions and the ecological quality of wetlands were used in this research to evaluate wetland sustainability.

1.3 Research questions

The following research questions guided the research process:

1. What are the major land use types on these two wetlands in Harare?
2. How do people on these wetlands value and use the wetlands in different ways?
3. What are the major changes in soil properties due to human activities on these wetlands and how can these changes be used to evaluate sustainability?
4. How do peoples' perceptions and understanding of different wetland functions and values be used to evaluate their sustainability?

1. 4 Knowledge gap of the study

Little research has been done in Africa integrating human perceptions and environmental quality of wetlands. Urban planners in Africa are not concerned much about urban wetlands (Schuyt, 2005). In some areas they are seen as waste lands because people who interact with these wetlands are left behind in most environmental research. Increasing people's awareness on wetland issues in this research will also contribute to other research done in Africa on urban wetlands. Evaluating sustainability through integrating human perceptions and ecological quality of wetlands will enhance sustainable management strategies.

1. 5 Aims, research questions and objectives

1.5.1 Aim

This research aims at investigating human understanding and perceptions on wetlands and assessing environmental effects of human utilisation of the wetlands as a way of evaluating their sustainability.

1.5. 2 Objectives

The objectives of this study are to:

1. Identify and make an inventory of different land uses on wetlands using GIS and the base map of the area,
2. Identify how people use wetlands through evaluating responses from questionnaires, interviews and focus group discussions,
3. Identify the spatial differences in soil properties on the utilised and the unutilised parts of the wetlands,
4. Evaluate human understanding of the importance and use of wetlands by analysing information gathered from questionnaires, interviews and focus group discussions administered to residents and wetland users.

1.6 Limitations of the study

This study focuses on human views, knowledge and understanding of urban wetlands and measuring of soil organic carbon content to identify nutrients in the soil. These were used to evaluate wetland sustainability. The research did not focus on views, knowledge and understanding of environmental authorities on urban importance of urban wetlands and how people are using them. Other soil parameters and water parameters were not measured in this research to evaluate wetland integrity.

1.7 Research outline /conclusion

The research has 7 chapters.

- ***Chapter 2: Literature review***

Based on the background and introduction of this study on human utilisation of wetlands, Chapter 2 is therefore going to review literature in detail on wetland studies both local and international. This study is therefore influenced by key studies on African wetlands by Scoones (1991), Schuyt (2005), Rebelo *et al*. (2010) and Marambanyika et *al*. (2016) which helped in finding out how people have been using wetlands in Africa since historic times.

- ***Chapter 3: Study area***

This chapter describes different aspects of the study area including the geology and topography, climate, ecosystems, settlement, population industry and Human activities. In this chapter, location of Belvedere and Borrowdale wetlands are also described.

- ***Chapter 4: Methodology***

This chapter describes in details how qualitative and quantitative methods were used to collect data. Sampling techniques used to select participants were also presented and explained in this chapter. Data analysis techniques used to analyse data were also used presented in this chapter.

- ***Chapter 5: Results***

This chapter presents empirical findings from the human environment (questionnaires, interviews and focus discussions and the physical environment (soil organic carbon content) through the use of tables, graphs, photographs and maps.

- ***Chapter 6: Discussion***

This chapter discusses results in relation to literature and other research. This chapter therefore evaluates why people use wetlands in different ways, peoples' knowledge, perceptions and knowledge about wetlands, effects of different landuses on wetland organic carbon content and evaluation of sustainability of wetlands using results from the physical or human environment.

- ***Chapter 7: Conclusions***

This chapter concludes the key findings of the research and provides recommendations for policy makers and future research.

Chapter 2: Literature Review

2.1 Introduction

This chapter reviews literature from different scholars on wetlands. Themes like wetland types in Africa, wetland functions, human activities on wetlands, and different approaches to wetland studies, models of wetland studies and wetlands and climate change will be discussed in this chapter. This chapter will therefore provide a context about this study and identify what is known and unknown about wetlands.

2.2 Wetland types in Africa

The Ramsar Convention (1971) defines wetlands as areas of marsh, peatland, fen or water including estuaries and open coast whether natural or artificial, permanent or temporary, with water that is static or flowing including areas of marine water, with depth at low tide which does not exceed six metres (Chopra *et al*., 2005). This definition is widely used but it lacks specific attributes of wetlands that affect their functions and values (Turner *et al***.**, 2000). The Ramsar Convention includes Polar, Alpine, Tropical and Temperate wetlands. Therefore, mountain, marine and coastal, inland and human made wetlands are all incorporated in the Ramsar definition. Although this definition is commonly used, it does not consider some small wetlands such as dambos which are common especially in Africa (Scott and Jones, 1995). Dambos which are also known as vleis in South Africa and Zimbabwe are shallow low lying wetlands at the source of drainage systems and are usually seasonally waterlogged (Mackel, 1974; McFarlane, 1989, Bullock, 1989; Heyden, 2004). Smaller wetlands in Africa have been estimated to cover 16% of the total area of the continent (Koohafkan *et al*., 1998).

African wetlands take up the space between terrestrial and aquatic ecosystems where the water table is usually at or near the surface or the land is covered by shallow water and therefore displays a range of habitats (Finlayson and Van der Valk, 1995). Wetland definition therefore should include seasonally wet areas since these are most common type of wetlands found in Africa because of the seasonal rainfall (Junk *et al*., 2014). Palustrine, riverine, estuarine mangroves and marshes are all commonly found in Africa, and these include floodplains, dambos (seasonal wetlands), deltas, valleys lakes and rivers (Roggeri, 1995; Taylor *et al*., 1995). The largest wetlands in Africa are the floodplains and deltas of Congo, Niger and Zambezi rivers, Okavango swamp, Lake Victoria and Lake Chad wetlands (UNEP, 2000).

Large and famous wetlands in Africa such as Okavango Delta, the Niger River floodplain also dry up sometimes during the year (Junk *et al*., 2014). Vleis or dambos are the most common type of wetlands in Africa and therefore should not be neglected in researches since they benefit livelihoods in different ways, as discussed below. These wetlands hold water seasonally and are lowlands covered with vegetation of different types (Whitlow, 1990; Matiza and Crafter, 1994).

The Environmental Management Agency of Zimbabwe (EMA) adapted the Ramsar Convention's definition in defining wetlands in Zimbabwe (EMA Act, 2007). According to this Act, wetlands in Zimbabwe are defined as any area of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is flowing or static, fresh, peatland or brackish or salt and includes riparian land adjacent to the wetland (EMA Act, 2007). The EMA Act definition has some loopholes as it also fails to consider small wetlands such as vleis and dambos. Human activities on wetlands change the state and characteristics of wetlands. Therefore the state of most wetlands at the centre of a single wetland will differ as one moves to the outskirts of the wetlands, due to different surrounding land uses and human activities. Although classification and inventories have been made on some wetlands in Africa and in Zimbabwe, there are no procedures on monitoring ecological changes on the wetlands identified (Scott and Jones, 1995). The dynamic nature of wetlands should therefore be considered in defining and classifying wetlands.

Although there have been disagreements on what constitutes a wetland and wetland classifications, common features have been used to classify these ecosystems (Turner *et al*., 2000). Wetlands are characterised by hydrophytic vegetation, hydric soils, and surface water during the growing season (Smith *et al*., 1995). However, considering the presence of hydrophytic and hydric soils only as wetland indicators has resulted in the neglect of other aspects of wetland delineation and management (Junk *et al*., 2014). Wetlands in Africa have been classified according to their nutrient and water source, ecological structure, geomorphological characteristics and vegetation type for example bogs, fen, marshes, swamps and peatlands (Roggeri, 1995; Smith *et al*., 1995; Taylor *et al*., 1995; Sieben *et al*., 2011). In this classification, hydrology was considered as the most important aspect, but destruction of the natural vegetation of these wetlands can alter their hydrological systems and functioning (Junk *et al*., 2014). In most African countries local terms are used to identify different wetland types. For example vleis are commonly known as *matoro* or *mapani* in Shona (Mbereko *et al*., 2007).

Wetlands in Africa can also be classified according to the type of soil, which can include histosols, gleysols, fluvisols and vertisols (Koohafkan *et al*., 1998). Some floodplains developed on fluvial sediments on granite can be covered by clay or loamy clay fluvisols and vertisols (Taylor *et al*., 1995). These wetland soils are sporadically or seasonally flooded by overflowing rivers, and are lowland storage areas that are important for flood reduction and sediment accumulation (Taylor *et al*., 1995). Inland valleys developed in gneiss and volcanic rock are associated with flooding which is either seasonal or permanent (Taylor, 2005). In Mozambique, and Namibia, the most common type of wetlands is coastal mangroves (Taylor *et al*., 1995). These African wetlands have been used by people for different functions depending on the type size and location of the wetland and its available resources. In Zimbabwe and Mozambique, dambos are used by small scale farmers for food production whilst in Zambia the Kafue Flats floodplains are used for the same function (Sakane *et al*., 2011).

Despite having a variety of wetlands in Africa, there is inadequate information on their hydrological, ecological and sediment properties, and their classification, mapping and planning policies are inconsistent, making it difficult to know their actual distributions and properties (Finlayson *et al*., 1999; Rebelo *et al*., 1999; Schuyt, 2005). Although a number of inventories on wetlands in Africa have been conducted, they are likely incomplete, and in southern Africa they are concentrated on small regions and large wetlands only (Finlayson and Van der Valk, 1995; Taylor, 1995). Providing such information will in turn help policymakers concerned with sustainable exploitation of wetlands and in drafting wetland conservation and management measures (Finlayson and Van der Valk, 1995; Taylor, 1995). Baseline information about different types of wetlands in a country or region is also important for designing national strategic plans for wetland management (Sekane *et al*., 2011). Most research has been done on large wetlands in Africa like the Okavango swamps in Botswana, Monavale wetland in Zimbabwe, and St Lucia wetland in South Africa (McCarthy et al., 1991; Schleyer and Celliers, 2003; Murungweni, 2013). However, most research on wetlands has concentrated on developed countries and for those done in developing countries, wetlands in Africa are inadequately represented (Schuyt, 2005). Little research has critically investigated extent of wetland destruction of wetlands through different human activities in Africa (Schuyt, 2005).

However, classification and inventories about small wetlands are generally neglected despite the fact that they are crucial for national development (Taylor *et al*., 1995). This research is therefore concentrated on two vleis because they are the most common type of wetlands found in Harare, Zimbabwe, and they are under threat from human activities. In this research, the term vlei will be used to refer to these wetlands. About 4,6% of Zimbabwe's land is covered by wetlands and vleis are the most common, covering 3,6% of the land (Whitlow, 1985; Chenje *et al*., 1998). Vleis are depressions or low lying areas that form a natural system of drainage, and can develop streams, and will have saturated soils during the rainy season that can remain so for a certain period of time (Thompson, 1972; Mharapara, 1998). Vleis are important for moisture retention during the dry season and support a variety of plant and animal species, but their functional values and importance are being threatened by different human activities (Houlahan *et al*., 2006; Dahwa *et al*., 2014).

However, pressure on these wetlands due to increase in population has caused the destruction of these valuable ecosystems especially in urban areas and the percentage of land covered by wetlands has decreased drastically (Bowyer-Bower *et al*., 1996; Paucharda *et al*., 2006). Therefore, there is increased use of vacant land of wetland areas for houses, roads and industrial development (Bowyer-Bower *et al*., 1996). Urbanisation has increased the drying up of wetland ecosystems since they are being replaced by concrete pavements and buildings (Bowyer-Bower *et al*., 1996; Paucharda *et al*., 2006). Pollution and sedimentation have led to the drying up and reduction in the size of some wetlands (Keddy *et al*., 2010). Besides pressure from people, climate change in Zimbabwe has also imposed a threat to wetland water, soil and species (Magadza, 1994). Most of the wetland studies in Zimbabwe have concentrated on rural wetlands, neglecting the urban ones which are being severely utilised. It is therefore the thrust of this research to investigate how different land uses on these urban wetlands are affecting environmental quality. This research will specifically focus on vleis in Harare because these are the most threatened wetlands.

2.2 Wetland functions

Wetlands perform important environmental, economic and social functions as a result of the interactions between physical, chemical and biological elements of wetland, such as soils, water, plants and animals (Smith *et al*., 1995; Finlayson *et al*., 1999). Functions of wetlands refer to their ability to meet human needs by providing goods and services (de Groot *et al*., 2002). Wetlands maintain natural cycles like recharging water supplies through groundwater sapping (Hansson *et al*., 2005). Wetlands are also an important part of nitrogen cycling because of the presence of oxygen which allows chemical changes of nitrogen to take place (Faulkner and Richardson, 1989). Wetlands can also be used in urban areas to treat sewage, and help retain nitrogen and phosphorus. The availability of plants and animals on wetlands allow nutrients to accumulate and reduces the flow of sewage water (Bolund and Hunhammar, 1999). People benefit from these wetlands in direct or indirect ways. In assessing the environmental condition of wetlands and how sustainable the function performed by a wetland is, various models have been used (Hruby, 1999).

As natural filters due to variety of vegetation and unique soils, wetlands can improve water quality by reducing eutrophication and storing sediments (Kadlec and Knight, 1996; Mitsch *et al*., 2001). This function will depend on where the wetland is located since this affects the amount and source of water available in the wetland. Wetlands in low lying areas such as swamps will receive more runoff as compared to those near mountains such as mountain bogs. Wetlands are also habitats of different animal and plant species and many African wild animals depend on wetlands during dry periods (Keddy, 2010). Unique plant species not found in other parts of the landscape are only available on these wetlands, and these include hydrophytic plants such as Typhaceae (Hugget *et al*., 2004). Fish, mammals, reptiles, amphibians rely on wetlands for breeding and migratory birds and many endangered species rely on wetlands for their survival (Hugget *et al*., 2004). These species can enhance the recreational values of wetlands (De Groot *et al*., 2002). Bird watching is one recreational activity attracting tourists at famous Ramsar sites such as Monavale vlei in Harare (Murungweni, 2013). Wetlands are valued for their aesthetic and cultural values and are economically important as tourist attraction places to generate revenue. Although tourism creates different opportunities, it can also lead to pollution of the natural resource (Turner *et al*., 2000).

Wetlands like most natural environments are also therapeutic (Bolund and Hunhammer, 1999). The green wetland plants can enhance the physical and psychological health of urban citizens (Ulrich *et al*., 1991). A study made on people who were under stress and exposed to different environments showed that the level of stress decreased in those people who were exposed to natural and green environments (Ulrich *et al*., 1991). Wetlands can therefore enhance the health of human beings through spiritual enhancement and cognitive development and provide different opportunities for reflection (Ulrich *et al*., 1991). Continued provision of these services and existence of these wetlands can only be guaranteed if people use these valuable ecosystems sustainably. Human activities impact on the natural structure of most wetlands such that some are failing to perform their functions effectively (Magadza, 1994).

Wetlands act as carbon sinks, storing carbon dioxide and thereby regulating the concentration of carbon dioxide in the atmosphere (Keddy, 2010). Wetlands help to reduce flooding because of the soils and vegetation which encourage infiltration at the expense of runoff, enhancing groundwater recharge and reducing downstream volume of water and peak discharge (Smith 1995; Kadlec and Knight, 1996; Bobbink *et al*., 2006). The vegetation structure on wetlands can alter the occurrence of natural hazards such as droughts since they increase water storage capacity (De Groot *et al*., 2002). Wetlands cannot stop flooding but they hold water temporarily and reduce the velocity of the water. This can reduce loss of crops by farmers and protect those who live in floodplain areas against the risk of property loss due to flooding (Smith *et al*., 1995).

Wetland soils hold water and release it in dry seasons for human, animal and plant use (Silvius *et al*., 2000). However, there has been debate about soil and water processes and the role of dambos in regulation of stream flow (Scoones, 1991). During the dry season, wetlands can reduce streamflow because of the high evapotranspiration from the wetland surface (Scoones, 1991). The water is, therefore, important in maintaining ecological processes within the wetland community. Pollutants can also be filtered by wetlands through the vegetation cover on wetlands when they are trapped and absorbed as nutrients, reducing them from reaching the adjacent rivers and lakes (De Groot *et al*., 2002). However, wetland functions depend on the nature and role of the surrounding landscape like human landscape transformation such as agriculture (Smith *et al*., 1995). The hydrological structure, water quality, and the nature of sediment accumulation in wetland ecology are all affected by different anthropogenic conversion of the surrounding landscape (Hill and Keddy, 1992; Ehrenfeld and Schneider, 1993). Different landuses such as waste dumping, infrastructural development and agriculture therefore affect the ecological and hydrological functioning of wetlands. The surrounding landscape also affects biomass concentration, amount of organic material, type of plant species and the ability of the wetland to provide refuge for different animal species (Knopf and Samson, 1994; Dolores-Holt, 1995; Holt *et al*., 1995).

Major nutrients such as nitrogen and phosphorous which are useful for plant growth are also found in wetlands. Availability of these nutrients attracts small scale farmers to grow different crops with limited external inputs because wetlands offer moist soils (de Groot *et al*., 2002). Wetlands produce goods such as fish, rice, berries and timber, and some societies depend on these goods for their wellbeing since they can sell or use them for human consumption (Keddy, 2000). It is important for people to understand the different functions so as to make strategic decisions on the exploitation and use of wetlands. Planning and management of wetlands are sometimes done without the involvement of all stakeholders. Much research on mapping wetlands and on the effects of wetland degradation does not always consider the roles of local people who use and value wetlands. It is therefore the aim of this study to investigate human use of wetlands and their environmental impacts.

2.3 Human activities on wetlands

Wetlands are vulnerable ecosystems in most parts of the world since they are extensively utilised by people. Globally, wetlands are being used in many cases unsustainably for different activities. European wetland loss due to agricultural activities dates back at least 2000 years (Hartig, 1997). Following the Ramsar Convention in 1971, signatories of the Convention set national regulations in 1975 to guard against the use of wetland (Turner *et al*., 2000). However governments find it difficult to enact wetland policies and regulations. Wetlands continue to be converted and modified to different uses by people. The Spanish Coto Donana National Park was damaged hydrologically as farmers were drawing water for irrigation (Llamas, 1988). Another Spanish wetland, the Tablas de Daimiel, no longer exists due to human use (Llamas, 1988). Lowering of the water table can cause wetlands to dry up and increase erosion through unsustainable use which can destroy the wetland ecosystem (Scoones, 1991). Destruction of wetland ecosystems means habitat loss or change in habitat quality (Quan *et al*., 2002).

In China, food security is a priority, so attempts to conserve natural wetlands have failed (Luan and Zhou, 2013). Improperly designed developmental activities and draining wetland for settlement and agriculture impose pressure on wetlands (Schuyt, 2005). Djoudj National Bird Park, Senegal, has been altered through dikes and dam construction for rice production and this has affected the water quality and quantity of the area (Schuyt, 2005). In most African rural areas, there has been intensive use of wetlands for livestock grazing and crop production, and competition for grazing land and agricultural land has resulted in the ecological destruction of wetlands (Scoones, 1991). In Nigeria, the Fadama agricultural project resulted in farmers expanding the cultivation area and therefore reduced the land available for livestock grazing during the dry season (Scoones, 1991). In Southern Brazil, most wetlands have been converted to croplands and some have been destroyed by road construction (Maclean *et al*., 2003).

Regardless of different regulations for sustainable management of wetlands, people have used wetlands to maintain their livelihoods (McLean *et al*., 2003). Globally increased use of wetlands has caused drying up and disappearing of some and loss of productivity in others. Community reliance on wetlands for cultivation has increased mainly because they are the most readily available and reliable natural ecosystems for use in arid and semi-arid areas (Scoones, 1991; Marambanyika *et al*., 2016). These wetlands are mainly used by subsistence farmers for crop production (Marambanyika *et al*., 2016). Vegetation clearance on wetlands for agricultural use has caused a drastic shift in the water balance, due to changes in infiltration rate which changes the rate of water loss and capacity to store water (Scoones, 1991). Increased runoff and reduction in infiltration due to bare land causes short lived flooding, soil erosion and eventually results in the drying up of wetlands (Scoones, 1991). Unsustainable use of wetlands can have a major influence on animal species since the change of water regimes changes the composition of invertebrates that provide food for many animals (Thompson and Hamilton, 1983). Anthropogenic pollution on Rietvlei wetland in South Africa affected the behaviour and reproductive rate of frogs in the area (Bridges and Semlitsch, 2000; Sparling *et al*., 2000). Waste dumping does not only damage wetlands but water pollution from both point and nonpoint sources can pose a threat to the health of the public and ecosystems (An *et al*., 2007).

Most urban wetlands have been threatened by human activities such as urban growth, infrastructural development, recreational and industrial activities (Mitsch and Gosselink, 2007; Murungweni, 2013). These urban activities are therefore destroying and degrading urban wetlands at an alarming rate (Finlayson *et al*., 1999). Insufficient knowledge and understanding of the benefits of these wetlands have contributed to their unsustainable use. The rapid increase of the world population and urbanisation in the 20th century threatened 58% of the urban wetlands (Ehrenfeld, 2000). Wetlands especially in developing countries cannot be used sustainably for food security because many planners and managers have inadequate information for the natural resource benefit and ways that can be implemented to achieve sustainability (Rebelo *et al*., 2010). Population increase in urban areas means that less land is available on wetlands, but that they become more valuable and as they are utilised by people for their benefit (Mitsch and Gosselink, 2000). Landuse change in urban areas has resulted in the alteration of the chemical components of water, destruction of biodiversity, habitat loss and soil erosion in most wetlands (Bowyer-Bower and Drakakis-Smith, 1996; Mlanga *et al*., 2014).

Urban landuse such as housing, road construction, industrial development, waste dumping and agriculture have affected urban wetlands such that they function differently from those in rural areas (Ehrenfeld, 2000). Unlike urban wetlands, most rural wetlands especially in Zimbabwe are used for agriculture, livestock grazing and burying children (Scoones, 1991; Marambanyika and Beckedahl, 2016). For example in dry rural areas such as Matebeleland South, Zimbabwe, wetlands are commonly used for grazing and agriculture (Ndlovu and Manjeru, 2014). This is because Matebeleland South lies in agro-ecological region 4 which receives erratic rainfall, and therefore local people rely on wetlands since they retain moisture during dry periods (Ndlovu and Manjeru, 2014). Traditional institutions have also played an important role in wetland conservation in some rural areas in Zimbabwe. Some vleis and dambos in rural areas such as Zvishavane, Zimbabwe, have been considered sacred since local people associate these wetlands with myths (Mbereko *et al*., 2007; Ndlovu and Manjeru, 2014). This has resulted in traditional chiefs prohibiting people from using such wetlands, thereby inadvertently preserving them (Mbereko *et al*., 2007; Ndlovu and Manjeru, 2014). Limited pressure is therefore being imposed on most African rural wetlands because of the low population densities in rural areas as compared to urban areas. High population densities in metropolitan cities such as Harare have led to shortage of land for different urban land uses, as discussed above (Mushamba, 2010). Therefore this has increased utilisation of most open spaces in urban areas covered by wetlands, constantly putting these valuable ecosystems under excessive pressure.

Acid mine drainage from both abandoned and active mines has affected the ecological quality of many wetlands (Gezia *et al*., 1996). In some parts of USA and UK, wetlands have been considered a favourable and cheap way of treating acid mine drainage because they are self-sustaining (Norton, 1992). Acid mine drainage treatment using wetlands has destroyed some wetland plants such as *Sphagnum* after failing to absorb toxic substances (Norton, 1992; Gezia *et al*., 1996). The increase of acid as a result of acid mine drainage on wetlands can also increase the toxicity of the water and thus affecting the food chain and the reproductive nature of species such as fish which may therefore decrease in number. Algae plants have also grown in some wetlands as a result of pollution contained in the wetland soils because of acid mine drainage (Norton, 1992). Fluctuation of the wetland water sources due to droughts and flooding in some cases has lowered the acid mine drainage treatment capability of most wetlands and this has increased pollution on wetlands (Norton, 1992).

In Zimbabwe, wetland use dates back to the period before European colonization when cultivation of dambos was practiced by traditional farmers. Dambo cultivation enabled the farmers to grow crops throughout the year, since these crops were irrigated in the dry season using water from dambo wells (Whitlow, 1990). Farmers grew crops such as maize, yams, rice and different vegetables and there was no excessive wetland degradation (Moyo, 1991). Traditional farming methods on wetlands such as the ridge and furrow system reduced runoff and minimised soil loss through erosion and disturbance of the soil profile (McFarlane and Whitlow, 1990). The enactment of environmental policies in Zimbabwe protecting against wetland cultivation has not been able to hinder wetland cultivation. The 1927 Water Act in Zimbabwe and the Natural Resource Acts of 1941, 1952 and 1975 were enacted to curtail wetland cultivation and destruction of wetland vegetation (Bell and Hotchickiss, 1989; Owen, 1994). The 1952 Natural Resource Act encouraged farmers to grow crops 30 m from wetlands but this was not effectively implemented. Inefficiency in policy management has increased uncontrolled use of wetlands in Zimbabwe (Matiza and Crafter, 1994). After 1950 in Zimbabwe, many dambos were under pressure from human and livestock population and this caused creation of gullies in many dambo covered rural areas (Whitlow, 1988).

The Economic Structural Adjustment Programme (ESAP) in the 1990s and the 1991-92 droughts in Zimbabwe resulted in food insecurity among most low income households and they resorted to growing food crops on wetlands to alleviate hunger (Drakakis-Smith and Kivell, 1990). The campaign which was set in 1991-92 by Harare city council against urban agriculture did not stop people from growing crops on wetlands (Mudimu, 2006). Although urban agriculture was illegal in urban areas in Zimbabwe, today there is no specific policy being implemented in response to problems of agriculture on wetlands (Mudimu, 2006). Increased urban wetland cultivation is mainly due to the fact that urban wetlands produce high and reliable crop yields because of fertile soils and availability of water (Whitlow and Campbell, 1989). Although the Harare city council had designated suitable land for cultivation in 1992 to co-operatives, urban agriculture on wetlands continued without regulation, imposing stress on most wetlands (Mbida, 1995; Bowyer-Bower and Drakakis–Smith, 1996; Mudimu, 2006).

In most developing countries there is an absence of strategic environmental assessment that guides activities and land uses on wetlands (Noble *et al.*, 2011). This is mainly because ownership of the land covered by urban wetlands is not very clear and most of these are not controlled or managed effectively by landowners (Schuyt, 2005). Wise planning and designing of activities on wetlands are therefore required. However there has been lack of practical implementation and consistency of government policies and urban wetlands have been modified and destroyed as a result (Schuyt, 2005). Planning and management of wetlands is also sometimes done without the involvement of all stakeholders, and urban ecosystems are not being considered by urban planners (Papa, 2014). Although past research acknowledges that human activities alter environmental quality (Richardson, 1994), no detailed research has been conducted to show the extent of the change of the environmental quality of wetlands, how quickly environmental degradation occurs or whether soils, water systems or vegetation are most vulnerable. This research, therefore, show how environmental quality of urban wetlands has been affected by human use, through investigating changes in hydrology, soil and vegetation. This is mainly because the ecological effects relating to human use of wetlands especially in urban agriculture have been neglected in many previous studies (Luan and Zhou, 2013).

In most African countries, some governments have seen other economic projects as more valuable and beneficial than protecting natural ecosystems (Schuyt, 2005). Harare local government has generated a lot of revenue from selling land for housing development and, as a result, most wetlands are occupied (Mushamba, 2010). The rapid increase of urban population in Harare led to the increased need for houses (Sithole and Goredema, 2013). Although wetlands seem to be protected under wetland legislation, wetland utilisation is continuing uncontrollably and construction is taking place on most wetlands (Mlanga *et al*., 2014). There has been rapid increase of house construction on wetland in Harare such as Monavale wetland, Borrowdale wetland (opposite race course), Budiriro 3 and 4 wetlands, Tynwald, Eastlea, Chisipite, Glenview, Glen Norah, Kuwadzana and Belvedere wetlands where a multi-purpose Chinese mall was constructed (Masara, 2012) (Figure 2.1).

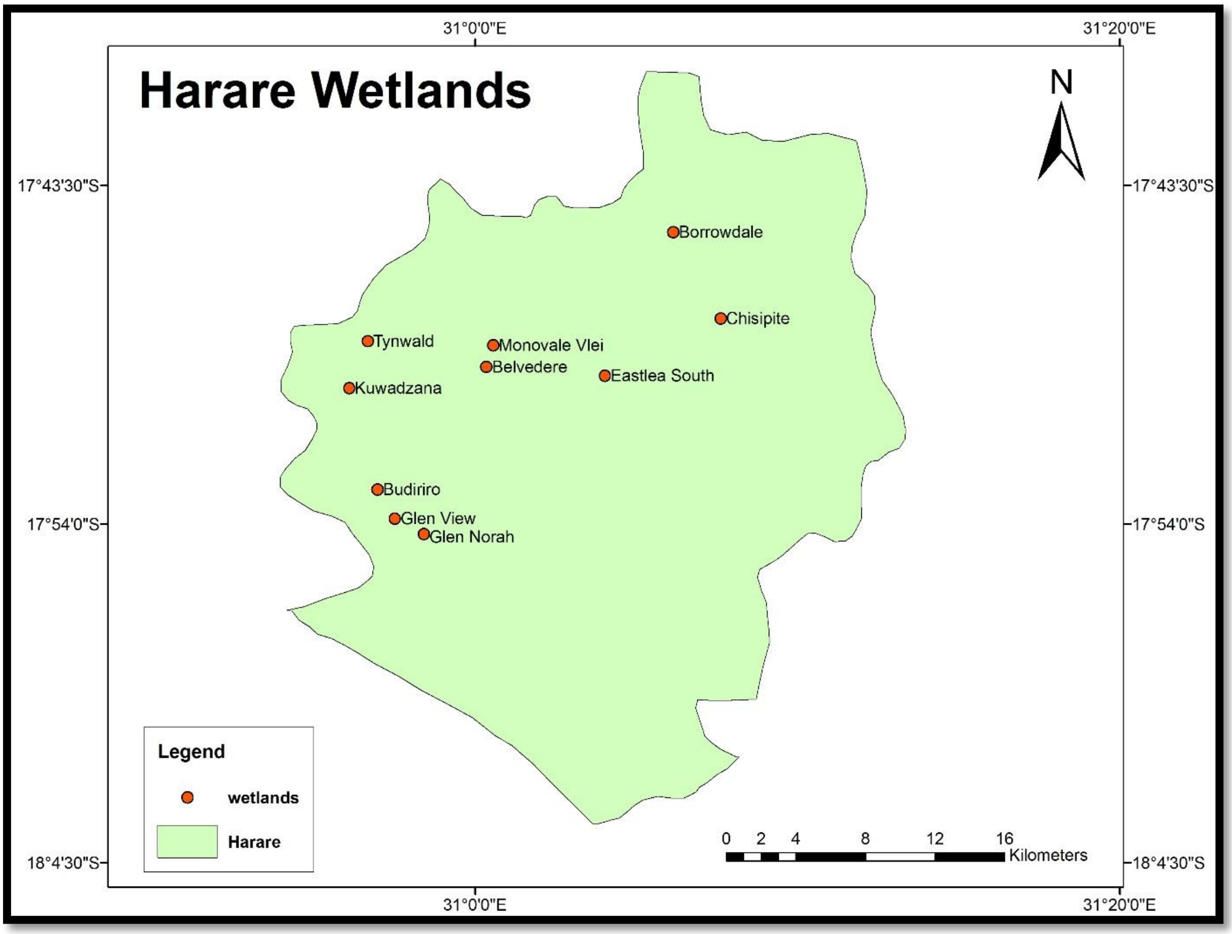

Figure 2.1: Wetlands in Harare affected by housing developments

Section 4 of the Zimbabwe Environmental Management Act (EMA) (Chapter 20:27), 2002, bestows to every citizen the right to live in a clean environment that is not harmful to their health, with access to environmental information, the right to protect the environment for the benefit of present and future generations, and the right to participate in the implementation of legislation and policies that prevent pollution, environmental degradation and sustainable management and use of natural resources, while promoting justifiable economic and social development (EMA, 2002). However, the rate of wetland loss in Harare is high and it seems some residents may not be aware of these environmental rights and responsibilities and therefore they continue to use these natural resources such as wetlands in an unsustainable way. Wetland utilisation is governed by Section 113 of the Environmental Management Act (Chapter 20:27). Although Section 113 (1) of the Environmental Management Act (Chapter 20:27) states that the minister may stop or limit development on ecologically sensitive areas (EMA Act, 2003), development on most wetlands in Harare has continued uncontrollably. Any activity conducted on a wetland, without a license from the agency, is considered illegal and is punishable, but this is not being effectively implemented.

Throughout the country, local governments also have the responsibility of protecting wetlands since they perform an environmental management function. Local government functions related to environmental management include management of open spaces and recreational facilities, conservation of natural resources, and effluent or refuse removal and treatment (Mushamba, 2010). In Africa, decision makers are often not very sensitive to the environmental value of wetlands and impounding water in dams is crucial since to them protecting wetlands may not be very important (Schuyt, 2005). Most major rivers in Africa tend to be dammed and this reduces peak discharge of rivers, changing the water quality (Davies, 1979; Adams, 1993). Law implementation in Zimbabwe tends to be impeded by lack of wetland inventory, inactiveness of local communities, and inadequate information about the law and gender discrimination (Marambanyika and Beckedahl, 2016). Zimbabwe does not have a specific national wetland policy but only general legislation. More wetland policies are required in Zimbabwe and a national wetland policy developed through the participation of all citizens would be more effective (Marambanyika and Beckedahl, 2016). This will help in adaptation and implementation of the regulations on wetlands used by residents (Marambanyika and Beckedahl, 2016).

Draining wetlands for agricultural, industrial activity and residential areas is preferred by some governments at the expense of sustainable wetland management (Schuyt, 2005). For example, half of Nakivubo wetland in Uganda has been reclaimed for agriculture, industry and settlement (Schuyt, 2005). In most African countries where people depend on agriculture it is difficult to stop further development on wetlands because people do not have other alternatives to provision of food to sustain livelihoods (Rebelo *et al*., 2010). Protecting and managing wetlands indicates that various goods and services which are valuable economically have also been protected and this can benefit the whole community.

2.4 Wetland health assessment

Wetland health or integrity assessment has become a topical issue as a result of rapid degradation and loss of wetlands because of unsustainable use. Wetland integrity or health refers to the interrelationship between different processes within the wetland. These include processes that take place within the hydrological, geomorphological and biodiversity set up of the wetland (Mtambanengwe, 2006, Fennessy *et al*., 2007). Thus integrity or health is when the wetland ecosystem is undiminished, unimpaired and is intact (Paetzold *et al*., 2010). Considering the physical, chemical and biological processes and different functions of the wetland ecological system also help in assessing wetland health (Innis *et al*., 2000). Wetland health assessment is important for designing sustainable management strategies to avoid the loss and degradation of wetlands (Innis *et al*., 2000). Different methods have been used to assess the health of wetland ecosystems. Assessment of wetland integrity has been done using remote data in wetland inventories, pictures and GIS information, rapid methods of wetland assessment and exhaustive and comprehensive methods of assessment (Stapanian *et al*., 2004). Research done on wetland health assessment include those by Innis *et al.* (2000), Stapanian *et al.* (2004), DeKeyser *et al.* (2003), Mtambanengwe (2006), Fennessy *et al.* (2007) and Quitier and Lavorel (2011). In most of these studies, rapid methods of assessment have been widely used since it involves assessment of wetland quality (Stapanian *et al*., 2004). Thus different wetland elements such as fauna, flora, hydrology, soil and different land use on the wetland are considered.

Landscape indicators such as percentage of natural vegetation, rate of erosion and rate of human activities within the wetland are also important in assessing wetland integrity (DeKeyser *et al*., 2000). Under rapid methods of assessing wetland integrity, vegetation has become a commonly used method internationally (Woodley *et al*., 1993). This is because vegetation tells a lot about different processes within the wetland. Assessment of vegetation should therefore include investigating the presence of different plants falling in different classes, and presence of exotic and rare species (Woodley *et al*., 1993). Presence of rare species is an indicator that the wetland is not negatively impacted by human activities therefore indicating that the wetland is healthy (Woodley *et al*., 1993). Vegetation traits have been used to assess wetland integrity because they also represent the typical structure of the nature of the plant community within the wetland (DeKeyser *et al*., 2000).

Water and soil chemistry are also important aspects of assessing wetland health. This is because survival of many wetland plants is dependent on soil and water parameters such as nutrient availability. Vegetation changes, changes in water and distribution of sediments were investigated in assessing the health of Intunjambili wetland in rural Zimbabwe (Mtambanengwe, 2006). Results for this assessment showed that the wetland health was still good (Mtambanengwe, 2006). A study by Guggenberger *et al*. (1994) on land-use effects on the composition of organic matter in particle-size separates of soil showed that different land uses can affect soil grain sizes. In this case small grain sizes were found in the soil due to disintegration of soil aggregates due to cultivation. The ecological quality of the wetlands and human perceptions on wetlands were therefore used to evaluate wetland sustainability.

2.4 Approaches to wetland studies

Wetland ecosystems have globally become a topical issue and different approaches have been used in the study of these valuable ecosystems.

2.4.1 The use of GIS and remote sensing in wetland studies

Estimation of the extent and distribution of wetlands in different areas has been made through different broad-scale approaches such as GIS and remote sensing (Finlayson *et al*., 1999). GIS and remote sensing has become a common tool in wetland research for inventories of mapping land cover and monitoring landuse changes to enhance understanding of the changing processes in wetlands (Franke *et al*., 2009). There has been a global increased use of GIS and remote sensing to gather information about wetland properties, location, distribution and type for proper protection measures. This is done because of lack of consistent wetland inventories for most countries around the world (Finlayson and Spiers, 1999). In Sri Lanka satellite data and GIS were used to map wetlands (Rebelo *et al*., 2009). Landsat imagery from 1992 to 2002 was used to capture the land cover and landuse of Muthurajawela marsh in Sri Lanka, and changes in wetland cover showed a loss of water areas, mangroves and marsh as a result of sedimentation, vegetation clearance and housing development (Rebelo *et al*., 2009). Shrinkage of Muthurajawela marsh areal extent was mainly due to urbanisation and industrialisation (Rebelo *et al*., 2009). This information has been useful for proper management restoration and conservation of Sri Lanka wetlands. GIS and remote sensing is appropriate for wetland inventories and monitoring especially in developing countries where there is little information available on the rate of wetland loss, and different land uses surrounding the wetland areas. GIS and remote sensing can also be used to monitor vegetation in a wetland using the spectral reflectance of vegetation within the wetland. MODIS (Moderate-resolution Imaging Spectroradiometer) medium resolution images have been used to monitor and quantify vegetation activity and changes of Dalhousie Springs Complex wetlands in Australia and this has increased knowledge and information associated with this wetland (Petus *et al*., 2012). MODIS images between July 2002 and May 2010 were used to calculate NDVI and as a change detection tool to map natural vegetation changes within the wetland (Petus *et al*., 2012). This has helped decision makers in making strategic management procedures for the wetland.

The application of GIS and remote sensing techniques has been seen as an appropriate way to produce a standard inventory for wetlands, because it provides accurate and consistent data essential for ascertaining past and current conditions of wetlands (Finlayson *et al*., 2005). Adequate inventory information and effective mapping and monitoring of wetlands can be used to improve local understanding of the ecological and socio-economic factors that affect them (Rebelo *et al*., 2009). This is because inventories can show the status of the wetlands and mapping will also indicate the changes in wetland size, structure, and factors that cause the changes. Globally, different methods have been used to identify classify, map and model wetlands using data derived from earth. Although wetland classification can be difficult due to spectral confusion with other landcover classes, multi-temporal data improves the classification of wetlands (Ozesmi and Bauer, 2000). The spatial resolution of satellite remote sensing systems, fuzzy and subpixel classification, and analysis of different spectral mixture also give more information on wetlands (Ozesmi and Bauer, 2000).

Remote sensing systems provide appropriate, current and detailed information of the wetland for sustainable management of wetland vegetation (Adam *et al*., 2010). GIS can combine data management for spatial and temporal analysis and is an important tool for strategic environmental assessment and therefore can be used in wetland habitat assessment (Toyra and Pietroniro, 2005; Atkinson and Canter, 2011). The spatial and temporal trends of wetland change therefore require knowledge of the relationship between wetland loss and pressure developing from various landuses on wetlands (Bartzen *et al*., 2010; Li *et al*., 2012).

In China, for example, satellite remote sensing methods have been widely used to map land use and land cover changes on wetlands (Wu *et al*., 2006). Several different GIS and remote sensing methods have been used for analysing wetland change and human impacts on wetlands. Remote sensing and GIS were also used to map wetland loss in China (Peng *et al*., 2010). Landsat Thematic Mapper (TM) images from 1987 to 1992 and Landsat enhanced Thematic Mapper Plus (EMT+) images from 1999 to 2002 were used to map wetland change in China using 1990 and 2000 as reference years. Landsat images were selected because they have high resolution and provided data required for processing (Peng *et al*., 2010). Change analysis was done through image to image registration and manual interpretation was used to enhance accurate mapping. Manual interpretation was done because of the complicated nature of China landscape appearance which hinders the application of computer based classification of images to classify wetlands. Google Earth was also used to for cross comparison and checking of errors to delineate wetland boundaries. The size of the total inland wetland lost through human use in China was mapped and changes amongst wetlands were identified (Peng *et al*., 2010). Results from this research showed that some wetlands in China were reduced in size whilst in some cases new wetlands were created. For example Inner Mongolia lost more than 18,000 km^2 of the original wetland and Jiangsu had more than 2000 km^2 of new wetland (Peng *et al*., 2010). However the rate of Chinese natural wetland loss was more than the change of natural wetlands to artificial ones, and these changes are mostly caused by humans. Therefore GIS and remote sensing has been very useful in classifying China's inland wetlands assessing future wetland change and in providing baseline data for environmental strategic assessment for future urban growth (Peng *et al*., 2010; Sizo *et al*., 2015).

In mapping wetland vegetation for Everglades National Park, Florida, USA, hyperspectral images acquired through Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) with spatial resolution of 20 m were used (Hirano *et al*., 2003). Remote sensing images were analysed using per-pixel image analysis. AVIRIS images were first cleaned of atmospheric effects and digital numbers were assigned to pixels in different spectral bands (Hirano *et al*., 2003). GIS is normally used to convert remote sensing imagery to tangible information which can be used with other data sets. Noise in AVIRIS hyperspectral images was cleaned using minimum noise fraction (MNF), in GIS software ENVI (Hirano *et al*., 2003). Automated classification was also done using the same GIS software and pixels were used for training samples. Application of automated classification method to the AVIRIS image data set led to the creation of a digital wetland vegetation map (Hirano *et al*., 2003). Quantifying remote sensing data has made more information available because of the use of satellite imagery with high resolution as they enlarge the visual area of wetlands (Franke *et al*., 2009). Different indices have also been proposed through the use of quantitative methods on wetland studies. The use of remote sensing and GIS in mapping changes of ecosystems of Alpine wetlands in Zoige Plateau, China, resulted in development of a landscape area index, landscape diversity index and landscape fragmentation index (Junhong *et al*., 2008). Through the use of these indices, an uneven distribution of various species within the wetland was found (Junhong *et al*., 2008).

In detecting wetland change of Kafue Flats floodplain wetlands of Zambia, Munyati (2000) selected high resolution images of Landsat TM at 30 m resolution and Landsat MSS (Multi-Spectral Scanner) at 80 m resolution. These images were all from September but from different years (Munyati, 2000). The high cost of Landsat TM images and the available data in archives necessitated the use of Landsat MSS images. Remote sensing methods used for change detection in this research were image differencing, classification and comparison. The images were normalised using radiometric correction and registered with geometric measurements as common map projection (Munyati, 2000). The images were separately classified into different categories of open water, dense, space and green vegetation and also dry and burnt land. All images were classified with a supervised classification and changes in each land cover were analysed using GIS. Change was detected by calculating the area covered by each class for each image and change from year to year was based on the increase or decrease in area shown on the images (Munyati, 2000). The classification comparison method therefore proved to be a very useful method in monitoring the wetlands. The Landsat images minimized the confusion caused by wetland vegetation within the surrounding land. GPS was also used to identify different sites with a variety of plant species (Munyati, 2000).

The use of different spectral bands from remote sensors allows the assessment of different aspects of tropical floodplains and different types of wetlands (Betbeder *et al*., 2014). Multispectral and hyperspectral remotely sensed imagery for vegetation identification can be used to map the biophysical and biochemical characteristics of wetland vegetation (Adam *et al*., 2010; Betbeder *et al*., 2014). High resolution images like Landsat images enlarge the visual field of the land making it possible to view the ecological components of the wetland ecosystem in more detail (Betbeder *et al*., 2014).

Spatially clear and relevant information on different landuses and landcover on wetlands which help in identifying degradation processes can only be available through the use of remote sensing (Franke *et al*., 2009). Remote sensing is the major element that can be used to develop a wetland inventory through mapping of different landuses and ecosystems, and addresses the problem of wetland inventories in Africa (Munyati, 2000). Different changes in wetland ecosystems can be mapped using remote sensing, giving information on how wetlands can be utilised and conserved. Unfortunately satellite resolution is sometimes too coarse to derive information about small wetlands (Franke *et al*., 2009). Images like SPOT (Satellite Pour l'Observation de la Terre) can be used to map small wetlands but they are very expensive. Advanced Very High Resolution Radiometer (AVHRR) data have been used since they are cheaper but their coarse resolution makes it difficult to accurately monitor changes in small wetlands (Munyati, 2000). The high cost of high resolution satellite image data for small wetlands and often expensive software systems are key limitations to wetland studies in using GIS and remote sensing (Munyati, 2000). However, challenges are still being encountered on how to make use of the data obtained through imagery processing (Munyati, 2010).

GIS and remote sensing has previously been used in Zimbabwe to study both rural and urban wetlands. Landsat TM thermal infrared data was used to study the evapotranspiration rate in wetlands of Seke Chihota in Zimbabwe (Lupankwa *et al*., 2000). Landsat Thematic Mapper can detect moisture content and was used for hydrological classification of some dambos. This was done to select dambos that will be wet in the dry season so that they can be used for agriculture. High evaporation rates were found in areas where a lot of water infiltrates into the soil and in dambos covered by tall and dense vegetation. Besides classification of wetlands, Landsat TM data can therefore be used to detect wetland areas with high or low evaporation rates (Lupankwa *et al*., 2000).

Landsat and SPOT data were used to map spatial and temporal changes that occurred between 1989 and 2009 on Borrowdale, National Sports, Highlands and Mukuvisi wetlands in Harare (Mhlanga *et al*., 2014). This research used Landsat Thematic Mapper (March, 1989), Enhanced Thematic Mapper (August, 2000) and SPOT images for August 2000 (Mhlanga *et al*., 2014). Images were classified using supervised classification and the brightness, greenness or wetness of the images were transformed using ArcGIS (Tasselled cap transformation). This was done to calculate the wetness indices of the areas, and Borrowdale and National Sports wetlands showed low levels of wetness and whilst Mukuvisi and Highlands showed high degree of wetness (Mhlanga *et al*., 2014). In mapping the spatial extent and temporal changes that occurred between 1989 and 2009 on the wetlands, classification was done using the wetland capability and Cowardin (hierarchical classification) wetland classification systems ((Mhlanga *et al*., 2014). Capability classification involved wetland classification according to degree of wetness (Mhlanga *et al*., 2000). Results showed that National Sports Stadium, Borrowdale and Mukuvisi wetlands shrunk between 1989 and 2009 and mapping development on these wetlands showed that these wetlands were affected by agriculture and building of houses (Mhlanga *et al*., 2014).

Wetlands can therefore be classified and mapped to show their spatial extent, and provide information on the physical and ecological quality of the wetlands. GIS can be used to investigate the changes in the state of the wetland because of its capability of overlaying data from different time periods to produce description of land use change (Murungweni, 2013). GIS and remote sensing are useful tools for assessing data which are spatially and temporally changing and therefore can be used for mapping and analysing these patterns (Zhang *et al*., 2002). However there is limited research on wetlands in Zimbabwe using GIS and remote sensing methods because interpretation of satellite images may be challenging and suitable high resolution data are not always available (Chopra *et al*., 2001). This research uses GIS in making an inventory of the different landuses on two wetlands in Harare, which are threatened by different human activities. GPS was also used to delineate wetland boundaries.

2.4.2 Quantitative methods in wetland studies

Past research has also used different quantitative methods such as experimental and non-experimental (survey) designs to study wetlands. Experimental methods involve correlational and casual comparative approaches in which different variables are taken into consideration (Creswell, 2014). Quantitative methods were used to investigate issues pertaining both human and physical environments. Effects of biochemical processes on wetlands can be determined through quantifying nitrogen retention in surface flow wetlands, such as in northern Germany (Trepel and Palmeri, 2002). In this study, nitrogen retention was quantified by sampling statistical modelling equations. The effect of wetlands on nitrogen retention potential was evaluated using the comparison model method, comparing the predictive ability of three different statistical models (Trepel and Palmeri, 2002). The calculation of the relationship between the nitrogen load of the wetland and the wetland itself overestimated the retention of nitrogen in wetlands downstream (Trepel and Palmeri, 2002). These statistical equations enhance the prediction of nitrogen removal rates on wetlands. This has helped in quantifying environmental planning for wetland use at a landscape scale, based on the available statistical data and knowledge (Trepel and Palmeri, 2002).

Effects of landuse on wetland species were also investigated through quantifying the relationship between dependent variables (plant species richness, community composition) and independent variables of land use such as forest cover, roads and buildings on wetlands in Canada (Houlaham *et al*., 2006). In addressing landuse effects on water quality and species composition on wetlands and community composition, multiple regression and ordination statistical analysis methods were used. Linear regression analysis was used to assess bivariate relationship between two variables, water and sediment nutrient (Houlaham *et al*., 2006). Results showed that plant species were affected by different landuses, indicating that management practices and regulation for landuse and proper conservation of wetland resources were required (Houlaham *et al*., 2006).

Regardless of using qualitative and quantitative methods that can involve human participation, there are other quantitative methods that can be used to investigate the effects of certain activities on wetlands. For example, the impacts of urbanisation on palustrine wetlands in Puget Sound region, USA, were investigated by measuring levels of storm water (Reinelt *et al*., 1998). Data collected between 1988 and 1995 on 19 urban wetlands showed the changes in the hydrology of the wetlands mainly due to impervious surfaces and that fluctuations in the water table led to species loss within wetlands. These water level values used to assess the relationship between landuse and wetland characteristics, indicating that urbanisation reduces infiltration rates thereby flooding the adjacent wetland areas (Reinelt *et al*., 1998). Quantifying the changes in inflows and outflows and the storage capacity of urban wetlands can help in managing urban storm waters (Reinelt *et al*., 1998). Specific wetland functions can also be quantified for management purposes (Whigham, 1999). This can be done through the use of an ecologically based hydrogeomorphic approach which has become a common tool for wetland assessment in the USA (Whigham, 1999). The hydrogeomorphic approach assesses wetland functions by analysing the hydrologic, biochemical and biological interactions of the wetland with the surrounding landscape. Thus the assessment is based on how measured or estimated variables deviate from wetlands of the same type (Whigham, 1999).

A variety of techniques has also been developed to quantitatively assess wetland use and non-use values. A contingent valuation method was used with a questionnaire in 30 different temperate wetlands in North America and Europe for use and non-use value of wetlands (Brouwer *et al*., 1999). Using contingent valuation technique involves asking people what they are willing to pay for specific wetland services. Willingness to pay (WTP) for goods and services for which no market exists was used in assessing the socio-economic values attributed to hydrological, biochemical and ecological functions of wetlands (Brouwer *et al*., 1999). Human perceptions and attitudes regarding wetland values were extracted and results from the study of these multiple wetlands were compared and synthesised statistically (Brouwer *et al*., 1999). The data were analysed using a generalised least squares regression technique called multilevel model. Multilevel model is a statistical approach used to analyse clustered grouped or repeated measures of data. In this case random variables were used to model results from surveys on the wetlands to test the statistical significance of wetland valuation and the mean and standard deviations for WTP were also calculated and compared (Brouwer *et al*., 1999). In this research a meta-analysis method which involved combining and contrasting results of different statistical research methods was used to analyse wetland values (Brouwer *et al*., 1999). Quantitative methods are therefore important in wetland studies because they provide quantified data and information which clearly show the extent of wetland degradation. This information is therefore important for planning future sustainable use of wetlands and strategic conservation measures.

2.4.3 Use of qualitative methods in wetland studies

Qualitative approaches have widely been used in different areas for wetland studies. The broadly used qualitative methods are individual interviews and focus group discussions. Most studies have used these methods to find out how people view and use wetlands. Individual interview and focus group discussions have been used to investigate different issues pertaining to human perceptions on wetland values, and functions, wetland restoration, wetland degradation and policies on wetlands. Face to face interviews were used to investigate the heterogeneity of wetlands attributes in Cheimaditada wetland in Greece (Birol *et al*., 2006). These interviews were administered to residents and the study showed that economically significant benefits were derived from wetland use. Community perceptions were also investigated on the impact of the recession of Lake Victoria waters on Nyando wetlands using individual interviews and focus group discussions (Obiero *et al*., 2012). Integrating individual interviews and focus group discussions enabled the researchers to gather enough information about utilisation of the wetland, income generation, household food production and fish catches in the Nyando area (Obiero *et al*., 2012). Human participation in wetland studies is important as it allows the researcher to have first-hand information on what is really happening on the ground, since the residents interact with the wetland ecosystem mostly on a daily basis.

With the increasing rate of wetland degradation and loss due to human activities, there has been also an increased need to make people aware of the importance of these valuable ecosystems. This attracted the use of individual interviews and focus group discussions as ways of gathering data on wetlands from human perception. Some researchers have used quantitative analysis for qualitative data. Focus group discussions and individual interviews were also used to investigate wetlands use in two areas in Chelem and Chuburna, Mexico (Kaplowitz, 2001). These qualitative methods were conducted to residents to gather information about the products and services offered by mangrove wetlands (Kaplowitz, 2001). Information gathered from focus groups and interviews was transcribed, openly and thematically coded, grouped into concepts and categorised (Kaplowitz, 2001). Gathering information using qualitative methods is important because it reveals wetland services, functions and products at a local level. Qualitative methods were also used to evaluate ecosystem services for wetland mitigation in Michigan, USA (Hoehn *et al*., 2003). The interviews examined the extent and type of knowledge that residents were aware of, pertaining to wetland use and their knowledge on wetland ecosystems (Hoehn *et al*., 2003). Results showed that residents have inconsistent knowledge about wetlands. Qualitative research therefore emphasises the role of knowledge as an important aspect in valuing wetland ecosystems (Hoehn *et al*., 2003).

Questionnaires and interviews were also used to investigate awareness of people on wetland policy and legislation on wetlands and their implementation in Midlands area, Zimbabwe (Marambanyika and Beckedahl, 2016). This research showed that people are not aware of the policy and legislation on wetlands and thus they are not properly implementing them (Marambanyika and Beckedahl, 2016). However, although both interviews and questionnaires were used, they were analysed in a quantitative way (Marambanyika and Beckedahl, 2016). Though questionnaires are a qualitative way of data collection, some researchers prefer to interpret data from questionnaires in a quantitative way. Assessment of gardening on wetlands in Mwaonazvawo communal village in Zimbabwe was also done using questionnaires and interviews (Svotwa *et al*., 2008). Information gathered from residents in this research was also coded, developed into concepts and categorised (Svotwa *et al*., 2008). Results showed that different crops were being grown on wetlands and sustainable methods were being used.

Qualitative models have also been used in wetland studies to give information about wetlands for management and conservation purposes. The loop model based on the participation of locals and the observed ecological information was constructed to assess the effects of economic activities in Esteros del Ibera wetland in Argentina (Loiselle *et al*., 2002). This involved analysis on the effects of economic activities on both the biotic components (phytoplankton, zooplankton, aquatic macrophytes) and the abiotic environment (nutrients and sediments). Therefore, a loop model was developed from field observation, information from local people, data from different literature and descriptive information from experts on wetlands in the region (Loiselle *et al*., 2002). Development of qualitative models like the loop model has helped other researchers in making more predictive models (Loiselle *et al*., 2002). This also enabled decision makers to have information about wetlands, important for wetland management and monitoring programmes (Loiselle *et al*, 2002). Qualitative methods of data collection such as those discussed above, are important in wetland studies because they give the researcher an opportunity to gather in-depth information about wetlands. In-depth information is gathered mostly through contextual knowledge from peoples' experience and interaction with the ecosystem. The subjective nature of qualitative data therefore allows the researcher to explore new themes and concepts that can arise from different views given by people about wetlands.

2.4.5 Mixed methods in wetland studies

Mixed research methods are also widely used in wetland studies. These studies use both qualitative and quantitative methods to collect data. In investigating wetland use and their sustainability in Ngaiti and Kitalalo areas of central Tanzania, focus group interviews and questionnaires were used (Mwakaje, 2009). Varied reasons were drawn from questionnaires and focus group interviews on the problems that stopped people from using wetlands sustainably (Mwakaje, 2009). Questionnaires were analysed using statistical methods and textual analysis was done on interview responses. Mixed methods proved to be very effective in gathering information about certain concepts on wetlands because of the varied techniques employed, allowing interpretation of data of different types.

In investigating rural peoples' strategies in promoting sustainable based food security, researchers also used questionnaires and interviews (Marambanyika *et al*., 2016). Data collected were analysed quantitatively and results showed that people should be involved in different approaches to wetland management (Marambanyika *et al*., 2016). In Zimbabwe mixed methods were commonly used by most researchers for wetland studies, especially in rural areas, but few have been done for urban wetlands. Questionnaires and interviews were also used in investigating wetland change in Belvedere and Epworth in Zimbabwe as a result of land degradation (Mutisi and Nhamo, 2015). This helped the researchers gather information about wetland degradation from peoples' views and through mapping wetland change using GIS (Mutisi and Nhamo, 2015). Aerial photos for 2002 were imported into a GIS. Google Earth images were also digitised to show land use change for the years 2008-14 (Mutisi and Nhamo, 2015). The digitised images showed wetland loss due to house construction and agriculture and this was supported by peoples' views since they confirmed that agriculture was carried out throughout the year on wetlands (Mutisi and Nhamo, 2015).

Mixed methods have also been used to evaluate information gathered from human and physical environments on the subjective estimates and objective quality of ecosystems (Moser, 1984). In France along the Loing River, subjective views gathered from semi-structured interviews pertaining to human perceptions on water pollution levels on the river were integrated with objective physical water pollution data acquired from water tests (Moser, 1984). Water temperature, total dissolved oxygen, nitrates and phosphates were tested to determine the water quality and degree of pollution from various points within the river. These water parameters were analysed quantitatively. People also described perceived water quality including factors such as colour, floating debris, water plants and algae (Moser, 1984). Pollution was seen to be less serious and responses from interviews showed that many people were tolerant of the water pollution. Mixing qualitative data from human perceptions and quantitative data from measuring the physical parameters within an ecosystem is a more informative technique of investigating and assessing natural ecosystems such as wetlands. This is because different characteristics, state, and ecological quality of the wetland can be explored from both human and physical perspectives.

Most qualitative methods encourage participation, hence the data collected will be influenced by peoples' experiences and opinions, whilst quantitative methods reveal the reality of the studied phenomenon through statistically measured data. Therefore integrating qualitative and quantitative method allows for continuous investigation of the studied phenomenon. In light of the above discussion, this research also used both qualitative and quantitative methods (mixed methods) in assessing human utilisation and the environmental quality of wetlands through integrating human perceptions and measured physical parameters of the wetlands. Statistically gathered data through quantitative methods show the extent of wetland degradation due to different landuse and integrating this data with human perceptions enhanced sustainability monitoring in this research.

2.5 Sustainability and wetlands

The concept of sustainability monitoring, evaluation and measurement has become an important issue in wetland studies. There seems to be no agreement on how to address the issue of sustainability but the indicators approach has been widely adopted and seen as a crucial way of measuring sustainability for natural ecosystems like wetlands (Diaz-Balteiro and Romero, 2004). Environmental crises have caused the issue of sustainability of wetland resources to become a topical issue. Wetlands therefore should be used to cater for the needs of the present generation without compromising the ability of the wetland ecosystem to meet the needs of future generations (cf. Brundtland Commission, 1987). Sustainability indicators such as economic, environmental quality and social issues have been widely used to establish sustainability indices of natural ecosystems like wetlands (Diaz-Balteiro and Romero, 2004; Nassuer, 2004). Indicators show the performance of a wetland resource as compared to what is expected (Waas *et al*., 2014). Most wetlands play a key role in supporting livelihoods but their integrity is being destroyed (Diaz-Balteiro and Romero, 2004). For example Bahi wetlands play a key role in supporting people in central Tanzania but overutilization from agricultural farming, livestock grazing and natural resources extraction is threatening wetland sustainability (Diaz-Balteiro and Romero, 2004).

A study done on various ways for sustainable use of wetlands in Midlands communal area, Zimbabwe, using sustainability theory, views local customs and values as important to the achievement of sustainability in a local context (Marambanyika *et al*., 2016). Therefore, local policy and institutions which do not divorce from what people value as effective wetland management measures can help in achieving sustainability (Marambanyika *et al*., 2016). However, food security production projects on wetlands should rely more on total involvement of the local communities in adopting environmentally friendly technologies and approaches in order to achieve sustainability of wetland use (Marambanyika *et al*., 2016). In some rural areas in Zimbabwe, sustainable measures are used for gardening on wetlands (Svotwa and Manyanhaire, 2008).

Gardening on wetlands in Mwaonazvawo rural community in Zimbabwe proved to be sustainable through the use of farming methods such as mulching, furrowing, crop rotation and use of organic manure which help in nutrient retention (Svotwa and Manyanhaire, 2008). This shows that in some rural areas in Zimbabwe, wetlands are better able to be used sustainably because of the presence of Agricultural Extension (AREX) officers who educate people about conservative farming methods (Svotwa and Manyanhaire, 2008; Marambanyika *et al*., 2016). In Zimbabwe little has been done in monitoring wetland sustainability of urban wetlands yet there are the most endangered as they are being over utilised. It is therefore the main focus of this research to evaluate sustainability of urban wetlands using sustainable indicators from both the physical and the human environment.

2.6 Wetlands and climate change

Apart from pressure that wetlands can experience from urbanisation, agriculture and waste dumping, wetlands are also experiencing additional stress from climate change (Mortsch, 1998). The rapid increase of global mean temperatures limits the adaptive capacity of wetland species, and any decline in biodiversity will affect many valuable and functional characteristics of wetlands (Leemans and Eickhout, 2004). The distribution of species on wetlands can be disturbed by climate change (Leemans and Eickhout, 2004). Recent global climatic change has also affected the biological and physical processes within wetland ecology (Brander *et al*., 2012). Change in temperatures and rainfall reliability due to climate change has induced stress on wetland soil temperatures, hydrology and wetland species (Bridgham *et al*., 1995). Change in precipitation poses a threat to species habitats on wetlands (Dawson *et al*., 2003). Research done on the Praire Pothole Region wetland in Canada shows that most animal species have disappeared due to changes in wetland biodiversity caused by climate change (Cudmore, 2011). Variation and changes in rainfall received seasonally can affect the interaction between species as a result of the disturbed wetland ecosystem (Chapin, 2000; Lawler *et al*., 2008).

Climate change has caused shifts in agricultural land use and this may bring increased encroachment of these agricultural activities in already degrading wetland areas (Hartig *et al*., 1997). Increased evapotranspiration and reduced runoff due to climate change can increase the rate of wetland losses (IPCC, 1990). The hydrological cycle can be changed due to reduced runoff and precipitation and this will decrease water recharge to inland wetlands (Mortsch, 1990). A change in water quality due to climate change on some wetland such as the Okavango swamp has also caused changes in plant communities (Bridgham *et al*., 1995; Lawler *et al*., 2008; Cudmore, 2011). Climate change can cause changes in the underground flow of water, increase heat stress on wetland species, cause diseases, flooding, soil erosion and decrease the quality and quantity of water (Erwin, 2008). Wetland size can also be reduced by changes in ground water levels (Brander *et al*., 2012). Although the future of most wetlands is not well known, it can be predicted that some wetland species can become extinct due to the effects of climate change (Keddy, 2010).

Unreliable rainfall due to climate change has influenced the growing of food crops on wetlands (Mbida, 1995). Little, sporadic and unreliable rainfall in Zimbabwe has caused excessive use of wetlands for agriculture both in rural and urban areas. Although many activities have been done to try and restore wetland resources wetland loss is impossible to rectify (Davidson, 2014). This provides the context for the wetlands studied in this project.

2.7 Conclusions

Although many studies have been done pertaining to wetlands in Africa, most literature does not present peoples' perceptions, views and knowledge pertaining to urban wetland uses, their importance and the integrity of these wetlands. It is therefore the thrust of this research to evaluate human perceptions knowledge and understanding of the importance of urban wetlands. This research also assesses the integrity of urban wetlands as they are used by people. Human and physical aspects were therefore used to assess wetland sustainability. The literature review discussed in this chapter form the basis of the methodology, data analysis and the overall conclusions of the dissertation and therefore led to the discussion of the study area on the next chapter (Chapter 3).

Chapter 3: Study Area

3.1 Introduction

This chapter aims at describing the geology and topography, climate, ecosystems, settlement, population industry and human activities of the study area. Harare occupies 961 km² of a highland plateau land and is located in the northern part of Zimbabwe (Figure 3.1). The two wetlands (Borrowdale and Belvedere) were purposively selected since they are amongst the biggest vleis in Harare with controversial issues pertaining to land uses and development on them. These vleis helped in gaining an insight into urban wetland use in developing countries as a way of evaluating wetland sustainability.

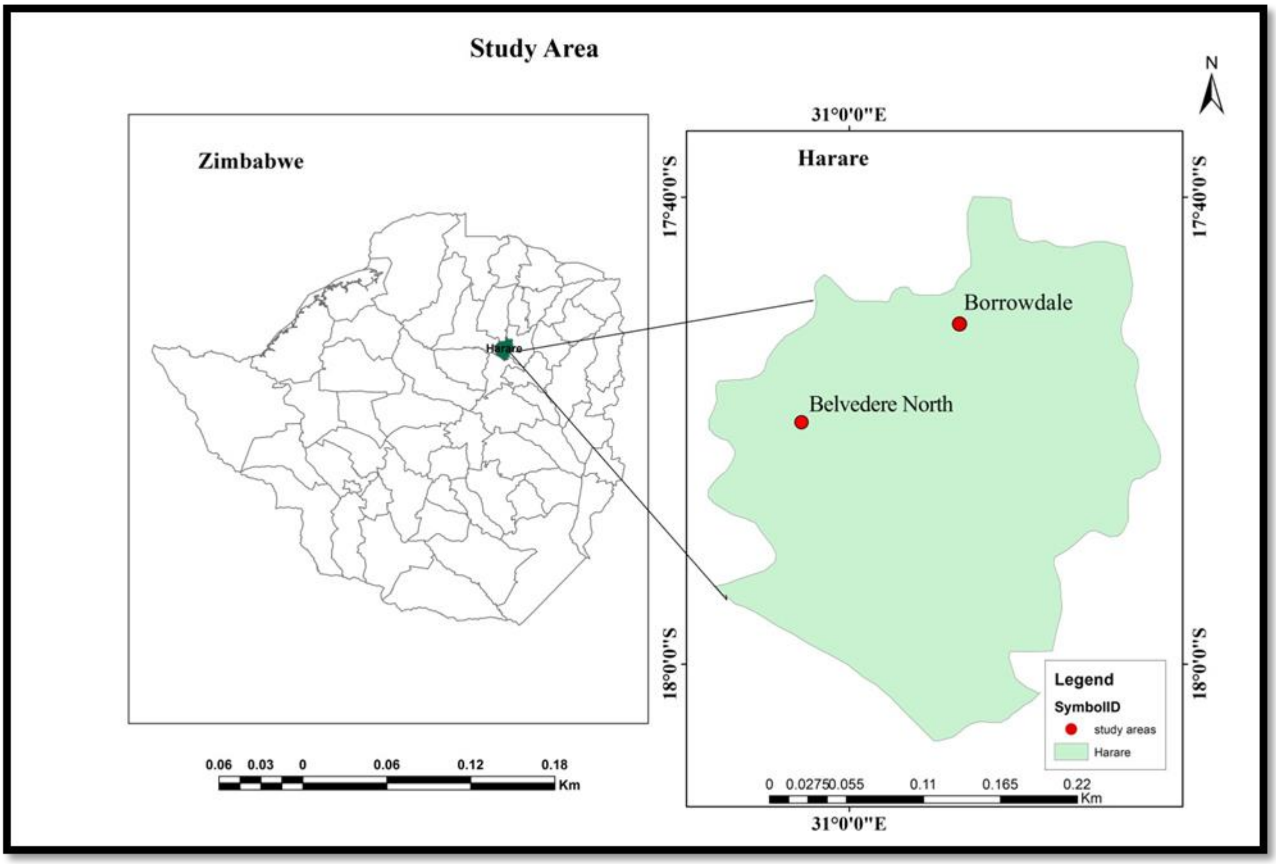

Figure 3.1: Map showing the study area

3.2 Geology and Topography

Harare is in the middle veld with an elevation of 1488 m. The study area is covered by greenstone (Harare Shamva greenstone), surrounded by granite from which greyish brown sandy loams and coarse textured sandy soils are derived (Nyamapfene, 1991; Venema, 1998;

Rees *et al*., 2006). In the upland areas and on vleis such as Borrowdale and Belvedere, deep black and reddish brown clay vertisols soils are found (Nyamapfene, 1991; Anderson *et al*., 1993; FAO, 1994). Andosols which are dark silt loam and gleysols are all found in other parts of Harare (FAO, 1994).

3.3 Climate

The study area has a tropical climate and lies in agro-ecological region 2 with the total rainfall for the year ranging from 800-1000 mm (Bohle *et al*., 1994). Temperatures for the day range between 7-22ºC especially in winter and 15-29ºC in summer (Bohle *et al*., 1994). Rainfall is seasonal and shows interannual variability (Washington and Preston, 2006; Chikozho, 2010). Most of it falls in summer and is mainly caused by the movement of the Inter Tropical Convergence Zone (ITCZ) from the equator to the Southern Hemisphere, leading to the convergence of the south-east and north-west trade winds (Taylor *et al*., 1995; Love *et al*., 2010). Droughts often occur in Zimbabwe caused by the El Nino-Southern Oscillation (ENSO) associated with high phase (Philander, 1990). Low and below average rainfall was received in 1991-92 and 1997-98 in Zimbabwe due to the ENSO, causing severe droughts (Love *et al*., 2010).

However, following years of sporadic rainfall in Zimbabwe, Harare has been experiencing water shortages, since most water bodies did not have enough water to cater for all the residents (The Financial Gazette, October 2014). Increase in temperatures during the hottest month of October has resulted in the drying up of the main rivers which supply water to Harare’s main water source (Lake Chivero). Water rationing in Harare has become a common thing due to limited water in Lake Chivero especially during the dry seasons (autumn, winter and spring) and failure by the city council to pay for water supplies from the Lake (Nhapi, 2008). Failure of the city council to supply water to all residential areas has increased drilling of private boreholes thereby affecting underground water by lowering the water table.

Water scarcity in Harare has also been increased by construction on main water catchment areas such as wetlands (Chronicle, December 2016). Some residential areas such as Borrowdale and Belvedere no longer rely on municipal water. This has forced some residents residing in low and medium density suburbs to buy water for domestic use from companies who are pumping underground water (Manzungu *et al*., 2016). Most rivers such as Ruwa, Nyatsime which feed into Manyame River have a lot of water from small streams during the rainy season (summer season) between November and March. Thus, Lake Chivero, the main source for industrial and domestic water for Harare only has inflow from Marimba and Manyame during the rainy season. Mukuvisi River is one of the longest rivers in Harare which flows throughout the year but is heavily affected by pollution from industries and fertilisers from cultivated fields (Moyo and Phiri, 2002). However, heavy and unexpected above average rainfall were received in Harare during the 2016-17 rainfall season in December and January 2017 due to El Nino associated with low phase, and this resulted in flooding of major lakes and rivers such as Lake Chivero and Manyame River (The Standard, January 2017). Most houses built on wetlands were affected by these floods and about 30 families were displaced from one residential suburb built on wetlands (Budiriro 5) after their houses were flooded (The Standard, January 2017).

3.4. Ecosystems

Natural vegetation of open woodland types is found in Harare and *Msasa brachystegia spiciformis* is the commonest tree. A variety of animal and plant species is found in Mukuvisi woodland (Mutowo and Murwira, 2012). The dominant tree species in Mukuvisi is Miombo woodland which includes trees such as *Isoberlinia* and *Julbernadia globiflora* (Campbell *et al.*, 1991; Mutowo and Murwira, 2012). Mammals such as giraffe, wildebeest, impala and eland are found in Mukuvisi woodland (Muboko *et al*., 2014). A variety of birds, reptiles and fish is also found in Harare (Muboko *et al*., 2014). Different types of wetlands are found in Harare. Riverine and palustrine are most common and these include floodplains, riverine systems, dambos, vleis, pans, swamp and artificial impoundments such as Lake Chivero (Matiza and Crafter, 1994). The main riverine systems include Mukuvisi, Manyame and Marimba rivers (Zaranyika *et al*., 1993). Vleis which are waterlogged seasonally are the most common wetlands in Harare (Mbida, 1995).

3.5 Settlement, population and industry

Founded in 1890, by Cecil Rhodes' mercenary group, Harare became a city in 1935 with few settlements (Muronda, 2008). Increase in Harare population due to rural urban migration led to the rapid increase of settlements especially after independence in 1980. New high, middle and low density suburbs emerged around the city to cater for the growing population (Munzwa and Jonga, 2010). This led to slums around the residential suburbs since some people could not afford to buy or rent houses built after independence (Muronda, 2008). The government engaged in decentralisation activities in the 1990s and growth points were built around most rural districts and these were meant to decentralise people from urban areas and stop rural urban migration (Muronda, 2008). However this failed to solve the problem of accommodation in Harare since most people were reluctant to go to growth points because of small scale and underdeveloped industries in these areas. As the metropolitan city, Harare has the highest urban population. The population of Harare has increased from 1 896 134 in 2002 to 2 123 132 in 2012 (ZIMSTAT, 2015). Besides rural urban migration, high birth rates also led to population increase the population of Harare.

Settlement increase in Harare was also as a result of the government's housing construction policy in 1992 whereby many houses were built in Harare (Munzwa and Jonga, 2010). More so, land developers and cooperatives took advantage of accommodation problems in Harare to use open spaces, selling residential stands to those people who were in need of houses. This increased the number of illegal structures within Harare. This has forced home seekers to build houses illegally in some parts of Harare. Operation Murambatsvina (operation 'restore order') in 2005 by the government led to destruction of all illegal structures in the backyard of most houses and all slums, thereby increasing the problem of accommodation (Bratton and Masunungure, 2006). Although the government wanted to send back some people to their rural areas through Operation Murambatsvina, only a few relocated to these rural areas. The population of Harare has therefore increased rapidly causing the expansion of the city on restricted areas like wetlands since they are the only open areas left. The government of Zimbabwe has been demolishing houses built illegally especially on wetlands. In August 2015, 100 houses built on a wetland in Budiriro were demolished by the Harare city council (NewsDay, August 2015). Despite the demolition of illegally constructed structures by the Harare city council, people continue to build houses on wetlands.

Harare has a variety of light and heavy industries in different parts of the city. Msasa (light and heavy industry) is the largest industrial site in the eastern side of the city (Parliament Research Department, 2011). Other industrial sites in Harare include Granite site (light industry) in the south east, Southerton (food and beverage processing industry), Willowvale (home for car assembling of Willowvale Mazda Motors) and Glen-Eagles (home for tobacco processing companies) (Parliament Research Department, 2011). The government adopted the Growth with Equity policy after independence in 1980 to boost economic growth. Drastic growth in Gross Domestic Product (GDP) was recorded between 1980 and 1981 as a result of the implementation of The Growth with Equity policy after independence (Fallon and Lucas, 1991; Brett, 2005). However, Zimbabwe's economic challenges which emanated from economic policies such as ESAP (Economic Structural Adjustment Programme) affected production of different goods forcing some industries to close, leaving many people without jobs (Carmody and Taylor, 2003). The Economic Structural Adjustment Programme (ESAP) was introduced in 1991 to transform Zimbabwe from a tightly controlled economic system to a more open, market-driven system. Although the ESAP sought to reduce poverty and unemployment, it was unfortunately met with the severe drought of 1991 and 1992 which left the country in recession. Some industries in Glean-Eagles and Southerton industrial parks in Harare have long been closed. Due to economic challenges, heavy and large scale industries have since been ignored in Harare. Small scale industries have grown for the past few years.

3.6 Human activities

Harare residents engage in different human activities such as settlement development, industrial activities and agriculture (Mudimu, 1997; The Standard, May 2015). High rates of unemployment and poverty due to economic crises has forced many people in Harare to be involved in informal industrial activities such as vending. Some people have turned to agriculture especially on open land such as wetlands to supplement their incomes and for food security. Government economic reforms like ESAP left some people jobless such that most families were affected by food insecurity and they turned to urban agriculture growing crops for food (Roggerson, 1993; Mudimu, 1997). Urban agriculture was illegal in Harare especially on public land, and in 1991-92 the authorities even destroyed all crops that were grown on open spaces (Drakakis-Smith *et al*., 1995; Mudimu, 1997). However authorities are now reluctant to implement the policies and urban agriculture seems to have been decriminalised by the government and law enforcement agencies due to other priorities (Drakakis-Smith *et al*., 1995). The main crops grown are maize, sweet potatoes, pumpkins and a variety of vegetables especially on vleis (Mbida, 1995).

3.7 Belvedere wetland

Belvedere wetland (vlei) is located 4 km west of Harare CBD at an elevation of 1452 m asl and covers an area of 85 km^2 (Figure 3.2). The area is underlain by greenstone (Harare Shamva greenstone), surrounded by granite from which deep black, reddish brown clay vertisols, sandy loams and coarse textured soils are derived (Nyamapfene, 1991; Anderson *et al.*, 1993; FAO, 1994). Marimba River which is one of the major rivers which flows into Lake Chivero, flows through Belvedere vlei. Harare town planners had left Belvedere vlei as an open space which was not designated for construction. A Chinese Mall which became operational in December 2013 was built on Belvedere vlei.

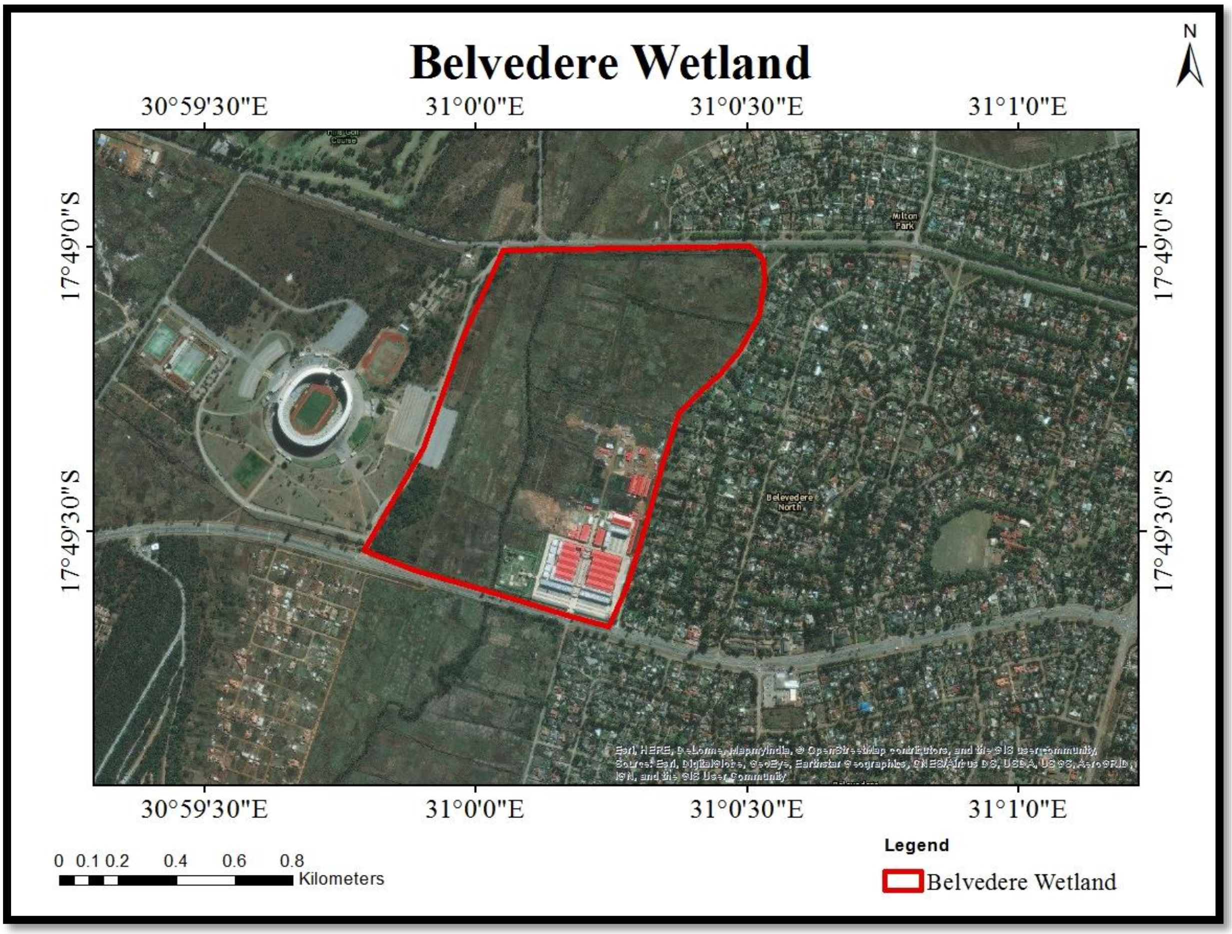

Figure 3.2: Belvedere wetland

Belvedere wetland is surrounded by Belvedere North, Belvedere West and Belvedere South residential areas and also the National Sports stadium which is to the west (Figure 3.2). It is also bounded by Bulawayo road to the south and Kirkman road to the north.

Figure 3.3 shows Belvedere vlei. The Chinese Mall was built on a place with a lot of water such that they are forced to drain the water from the wetland and impound it into artificial ponds to stop the water from disturbing the buildings (Figure 3.3a-c). Banana trees were also planted around the wetland to suck water from the wetland (Figure 3.3d). A luna park was constructed on the western part of the Chinese Mall for children to play (Figure 3.3e, f). Pipes were also inserted from underground to drain water from the wetland into artificial ponds (Figure 3.3g, h). Water impounded at the mall was being drained into Marimba River which passes through Belvedere vlei (Figure 3.3i, j). The Chinese Mall was constructed on the wetland and the reeds shown indicate some of the vegetation still found on the Belvedere wetland (Figure 3.3k).

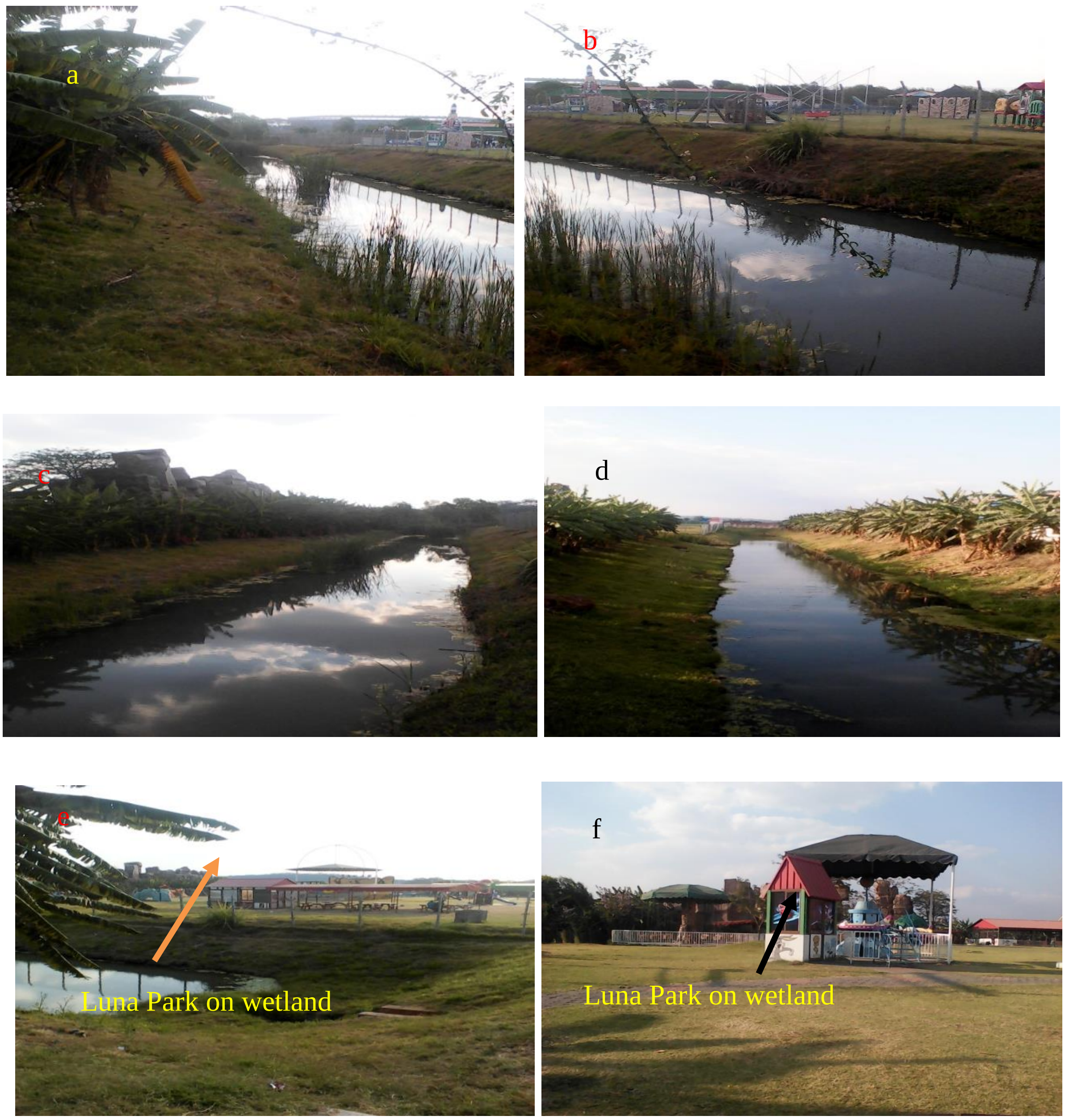


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Figure 3.3: Belvedere wetland photos. (a-c) water drained from wetland impounded into man made ponds, (d) banana trees grown to suck water from the wetland, (e, f) children's play centre built on wetland; (g, h) pipes installed to drain water from the wetland; (i, j) part of the river; (k) part of the Chinese mall built on the wetland; (l, m) unutilised part of the wetland; (n) part of the wetland burnt for land preparation to grow crops; (o, p) part of the wetland under cultivation; (q) unutilised part of the wetland; (r) sugarcane grown on the wetland.

The other part of the Belvedere wetland which was unutilised had long grass (Figure 3.3i, m). Farmers used veld fires to clear the land in preparation to grow crops and dirt roads were also created within the wetland (Figure 3.3n). Farmers had cultivated part of the wetland with deep black soil in preparation to grow crops (Figure 3.3o). The other part of the wetland was also used for cultivation since it had remains of harvested maize cobs (Figure 3.3p). Part of the wetland had dense vegetation (Figure 3.3q) whilst the other part was used to grow sugarcane (Figure 3.3r).

3.8 Borrowdale wetland

Borrowdale wetland (vlei) is located 10,5 km north of Harare at an elevation of 1539 m asl in the commercial business and low density residential area of Borrowdale. Borrowdale wetland covers an area of 52 km^2. Named after Henry Borrow in 1890, Borrowdale area started as an estate covered by residential and farming areas. Harare town planners had left Borrowdale vlei as an open space but building of a residential area started on the wetland in 2014 (Figure 3.4). Although there is no river that passes through Borrowdale vlei, the vlei supplies water to other major rivers such as Manyame and Gwebi. Borrowdale area is also underlain by greenstone (Harare Shamva greenstone) and with vertisols and sandy loams (Nyamapfene, 1991; Anderson *et al.*, 1993; FAO, 1994). Climate is the same as for Belvedere.

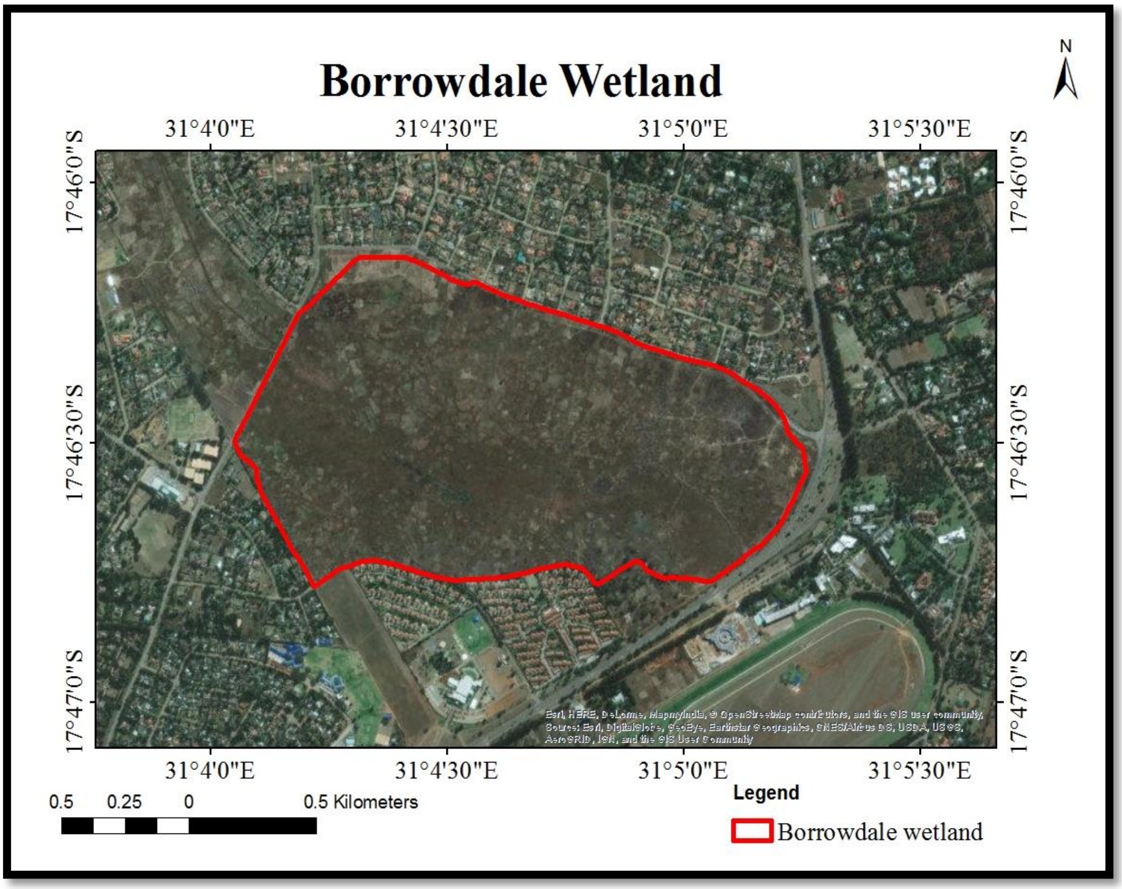

Figure 3.4: Borrowdale wetland

Borrowdale vlei is bounded by Ballantyne Park residential area and Borrowdale Race Course to the east, Vainona and Groombridge residential areas to the West, Dandaro village and Old peoples' home to the south and Borrowdale residential area to the North and Whitwell roads (Figure 3.4). Whitwell, Teviotdale and Borrowdale roads also encompass Borrowdale vlei.

The lower part of Borrowdale wetland is moist and has evergreen vegetation throughout the year (Figure 3.5a, b). Part of Borrowdale vlei is affected by sewage (Figure 3.5c). Borrowdale vlei had other parts of the vlei which were not being utilised (Figure 3.5d, m-p). The other unutilised parts of the wetland were fenced (Figure, 3.5o). Land was cleared on some parts of the wetland for construction (Figure 3.5e, f).


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Figure 3.5: Borrowdale wetland. (a-d) Unutilised parts of the wetland; (e, f) land cleared for construction; (g, h) part of the wetland cleared by veld fires; (i, j) part of the wetland showing dirt roads; (k, l) cultivated land; (m-p) unutilised parts of the wetland; (q, r) tarred roads constructed on the other part of the wetland.

Figure 3.5g shows the other part of the vlei affected by veld fires. Figure 3.5h shows car wreckage dumped in the wetland. Dirt roads were also seen on the wetland (Figure 3.5i, j). The other part of Borrowdale vlei had few trees left on the wetland (Figure 3.5j). Tarred roads have been constructed (Figure 3.5q, r).

3.9 Conclusions

Different aspects of the study site were discussed in this chapter and this helped in understanding the study area. Different methods used to collect data from this study area will therefore be presented in the next chapter (Chapter 4).

Chapter 4: Methodology

4.1 Introduction

This chapter focuses on the methods used to collect and analyse data. In this study human utilisation and the environmental quality of wetlands were investigated on Borrowdale and Belvedere wetlands. This was done to gain an insight into urban wetland use in developing countries as a way of evaluating wetland sustainability. Information from each case study was obtained through detailed questionnaires, individual interviews, focus group discussions and observations. Information on the environmental quality of wetlands from both wetlands was obtained through testing soil organic carbon content and grain size analysis. Organic carbon content and grain size distribution were chosen instead of other soil quality indicators because they help in determining nutrients within the soil in order to assess soil fertility. Participatory interviews (individual and focus group) provided information on what exactly was happening on the wetlands. A mixed method technique (qualitative and quantitative methods) was used.

4.2 Background information on methods used

In this research, both qualitative and quantitative methods of data collection were used. Qualitative research helps in obtaining the realistic nature of the wetlands under study through the subjective views of residents (Matveev, 2002). Thus information on Belvedere and Borrowdale wetlands was obtained based on peoples' opinions and views about wetlands, and these complemented data from questionnaires. Since information from respondents cannot be fully quantified through qualitative research methods, questionnaires were also used to supplement interviews. However, quantitative research cannot give knowledge about the contextual situation of the phenomenon under study (Matveev, 2000). Qualitative methods therefore allowed the researcher to have closeness to the situation through critical evaluation of respondents' views (Jick, 1979). In addition, qualitative data brings clarity, detailed and authentic information drawn from the experiences of the wetland users. Questionnaires, individual interviews and focus group discussions were administered to females and males aged 18 years and above. Ethics clearance was obtained prior to data collection.

Observation was also used to gather information on different land uses on the wetland and to observe the present situation of all wetlands. Therefore methodological triangulation which entails combining different methods was used in this research to yield a comprehensive overview of the human environment (peoples' perceptions and views) and the physical environment (environmental quality of wetlands) as a means of evaluating sustainability. Quantitative methods which included land use mapping and soil sample analysis were combined with qualitative methods (interviews and questionnaires) to investigate wetland utilisation. Questionnaires, interviews and focus group discussions were administered to residents of Belvedere and Borrowdale whose houses are built on wetlands or those who were found working on the wetlands. Questionnaires, interviews and focus group discussions were explained to the respondents to ensure maximum response rate and for clarity of some questions, since the instruments used were written in English. Soil and water samples were collected from the unutilised and the utilised parts of the wetlands. Although a triangulation technique validates results and encourages productive research, it is time consuming (Jick, 1979).

4.2. Finding research participants

Since population in Harare residential areas is structured according to wards which comprises of different overlapping residential areas, it was difficult to have the actual or estimate population of Borrowdale and Belvedere. In this research, convenience and snowball sampling were therefore used to select participants for questionnaires, interviews and focus groups. Convenience and snowball sampling are non- probability sampling methods in which individuals in the population are not guaranteed of equal chances of selection (Heckathon, 2011). Non-probability methods of sampling were used to avoid random selection of irrelevant respondents to the phenomenon under study. Convenience sampling involves finding respondents known by the researcher or readily available, accessible or willing to participate (Etikan *et al*., 2016). Questionnaires and interviews were administered to respondents as they were met accidentally on the road, working in the fields and at their homes. Thus respondents were selected as they happen to be located spatially near where the researcher was on the wetlands. Focus group discussions usually include more than two people. Therefore respondents to focus group discussions were selected snowball sampling (through chain referral). Snowball sampling involves personal networking or chain referral, where in some cases participants are friends or relatives (Brown, 2005). During data collection, some respondents asked their friends and relatives, especially those who were working on the wetlands, to participate in the research. This gave the researcher an opportunity of finding respondents who had experience with wetlands. Convenience and snowball sampling were the most appropriate sampling methods for collecting data from Belvedere and Borrowdale because the population in these two residential areas is hard to reach since one is a low density area (Borrowdale) and the other is medium density area (Belvedere).

Through convenience and snowball sampling, 40 questionnaire respondents were found for Borrowdale and 39 respondents for Belvedere. For interviews, 10 respondents were interviewed for Borrowdale and 12 respondents were interviewed for Belvedere. Two focus group discussions were conducted for Borrowdale and 1 focus group for Belvedere. Few people were selected for interviews and focus group discussions because sample size for qualitative research should be small so that perception on human understanding of wetlands is discovered more easily (Ritchie *et al*., 2003).

4.3 Questionnaire structure

In order to investigate human perceptions and understanding of the functions and values of wetlands, semi-structured questionnaires were distributed to residents of Borrowdale and Belvedere and people found working on the wetlands. The questionnaire was designed in a 5 point Likert scale way in which a tick box method was required. The questionnaire had sections A and B (Appendix 1). The first part of the questionnaire was based on background information of the respondents and therefore asked about gender, age, education qualifications, employment status, type of employment and distance from the wetland. This helped the researcher to have an overview of the type of people the questionnaires were administered to. Gender and age were important to see how human perceptions and understanding of wetlands vary according to gender and age. Education qualification and employment status of respondents were also important since they helped to determine how people with different education qualifications and employment status value wetlands. It was also important to consider where one stays from the wetland to see the catchment areas of the two wetlands. The second part of the questionnaire had both closed and open questions. Closed questions asked respondents to express how they are using wetlands and how they have benefited economically and socially from using wetlands. The questionnaire also asked questions related to environmental benefits and effects of different land use on wetlands. Open questions asked the respondents to express their opinions, views and understanding, allowing unlimited number of answers which could be compared. These included questions on threats to wetland elements, ways of dealing with these threats and ways of conserving and using wetlands in a sustainable way. Asking all these questions assisted the researcher in evaluating human perceptions and understanding of wetland values and functions.

4.4. Interview schedule

In-depth face to face interviews were administered to residents of Borrowdale and Belvedere and people found working on the wetlands. In-depth, face to face interviews allowed the researcher to gather information which was more detailed because of high rate of responses (Kelly *et al*., 2000). The interview schedule had two sections with 28 structured questions (Appendix 2). More questions were asked on the background information for respondents. These included questions about family size, number of children going to school, whether they had a farm or not and whether they were sending children to cultivate the fields. This helped the researcher to evaluate whether the size of the family had an influence on how people used wetlands in different ways. Section B of the interview schedule had different questions which included changes observed on different wetland elements, economic and social pressure, development, and political pressure on wetlands. Different questions in the interview schedule helped the researcher to gather different subjective views from respondents, allowing the researcher to probe more questions of interest. However face to face interviews attract responses which sometimes depart from context since the researcher can devise different ways of probing responses from respondents (Matveev, 2000).

4.5 Focus group schedule

In-depth structured focus groups were administered to Borrowdale and Belvedere residents and wetland users. Focus groups are well planned discussions designed to know about a certain phenomenon in a friendly environment (Kaplowitz, 2001). Focus group discussions used 16 structured questions (Appendix 3). Questions like conflict between different land uses, effects of the spread of the city on wetlands and ways of conserving wetlands were also explored (Appendix 3). Through focus group discussions, the researcher can obtain detailed additional information on human perceptions and understanding about wetlands (Bryman, 2016). The researcher therefore gathered varied information pertaining to perceptions, knowledge and understanding of the importance and value of wetlands.

4.6 Data collection process

4.6.1 Questionnaires, interviews and focus groups

Data for both human (questionnaires, interviews and focus group) and physical environments were collected from 14 August to 2 September 2016. Clarification was required in the vernacular (Shona), since all questions were written in English which some respondents did not understand. A pilot survey was done for all instruments (questionnaires, interviews and focus groups) to test the adequacy of the instruments and eliminate all systematic errors (Teijlingen and Hundley, 2002). A pre-test of the instruments was conducted with friends at University of Witwatersrand before the actual survey. The instruments were pretested on 10 people for questionnaire, 2 people for interviews and one focus group with three females and two males. Some modifications were made based upon the pre-test.

Using both snowball sampling and convenience sampling, 40 questionnaires and 39 questionnaires were administered in Borrowdale and Belvedere respectively. Field work was done between 8 am and 5 pm. This was the time I could meet people on the road, at their homes or working on the wetlands. Respondents for questionnaires, interviews and focus group discussions were first given an information sheet which explains to them the purpose of the research, their right to participate voluntarily without being coerced and their privacy and confidentiality during participation (Appendix 4). Respondents were also given consent forms (Appendix 5) to sign after agreeing to participate in the research. Thus information from Borrowdale and Belvedere wetlands was gathered from willing participants who were not coerced into participation. Some read the information sheet and refused to participate in the research, which was respected. I read and explained the contents of the information sheet in the vernacular to most respondents since they were reluctant to read.

Most of the people I met working on the wetlands referred me to their relatives and friends who were also working on the wetlands. Questionnaires, interviews and focus group discussions were administered concurrently, depending on the willingness of the respondents to agree to participate in any of the three instruments. Questions were explained in the vernacular to most people who did not understand English. Some respondents to the questionnaires answered the questions in Shona and most of the respondents did not want to write on the questionnaires. Most respondents urged me to write on the questionnaire for them since they were cultivating on the wetlands and felt their hands were dirty to handle papers. Some people were just reluctant to write, so I ended up writing their answers on the questionnaire as I asked them the questions orally. Filling up the questionnaire took approximately 10 minutes.

Interviews were administered to 6 males and 4 females (10 respondents) in Borrowdale and 8 males and 4 females (12 respondents) in Belvedere. All respondents were over 18 years of age. Respondents for interviews were also selected through snowball and convenience sampling. Most of these respondents were found working on the wetlands in the morning between 7 am and 11 am and some came in the fields between 3-5 pm. Few people were found on the road and at their homes. Each interview was administered for approximately 20 to 25 minutes. Focus group discussions were administered to people found working on the wetlands. Two focus group discussions were administered to residents of Borrowdale with one focus group having 2 females and 1 male and the other focus group had 3 males only. One focus group with 5 male respondents was administered to residence of Belvedere. Each focus group discussion took approximately between 40 to 50 minutes to administer. Most interviews and focus group discussions were audio recorded with the permission of the respondents. I explained most questions from the interview and focus group schedules to respondents in vernacular before they responded, to make sure that they understood. In some cases where respondents refused to be audio recorded, I jotted down the notes of what respondents were saying during the interview and discussion sessions. Audio recording was important for transcribing and translation since most interviews were conducted in the vernacular.

4.6.2 Wetland delineation and land use mapping

Wetland delineation using a hand held GPS receiver was done in the early hours of the morning and the coordinate points were recorded in the GPS receiver. GPS model e-Trex 20 was used to map wetland extent. Wetland delineation involved moving around the wetland demarcating wetland extent and recording the coordinates. Demarcation of the wetland was identified first by looking at the soils and vegetation. Thus hydrophytic soils and water-loving plants such as reed grass, narrow-leaved cattail and arrow arum were considered to mark the demarcation of the wetlands. An inventory of different land uses was done through transecting across the wetlands, identifying different land uses and then mapping them using GPS receiver and saving the coordinates. Different land uses commonly identified on both wetlands included waste ground, cultivation and buildings.

4.6.3 Collecting soil samples

In order to detect the impacts of different land use on wetlands, the environmental quality of both wetlands was investigated through testing soil parameters. Soil samples were tested for organic carbon content. Soil samples were collected from the utilised parts of the wetlands and the unutilised parts of the wetlands. The utilised parts of the wetlands were shown by different land uses whilst the unutilised parts had no modified or anthropogenic land uses on them. Soil samples were collected to be tested for soil organic carbon content because this helps in classifying the soil and assessment of carbon stores within the soil (Slepetiene *et al*., 2008). Subsurface and surface (2 cm depth) soil samples were collected from utilised and unutilised parts of the wetlands. In total 20 samples were collected from each wetland (40 in total) using the GPS receiver to mark the sites. Soil samples were taken from the ground using a hand garden trowel and were put into sample bags. All soil samples were taken to the laboratory.

4.7 Data analysis

4.7.1 Wetland delineation and land use mapping

GPS points for wetland delineation and different land use were imported from the GPS receiver and saved into the computer. Saved points were imported into Google Earth and wetlands and different land uses were mapped using polygons which were saved as KML files. These KML files were changed from KML to layer in ArcGIS version 10.3 (imported to ArcMap) and maps showing wetland extent and different land uses were produced. Field observations enabled the researcher to take photos and notes from both wetlands as evidence to show different land uses and their effects on wetlands.

4.7.2 Questionnaires

Questionnaire responses were clarified for consistency. Data were entered into an Excel spread sheet for preparation. Subject numbers were provided for the data sets since questionnaires were anonymous. The data were coded, creating item names, and were checked for errors and missing data. The data were imported to SPSS version 23 for logical statistical analysis. SPSS is efficient in analysing statistical data and avoids errors when analysing (Landau and Everitt, 2004). One advantage of SPSS is that it allows understanding of different concepts and materials related to the phenomenon under study, enhancing output interpretation and communication of findings (Weinberg and Abrahamowitz, 2002). Frequency and custom tables with different variables were produced from SPSS. Descriptive statistics were therefore used to draw conclusions from the data. Descriptive statistics helped in summarising and showing what the data look like (Brace *et al*., 2012; Leech *et al*., 2015). Independent and dependent variables were also included in the analysis. Bar graphs, histograms, pie charts and tables were used to present the results.

4.7.3 Interviews and focus group discussions

Each interview and focus group discussion was first transcribed from Shona to English. I listened to all audio recorded interviews and discussions and wrote down everything the respondents were saying changing it from Shona to English. Transcription made it easy to present and analyse data because responses were transcribed to similar language. Content analysis was done for interviews and focus group discussions. Content analysis is a method of analysing textual data through coding raw information collected either through interviews or focus groups (Kondrack *et al*., 2002). Responses for both individual and focus groups were edited for clarity and coded separately. Coded responses from individual interviews and focus group interviews were categorised separately. Relationships between individual interviews responses were identified and explored. Concepts were identified for interviews and focus group responses and relationships between them were explored. Concepts and themes identified from focus groups and interviews were collated with results from questionnaires to evaluate respondents' understanding of the importance and use of wetlands.

Inductive approaches for analysing individual interviews and focus group interviews responses were also adopted by the researcher. The inductive approach includes observation of the responses, drawing the pattern between the observed phenomena and then deriving tentative theories (Thomas, 2006). The inductive approach involved the bottom up approach in which the researcher investigated new phenomena and looked at wetlands with different perspectives from previous research on wetlands. Relevant and significant responses were classified and ideas that made up major themes and sub-themes were also identified and compared.

4.7.4 Soil analysis

In total 40 soil samples from utilised and unutilised parts of the wetlands were taken to the laboratory and air dried for a day on paper plates. Paper plates were used because they are porous and they allow air to enter through, drying up the soil. Each soil sample was crushed using mortar and pestle to separate the soil particles and allow them to pass through a 2 mm sieve. Dry sieving was done on each sample at 0.25ϕ intervals between 2000 and 63 µm. Grain particles from each sieve were weighed on a balance to find the mass of different grain sizes in each sample. The Gradistat software was then used to calculate the mean, skewness and kurtosis and calculate the percentage distribution of different grain size distribution in each size class (Blott and Pye, 2001). The Gradistat analysis package was chosen because it can analyse many samples quickly and allow grain size statistics of these different samples to be compared (Blott and Pye, 2001). The arithmetic method of moments was considered, determining the mean, skewness and kurtosis of the soil samples. An example of the calculations of grain size distribution for one soil sample from Borrowdale utilised part of the wetland (BR unutilised 5) is shown (Appendix 6).

In order to test for organic carbon content in the soil, soil samples were put into porcelain crucibles because porcelain is chemically stable under high temperatures. Empty dry crucibles were first weighed and the weight recorded. Soil samples were put into crucibles and the weight of soil samples plus soil were recorded on a record sheet. The loss on ignition method was used to calculate total organic carbon content in each soil sample. Loss on ignition involves burning the soil under high temperatures. The soil samples were burnt in the furnace for 430°C for 8 hours. Burnt soil samples were weighed and the weight in grams was recorded on the loss on ignition record sheet. Loss in weight for each soil sample was calculated by subtracting the weight of the soil and crucible after ignition from the weight of the soil and crucible before ignition. Combustible organic carbon content % was then calculated by dividing loss in weight of the soil by soil weight and then multiplied by 100. Graphs were used to present data for different grain size distribution of soil samples from utilised part of the wetland and unutilised part of the wetland. Different maps were also created (Chapter 5) to present data on different values of mean, skewness, kurtosis and organic carbon content for soil samples from utilised and unutilised parts of the wetlands.

4.8 Sustainability evaluation

Sustainability evaluation was done qualitatively through assessing human perceptions and environmental impacts of different land uses on wetlands. Sustainability evaluation was determined by comparing benefits of different land uses to people and the load imposed on the ecological quality of the wetlands due to human use (Brown and Ulgiati, 1997). This involves evaluating the interactions among the environmental impacts of different land uses, pressure on environment and perceptions by people. These viewpoints of sustainability gave information about the state of the wetlands, which in turn may allow policy makers and different wetland users to think of ways to sustainably develop or conserve these wetlands (Spilanis *et al*., 2009). Thus environmental sustainability encompasses the capacity of wetlands to sustain important biophysical processes which support plant and animal life (Basiago, 1999). Environmental sustainability theory was therefore derived through looking at economic challenges (for example unemployment) which have caused social problems (poverty) compelling people to turn to wetlands and engage in different land uses, impacting on the environmental quality of wetlands.

4.9 Ethical considerations

Application of ethical principles in conducting the research was done to make sure that participants participate voluntarily. Ethics approval to continue with the research after thorough scrutiny of the research instruments, information sheets and consent forms was granted by the University Ethics Committee (Protocol Number:H16/06/19; Appendix 7). The University Ethics Committee helped me plan the proper of way conducting my research, thereby minimising and eliminating some of the problems. Ethics guaranteed participants' safety, anonymity and confidentiality (Burns and Burns, 2008). Therefore participants were free to be part of the survey or not after reading the information sheets and consent forms. Each instrument had its own information sheet, clarifying the purpose of the study to the participants. Consent forms were also made for participants to sign making sure the research was conducted authentically without forcing participants.

4.10 Limitations of the study

There were a lot of limitations that I encountered during data collection. Most respondents had difficulties in interpreting questions since they were written in English. In order to overcome this obstacle, I explained misunderstood and misinterpreted questions in their vernacular.

During interviews and group discussions, some participants refused to be audio recorded. Notes were therefore handwritten from interviews and group discussions which were not audio recorded. Some participants refused to write on the questionnaires so that I ended up filling up most of the questionnaires as they were giving me their own views and opinions. Some participants urged me to leave them with the questionnaires and collect the next day. Unfortunately most people I left with the questionnaires did not complete them so I ended up collecting them and give them to other participants who were willing to fill up the questionnaires. Some people were not welcoming at their homes and in some cases I was chased by vicious dogs. In order to deal with this problem, I avoided most houses and ended up looking for people working on the wetlands and those I met on the road to participant in the survey.

Data collection was done in August and September amidst protests and political unrest in Harare which made many people become very sceptical of my agenda in collecting data on sensitive wetlands. On 24 and 26 August 2016 there were political demonstrations organised by opposition political parties. This led to intimidation and harassment of people by police from their residential areas soon after the protests. Many people were therefore scared to participate in the surveys. Some people even mentioned that they were scared of being abducted since they thought my research was politically motivated. Political conflicts pertaining land uses on Belvedere and Borrowdale wetlands made them sensitive areas which most people did not want to talk about. Some residents and people who were working on the wetlands thought I was an official from Environmental Management Agency (EMA) who wanted to arrest them for abusing wetlands. Most people who were taking top soil from the wetlands even ran away from me when I tried to talk to them. It took me a lot of time to explain to people what my research was all about since most people thought I was not genuine. It was therefore not easy to convince people that I was doing a research project for Masters. In some cases I ended up showing them my valid school identity card to convince them that I was really a student since some participants asked for it. Snowball sampling was also another appropriate way of dealing with these problems since most participants who trusted and believed me had to refer me to their friends and relative to also participate in the survey. Some participants who were once robbed told me that there were thieves residing in both wetlands and I was therefore scared to move around the wetlands alone. I was therefore compelled to map land uses and collect soil samples within the wetland with the help of two of my sisters.

In this study, only two case studies were used to represent all vleis in Harare. The number of wetlands used might be too small to represent all vleis but only these two were selected due to limited time and resources. The study managed to assess these wetlands which had a lot of land use conflicts and sensitive issues pertaining to their use. To assess the rationale of the study, few people and soils samples were used to investigate approaches used for exploiting wetlands in order to evaluate wetland sustainability. Only 20 samples were collected from each wetland to test for organic carbon content and this might not be a representative of the total area. Therefore, due to limited time and resources research was conducted with most people found working on the wetland and soil samples were collected the similar days when interviews, questionnaires and focus group discussions were administered. If this research is to be carried again in the near future, more time and enough resources (financial) will be required. More time is needed to carry out the study with many wetlands and respondents in urban areas. More time will also be required to collect a lot of soil samples from the wetlands that would have been selected. To collect informative data on more wetlands, research assistants will also be required.

4.11 Conclusions

This study used a mixed method approach to investigate human utilisation and the environmental quality of urban wetlands. Land uses on Belvedere and Borrowdale wetlands were mapped using GIS techniques (with GPS receiver). Different objective and subjective views and opinions were gathered from the human environment through different surveys (questionnaires, interviews and focus groups) administered to participants from Borrowdale and Belvedere residents and wetland users selected through snowball and convenience sampling. Soil and water parameters were tested from the physical environment to have an overview of the environmental quality of these urban wetlands. Environmental sustainability theory was therefore developed through integrating results from human and physical environment. All the research methods worked efficiently in gathering information required to answer the research questions and achieve the objectives of the study. Results for all the data collected using different methods will be presented in the next chapter (Chapter 5).

Chapter 5: Results

5.1 Introduction

This chapter aims at presenting data, to address the objectives and questions of this research. Maps were used to present data collected on wetland delineation and different land uses on Borrowdale and Belvedere wetlands. Descriptive statistics, graphs and tables were used to present results and findings from questionnaires. Content analysis was used to analyse results from individual interviews and focus group discussions. Through content analysis, themes were identified categorised, coded and then collated with results from questionnaires to have an overview of human understanding and knowledge of the importance of wetlands. This was also meant to answer research question 4, addressing human perceptions and understanding of different wetland functions and values as a way of evaluating sustainability. Photographs were also used to present information about different human activities at Borrowdale and Belvedere wetlands. This chapter also presents data on the ecological quality of wetlands from tested soil organic carbon content. Maps, graphs and tables were used to show grain size distribution, grain size mean, skewness, kurtosis and organic carbon content of different soil samples collected from utilised parts and unutilised parts of the wetland.

5.1 Land use mapping

5.1.1 Borrowdale wetland land use

Different human induced land uses were identified on Borrowdale wetlands and these included agriculture (4.4%), building (0.2%), waste dumping (0.01%), and religious practice (0.01%). Natural land use (grassland) covered the greater part of the wetland (95.39%) (Figure 5.1). People have small farms within the wetland with large farms measuring about 50 m by 30 m. In some of the areas with too much water, farmers used the ridge system to grow their crops. Most farmers were using zero tillage to prepare their farms. Apart from agriculture, part of the wetland had construction of tarred roads and houses underway. Borrowdale wetland is also used for waste dumping and different religious practices.

5.1.2 Belvedere wetland land use

Different land uses were identified on Belvedere vlei and these were agriculture (0.6%), waste dumping (0.02%) and building (19.7%). Natural land use (grassland) covered the greater part of the wetland (79.64%) (Figure 5.2). Building was the most common land use in which the Longchen Chinese Mall occupies the greater part of the wetland (Figure 5.2). The mall was built on the wetland (Figure 5.3a, b) and water is being drained from the wetland and impounded into artificial ponds (Figure 5.3c, d) to make sure the buildings are not affected by the water. People had large fields on Belvedere wetland with some measuring 100 m by 60 m and some farmers even use tractors to plough their farms.

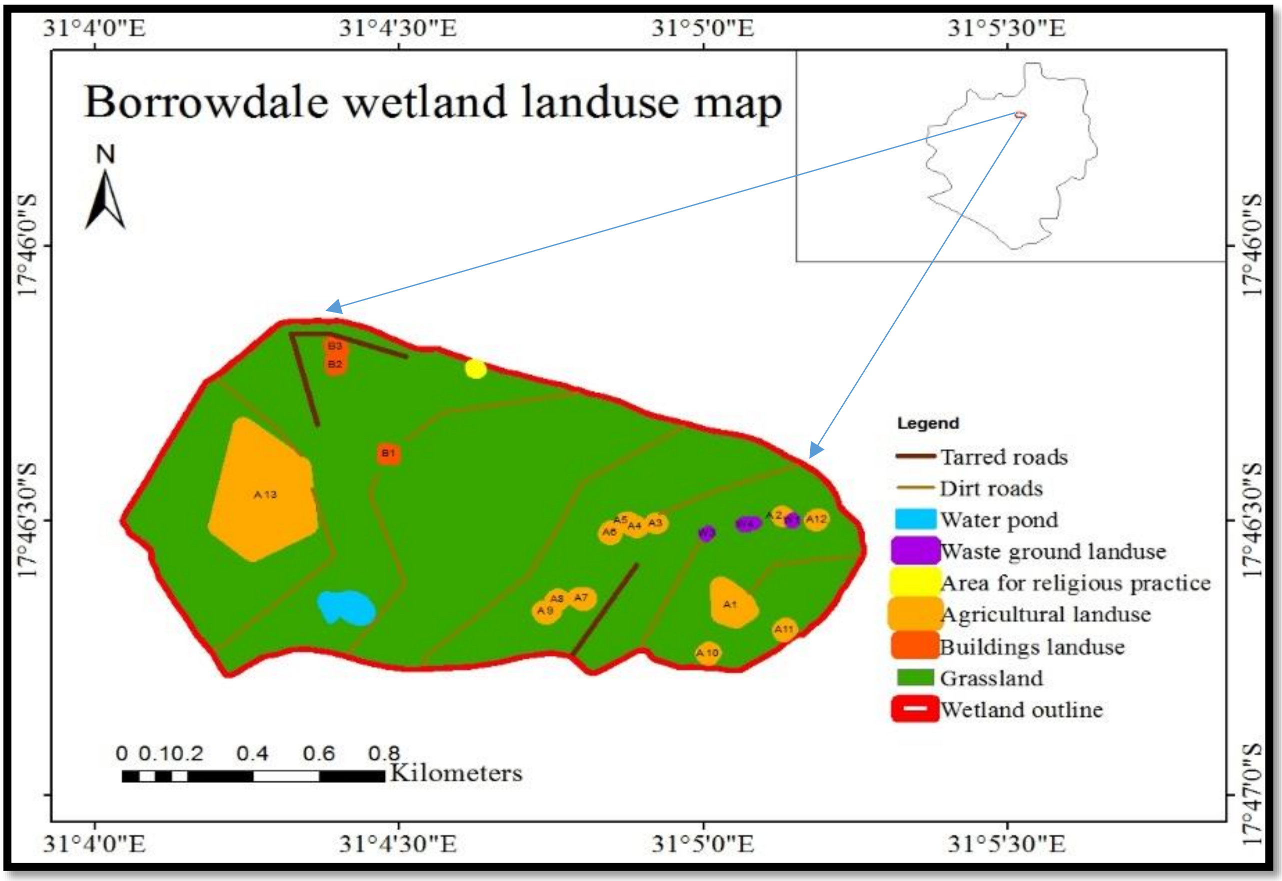


Figure 5.1: Borrowdale wetland land use

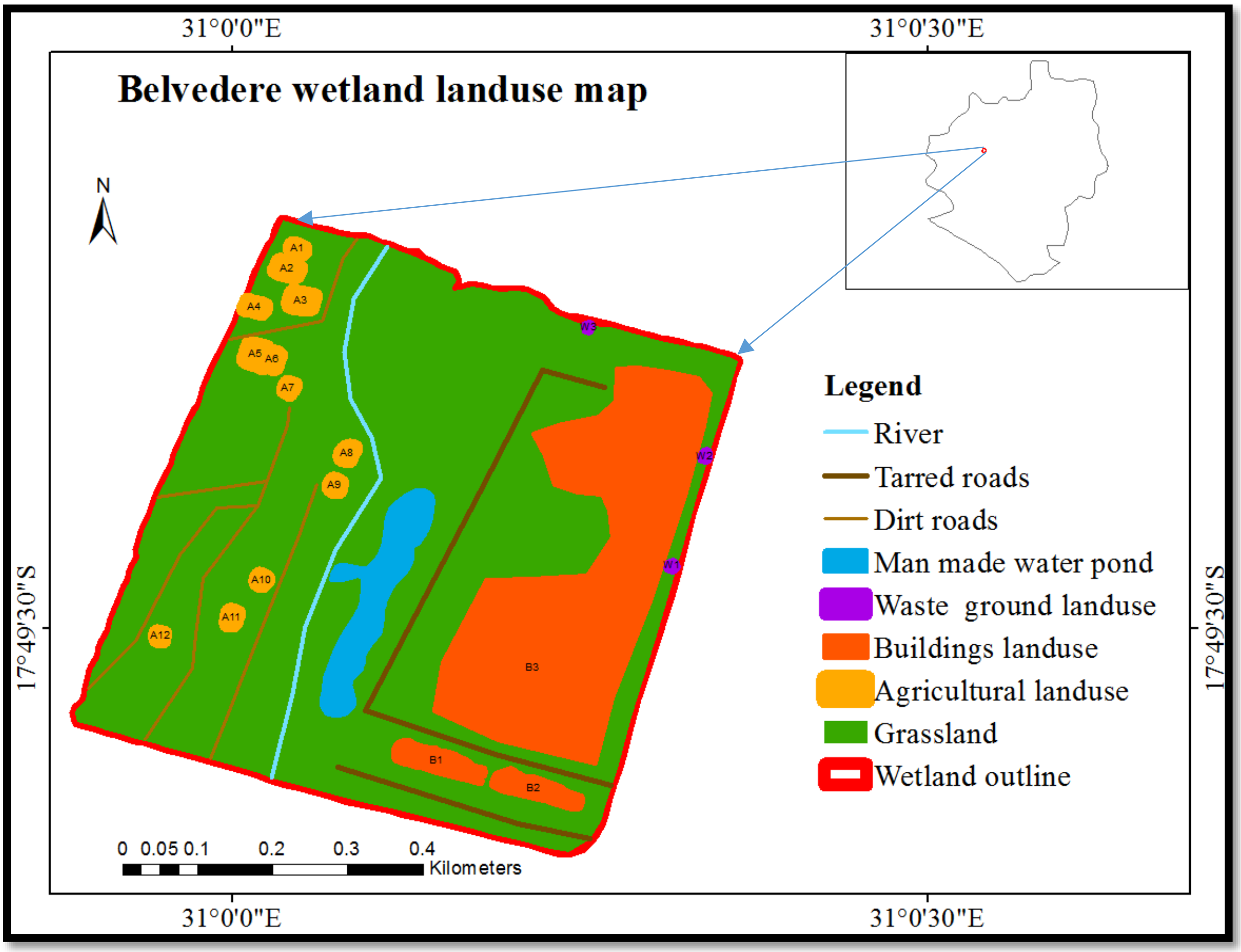


Figure 5.2: Belvedere wetland land use

Figure 5.3: Belvedere wetland photos: (a, b) Longchen Chinese Mall built on Belvedere wetland; (c, d) water drained from the wetland.

5.2. Borrowdale questionnaire, interview and focus group

5.2.1 Age

In total 40 questionnaires were administered to Borrowdale residents and people found working in the wetland. Most respondents were of working age. Only 10% of the respondents were between 46-59 years and none was above 60 years (Table 1). Few people above the age of 60 are still found in urban areas especially in developing countries like Zimbabwe because most have relocated to rural areas after retirement. Respondents included both females (52,5%) and males (47,5%). Individual interviews (10) for Borrowdale were administered to 60% males and 40 % females. Focus group discussions were administered to one group with 2 females and 1 male and the other one with 3 males. All focus groups were administered to people who were found cultivating on the wetland.

Table 1: Respondents' demographic structure

Gender	**Male**			**Female**		
Number of respondents	19			21		
Percentage	47.5			52.5		
Age	**18-25 years**	**26-35 years**	**36-45 years**	**46-59 years**		
Number of respondents	8	14	14	4		
Percentage	20	35	35	10		
Education	**Primary**	**Secondary**	**A- Level**	**Tertiary**		
Number of respondents	1	17	3	19		
Percentage	2.5	42.5	7,5	47.5		
Employment status	**None**	**Employed**	**Self- employed**			
Number of respondents	12	22	6			
Percentage	30	55	15			
Employment type	**None**	**Temporary**	**Permanent**	**Full- time**	**Part- time**	**contract**
Number of respondents	12	2	14	8	0	4
Percentage	30	5	35	20	0	10
Distance from wetland	**Less than a km**	**1-2 km**	**3-5 km**	**More than 5 km**		
Number of respondents	21	8	7	4		
Percentage	52.5	20	17.5	10		

5.2.2 Education level

Education qualifications of respondents to Borrowdale questionnaire ranged from primary to tertiary level. Some respondents had tertiary education qualifications (47.5%), and one person went to school up to primary level only (Table 1). Interviews were administered to respondents with different educational qualifications. Of these, 50% attained secondary education, 20% attained primary and 30% attained tertiary education.

5.2.3 Employment status

Out of 40 respondents, 55% were employed, 15% were self-employed and 30% were not employed (Table 1). Urban wetlands are therefore used by both unemployed and employed people especially for agriculture. Some of the respondents were employed permanently (35%), full time (20%) and some were not employed (30%). Out of the 10 interviewed people, 60% were employed, 30% were unemployed and 10% were self-employed.

5.2.4 Distance from the wetland

People who were using Borrowdale wetland stayed in different areas from the wetland. Most people stayed less than a kilometre from the wetland (52.5%), 20% stayed 2-3 km from the wetland, 17.5% stay 3-5 km from the wetland and only 10% stayed more than 5 km from the wetland. Borrowdale wetland was therefore being used by most people who stayed in Borrowdale. Out of 10 interviewed people, 70% stayed less than a kilometre from the wetland and 10% stayed between 1-2 kilometres, 10 % stayed between 3-5 kilometres from the wetland and 10% stay more than 5 kilometres from the wetland. Most of the Borrowdale interview respondents had farms on Borrowdale wetlands (80%), 10% did not have and 10% had a farm since 2002 but it was taken by the government for housing development. Out of these respondents, 90% had more than one child who needed to be fed and 10% did not have children. Of the respondents, 50% sent their children to cultivate their fields whilst the other 50% did not send their children to cultivate the fields. Most of the interviewed people had one or more children (90%), with one having the biggest family of 5 children. Interviews were also administered to 90% of the people with children still going to school therefore these parents were forced to work in the fields to fend for their children. Most respondents to interviews indicated that they had used the wetland for a year or more (80%), whilst 20% indicated that they have not been using wetlands at all. Respondents had been using the wetland for the following number of years: 12, 23, 16, 12, 10, 24 and 1.

5.2.5 Human perceptions and knowledge about wetlands

People had varied perceptions and knowledge about wetlands (Figure 5.4). Most respondents (78%) disagreed with the view that wetlands are wastelands that should be destroyed. Quite a number (68%), agreed with the fact that wetlands allow mosquito to breed. Some respondents (43%) agreed with the perception that wetlands are dangerous since children can drown and 28% remained neutral on this perception.

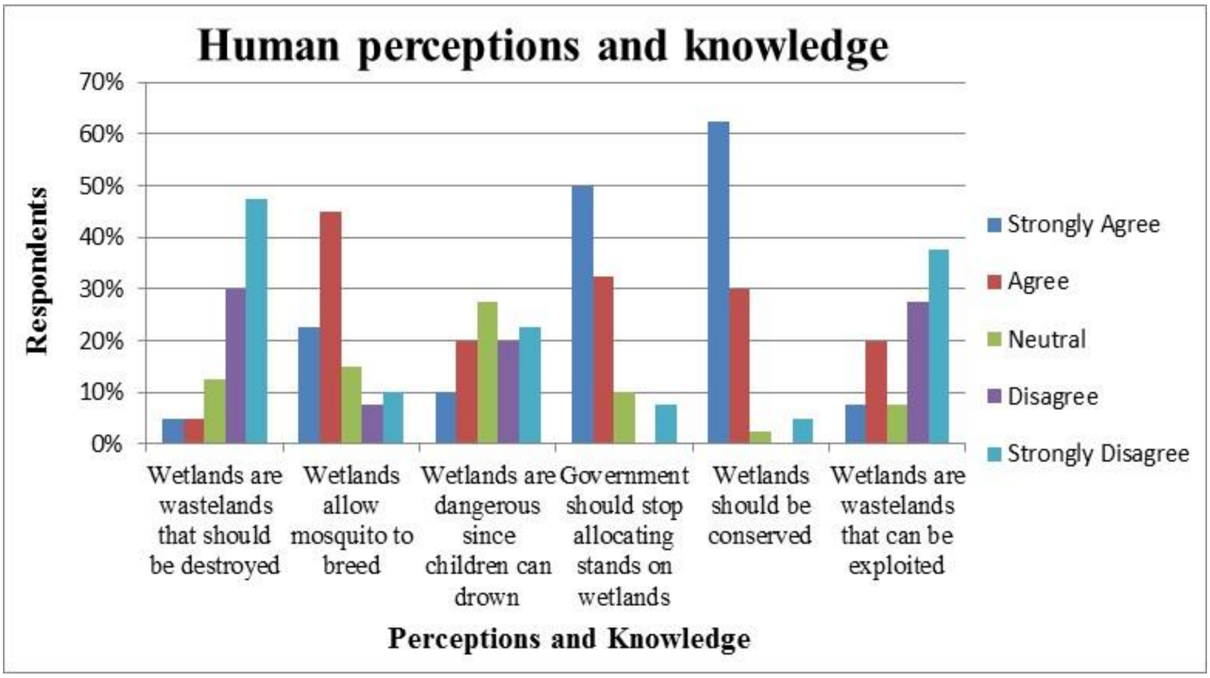


Figure: 5.4: Human perceptions and knowledge about wetlands

Most of the questionnaire respondents argued that government should stop allocating stands on wetlands (83%). One respondent said:

> *Government should stop allocating residential stands on wetlands because only few people benefit. Right now they have allocated part of Borrowdale wetland for residential stands and we do not know where we are going to grow our crops. May you please send our grievances to the government? Please tell them we want to use this wetland to grow our crops so that we can have food. We will die of hunger if they continue using these wetlands for housing development.* (BR respondent 4)

Most respondents agreed with the issue of conserving wetlands thereby appreciating their importance (93%). More so, 66% disagreed with the perception that wetlands are wastelands that should be destroyed. Respondents supported the importance of the continual existence of wetlands and their conservation because they hold water, and that they can continue to grow crops. Existence of wetlands in the future will also allow their children to learn about wetland birds, plants and animals and to have land to grow their crops. One resident who believed that wetlands should continue to exist complained about how destruction of wetlands has given them problems:

> *We are buying water to drink because there is shortage of water and our boreholes are dry because of the construction which started here. The government is cruel because it is selling wetlands to people for developmental purposes. Initial physical town planners left these wetlands because they are waterways. The government is ignorant of the future generation and it's not fair that they are constructing on this wetland without consulting residents of Borrowdale.* (BR respondent 3)

Borrowdale residents, therefore, were against the construction of Pokugara Residential Estate which was underway on Borrowdale wetland. Wetlands like Borrowdale supply water to other surrounding residential areas like Vainona, Elexandra Park, Blantyne, Mount Pleasant, Groombridge, Gunhill and Borrowdale West.

5.2.6 Wetland uses for Borrowdale residents and land use conflict

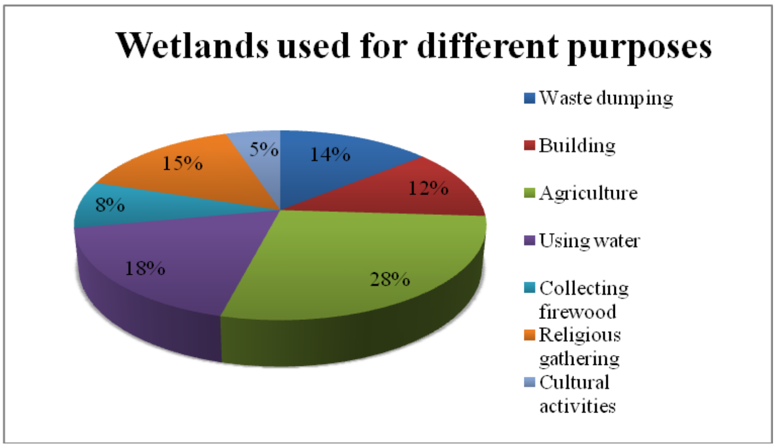


Figure 5.5: Different uses of wetlands

Wetlands in Harare were used for different purposes (Figure 5.5). Despite having 13 respondents using Borrowdale wetland for only one use and three respondents who were not using the wetland at all, the majority (24 respondents) were using the wetland for more than one purpose. For example, 3 respondents were using the wetland for six different purposes and one of these respondents was using the wetland for six purposes mentioned in Figure 7 except for waste dumping. In addition, 7 respondents used wetlands for two different purposes. Out of these 7 respondents one used the wetlands for waste dumping and agriculture. More so, 3 respondents used the wetlands for 5 different purposes, for example one respondent indicated that he was using the wetland for waste dumping, building, agriculture, collecting firewood and religious gathering. Some respondents (7) indicated that they were using the wetland for three different purposes and one of them indicated that she was using wetlands for agriculture, using wetland water and religious gathering. In addition, 4 respondents were using the wetlands for four different purposes, for example one respondent indicated that she was using the wetland for waste dumping, agriculture, building and using water. Residents who were using the wetland for agriculture grew maize, groundnuts sweet potatoes, beans and vegetables mainly for consumption and to sell. Few people use wetlands for cultural activities (5%).

Table 2: Reasons for using wetlands (n=40)

Reason for using wetlands	**% of respondents**
Not using wetlands	7.5
Water availability	37.5
Open and idle space left	35
Close place for dumping	2.5
To get extra income	2.5
Food security and survival	5
There are fertile soils for agriculture	5
For young generations to know their culture	2.5
To alleviate accommodation problems	2.5

Although 7.5% indicated that they were not using wetlands, 37.5% of the respondents chose to use wetlands for agriculture because of the availability of water (Table 2) and 18% of the respondents were also using wetland water for domestic purposes. In giving reasons as to why they use wetlands for agriculture respondents for focus group 2 said:

> *We use wetlands to grow crops because we want to survive. Food is very expensive and we cannot afford to buy it. Besides on wetlands on wetlands there is no open other land in Harare to grow crops. Some parts of wetlands are just idle places so we prefer using them to grow crops to feed our families. We also grow crops on this wetland to clear the land in in order to stop thieves from hiding behind the tall*

grass. Some people have been robbed around this area by thieves who hide in this tall grass. (BR focus group 2)

Some respondents use wetlands because they are the only open spaces left in urban areas (35%) (Table 2). The number of people cultivating wetlands has likely increased due to unemployment and poverty. Absence of enough and reliable rainfall has increased urban agriculture on wetlands since people are guaranteed of good harvests on wetlands. Commenting on this, respondents from one focus group said:

> *The number of people growing crops on this wetland has increased because of hunger and poverty. Many people cannot afford to buy food because they are not employed. We are also not receiving enough rainfall so we can only grow crops on these wetlands and also give our relatives in rural areas because they are also not harvesting much because of these recurring droughts.* (BR focus group 2)

Taking top black soil from Borrowdale wetland to sell has become a source of money for some people. Although government and EMA officials seem to be against the taking of top soil by these people, no action is being taken. One resident pointed out that:

> *We always fight with people who take top soil from our farms. Farmers and the Environmental Management Agency are against these people. We do not like these people because they take top fertile soil from our fields and we will end up growing crops on unfertile soils and this affects our yields. That's why I looked for a new farm near the road because they are scared of taking top soil near the road. The government is not arresting these people and the rate at which we are losing top soil is high leading to land degradation*. (BR respondent 6).

Out of 40 respondents, only 18% use wetlands for waste dumping (Figure 5.6). Failure of the city council to collect refuse forced some people to dump their waste on other people's fields on the wetland because it is near their homes. Dumping waste on wetlands is mostly done at night to avoid being seen.

Figure 5.6: (a) Pit left after soil removal from a farm at Borrowdale; (b) pit left after top soil is taken from an unutilised part of the wetland; (c) rubble dumped on a farm.

Borrowdale wetland has become a sensitive issue because of the political conflict between some politicians and government officials on how to use the wetland. This conflict was confirmed by one resident who said:

> *There were some disagreements among amongst government officials on whether to build on it or not. Part of this wetland was fenced for four years because it had been sold to some foreign investors who wanted to build a mall which Borrowdale residence and Semi levy (1 km) shopping centre businessman lobbed against*. (BR respondent 4)

5.2.7 Economic benefits of wetlands

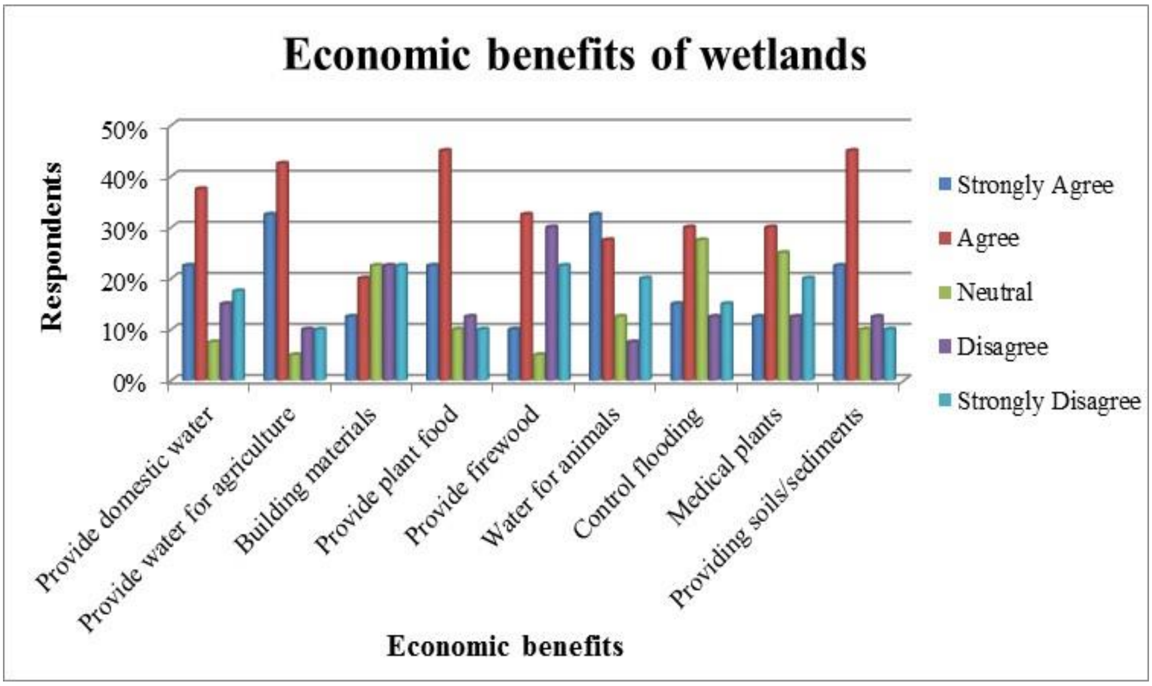


Figure 5.7: Economic benefits of wetlands

Borrowdale residents and people from surrounding areas have benefited economically from using wetlands. Most of the respondents (61%) were getting water to use at home from wetlands (Figure 5.7). Borrowdale Out of 40 respondents, 76% agreed that wetlands provide water for agriculture (Figure 5.7) and most people in Harare rely on wetlands for urban farming. Urban dwellers are benefiting economically in different ways through farming on wetlands. Commenting on the economic benefits of wetlands one farmer said:

> *I harvest a lot of maize for mealie meal on this wetland because there is water. Every year I sent maize to my parents in rural area because there is drought there. I also sell my harvest to pay my children's school fees and buy them clothes. The government should not take these wetland because we are surviving on them.* (BR respondent 4)

Some respondents disagreed with the fact that wetlands provide building materials (46%). Most respondents were in agreement with the fact that wetlands provide plant food (68%). Unique plants are found in the wetland because of fertile soils. Some respondents disagreed with the issue of wetlands providing them with firewood (53%). Observed situation and information from interviews and focus group discussions revealed the absence of trees on the wetland for firewood. There are few trees left on the wetland and most respondents deny collecting firewood from Borrowdale wetland. Most people (61%) agreed to the fact that wetlands provide water for animals. Few animals such as duiker, rabits and snakes were still being found in the wetland. This was evidenced by animal droppings indicating the presence of wild animals which survived in the wetland because of the availability of food and water (Figure 5.8).

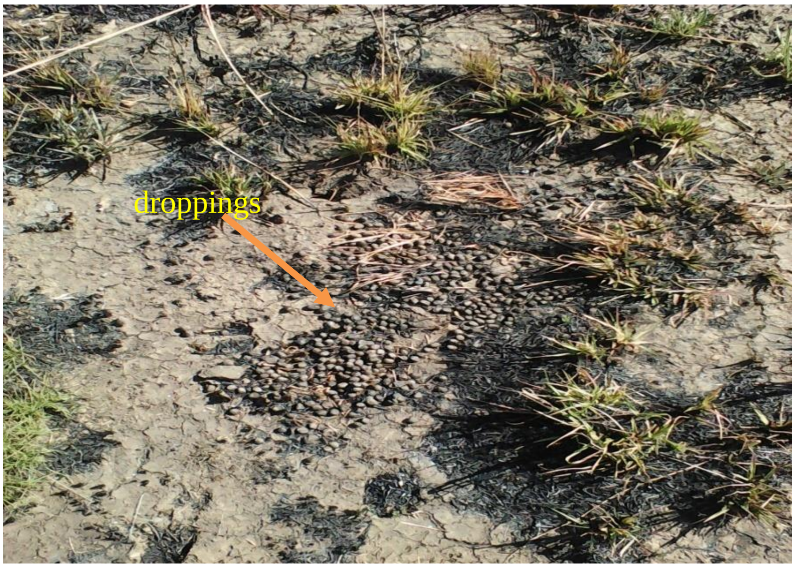


Figure 5.8: Animal droppings

Some respondents agreed with the fact that wetland control flooding (45%) and provide medicinal plants (43%). A lot of respondents (68%) appreciated the presence of soils or sediments in the wetland which some use as lawn manure. Most residents were therefore benefiting economically from Borrowdale wetland in different ways.

5.2.8 Social benefits of wetlands

Borrowdale respondents had varied responses on different social benefits of wetlands. Most respondents agreed with the fact that wetlands are centres of recreation for activities such as wildlife viewing and birdwatching (67.5%) (Table 3). Out of 40 respondents, 62% of the respondents viewed wetlands as centres of learning whereby people learn about birds, animals and plants found in wetlands.

Table 3: Social benefits

Social benefit of wetlands	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Centre of recreation for activities such as wildlife viewing and bird watching	12.5%	55%	5%	15%	12.5%
Centre of learning about birds, animals and plants found in wetlands	11.5%	52.5%	5%	15%	10%
Place were people can stay	2.5%	27.5%	2.5%	35%	32.5%

One interviewed resident supported the idea of keeping wetlands in their natural state. She said:

> *Wetlands like this Borrowdale wetland should not be fenced or destroyed because my children are learning about plants animals and birds found on wetlands. I cannot afford to go and pay at Mukuvisi woodland wetland for my children to see these animals, plants and birds.* (BR respondent 3)

Most respondents (67.5%) disagreed with the view that people can stay on wetlands. Some interviewed respondents argued that people should not build on wetlands since they risk being affected by floods. One focus group said:

> *Houses build on wetlands can drown during flooding. It is also expensive to build on wetlands since special foundations and expensive reinforcement is required.* (BR focus group 2)

Residents argued that the construction of the tarred roads on the other part of the Borrowadale wetland reduced the amount of water in the wetland such that the wetland was drying up and had also led to the loss of the aesthetic value of the wetland.

5.2.9 Environmental benefits of wetlands

Most respondents demostrated that they understood the environmental benefits of wetlands. Most respondents (68%) agreed to the view that wetlands modify climate (Figure 5.9). Moreso, 85% agreed with the fact that wetlands are habitat for plants and animals because they get water and food from the wetlands. Although 48% were of the view that wetlands improve water quality, some respondents were a bit sceptical about this environmental benefit of wetlands and therefore did not support this view (23%) and 30% were also neutral about this view (Figure 5.9). Most respondents (75%) agreed with the fact that wetlands enhance groundwater (raise the level of water underground). Residents in Borrowdale west have boreholes which draw water from underground recharged by wetlands.

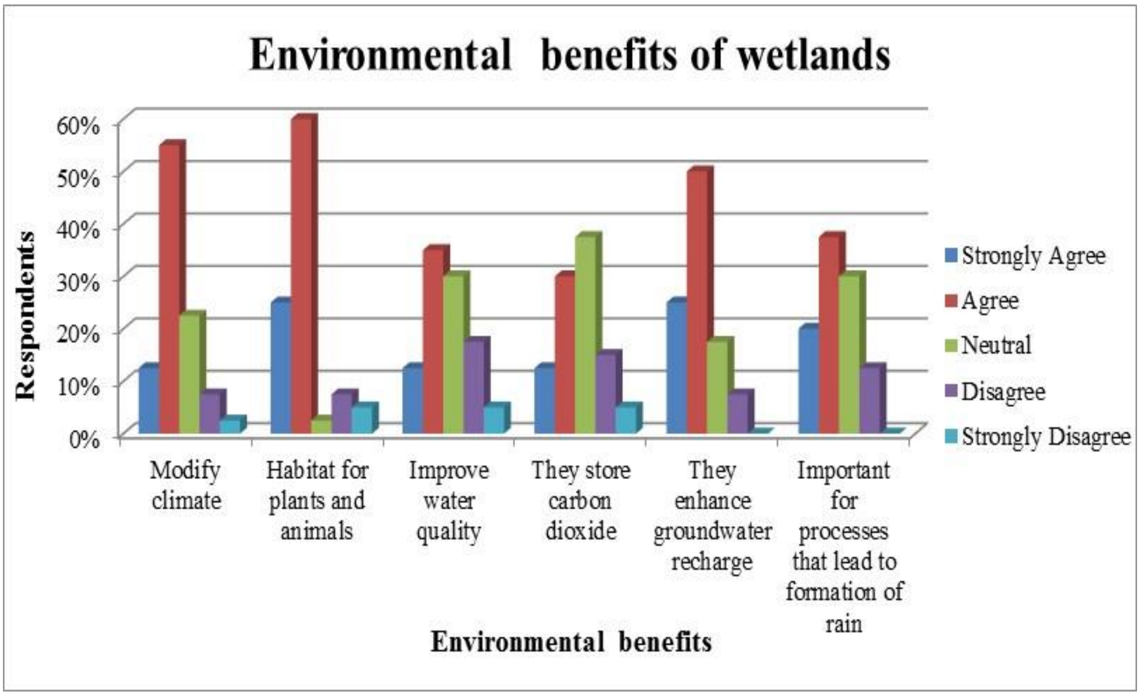


Figure 5.9: Environmental benefits of wetlands

5.2.10 Effects of different landuses on wetlands

Different landuse on wetlands such as agriculture, waste ground and building have different impacts on wetland elements. Although respondents had different views about effects of different landuse on wetlands, most of them agreed to their negative impacts (Figure 5.10). This is shown by the number of respondents who agreed; waste dumping pollutes wetland water (88%), cultivation on wetlands causes soil erosion (68%), building houses and cultivation destroy habitats for animals (76%), birds have migrated since houses were built here (73%), wetland soils loose fertility due to cultivation (75%), some species die due to waste dumping on wetlands (88%), wetland cultivation destroys the beauty of wetlands (88%), building houses on wetlands destroys the soil quality of wetlands (68%). Although people continue to use wetlands, they are aware of the different negative effects different landuses have on wetlands as indicated above. Besides pollution from waste dumping, blockage and bursting of the sewer pipes and manholes aligned in the wetland also pollute the wetland water and soil. One interview respondent had this to say about pollution on the wetland;

> *We have complained several times to the city council about the sewage system which is always bursting on this wetland, but no action was taken. The sewage is polluting the wetland water. The city council should do something about this issue.* (BR respondent 5)

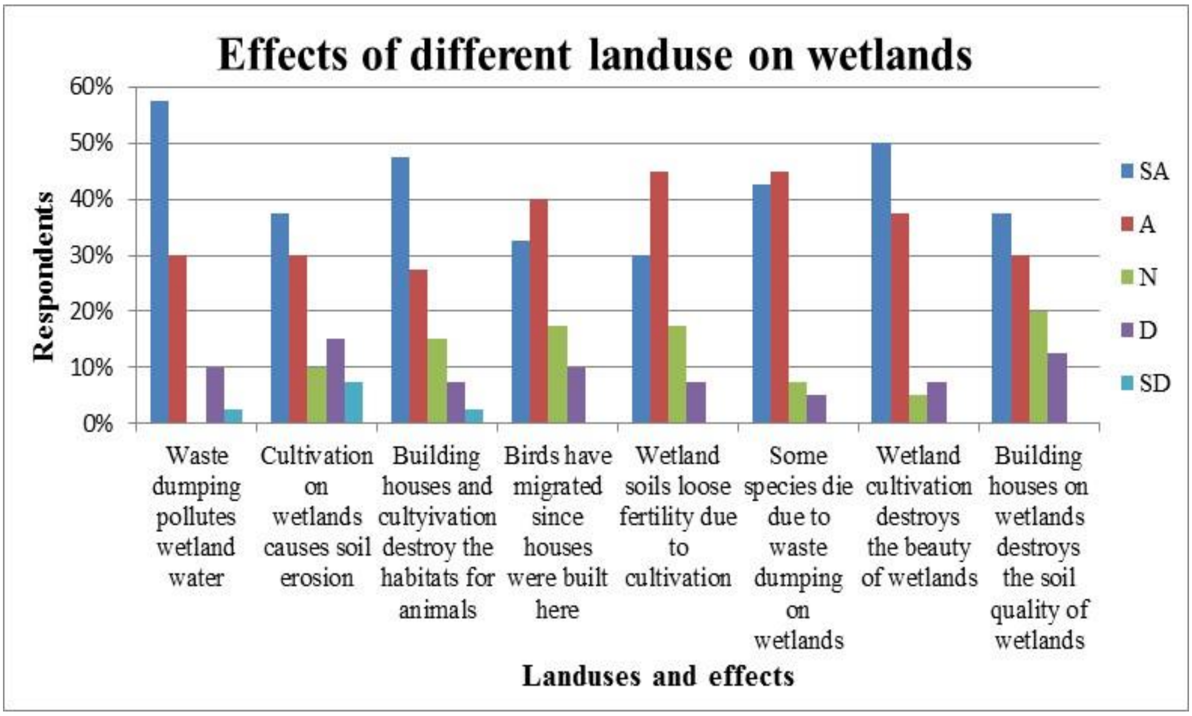


Figure 5.10: Effects of different landuse on wetlands

Cultivation had also serious negative effects on wetlands such that one farmer had this to say;

> *I abandoned my old farm which I started using in 2000 and I looked for a new farm because the soil was no longer fertile and my harvest had just deteriorated. Vegetation is becoming less and we no longer see some plants and flowers we used to see in this wetland and new plants have emerged* (BR respondent 3).

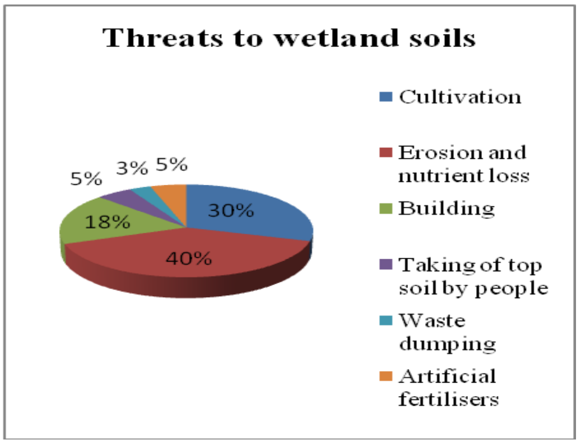
Although urban wetland users agreed to the view that cultivation can destroy wetlands, but most of them argued that it was better if they could be allowed to continue using wetlands for agriculture than the government allowing people to build on them. One farmer said;

Housing development on this wetland is dangerous since water is being drained and the wetland is drying up. It's better we use them for agriculture. (BR respondent 9)

5.2.11 Threats to wetland elements

5.2.11.1 Threats to wetlands soils and water

Respondents mentioned different threats to wetland soils (Figure 5.11a). Some respondents (40%) identified erosion and nutrient loss as the major threat mainly caused by cultivation (30%) which loosen the soil making it unfertile and dry.



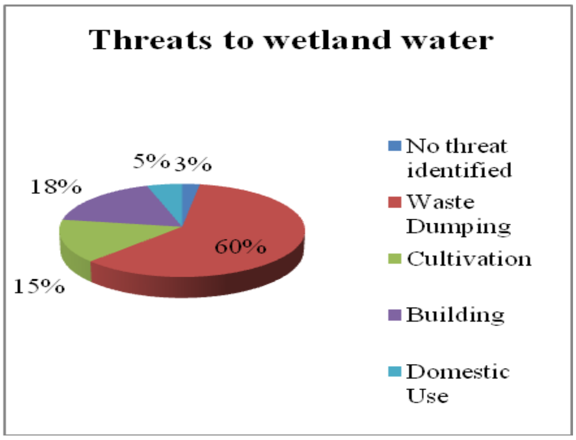


Figure 5.11: (a) Threats to wetland soils, (b) threats to wetland water

Different threats to wetland water were also identified by respondents (Figure 5. 11b) waste dumping was identified as the main threat to wetland water (60%) because it pollutes water. Building (18%) also threatens wetland because of the concrete surfaces which destroy the wetland's natural ecosystem balance. Boreholes drilled in Borrowdale West have also affected wetland water. One focus group said:

Most boreholes in Borrowdale West are taking water from this wetland and this has lowered the water table and affected amount of water in this wetland. We never used to grow crops on this wetland because there was a lot of water. (BR focus group 1)

Different human activities have caused deterioration of wetland water levels (Figure 5.11b). Some parts of the wetland have dried up and surface water is only available in the low lying areas of the wetland during the dry season (Figure 5.12).

Figure 5.12: a and b) drier part of the wetland, c and d) wet part of the wetland

This has also affected groundwater recharge. One respondent commented on how human utilisation has affected wetland water:

> *I started using this wetland in 2004 and it was difficult to walk around the wetland and worse to try to cultivate soon after the rains because of too much water (waterlogging) around the whole wetland. But nowadays there is little water available on this Borrowdale wetland.* (BR respondent 2)

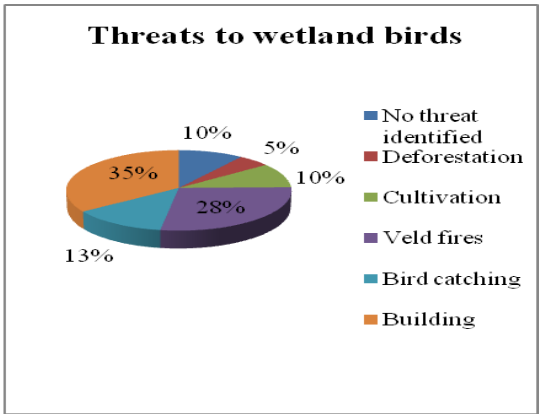
Some of the most disturbing threats to wetland elements are shown in Figure 5.13.


a
c
d
f
g
h

Figure 5.13: Wetland threats: (a) pits left after removal of top soil; (b) waste dumping; (c) squatter homes; (d) housing development; (e) tarred road 2 m deep and land cleared for housing development; (f) borehole installed at a housing stand; (g) pollution from burst sewer and waste dumping; (h) sewer manhole; (i, j) cultivated land; (k) soil taken from wetland for lawn manure; (l) part of the wetland affected by veld fires and waste dumping.

5.2.11.2 Threats to wetland birds and animals

Most respondents indicated building (35%) as the main activity that threatens wetland birds (Figure 5.14a). The use of noisy machines such as bulldozers scares away animals and destroy their habits and some birds and animals have since migrated from Borrowdale wetland. One farmer pointed out that only three duikers were left in Borrowdale wetland and the rest have since migrated and some killed. Some people also catch birds (13%) for their meat and therefore reducing their numbers (Figure 5.14a).



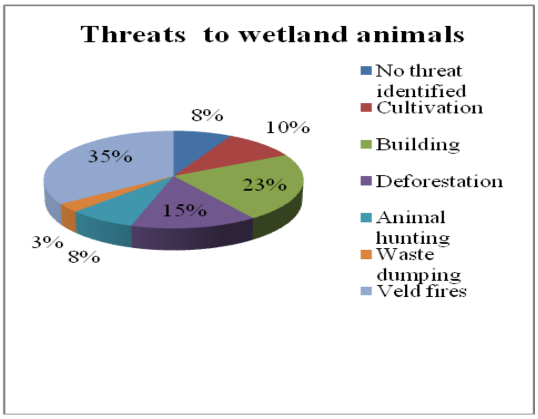


Figure 5.14: a) threats to wetland birds, b) threats to wetland animals

Although cultivation (10%) was identified by some respondents as a threat to wetland birds, some farmers argued that most birds survived on their crops. However cultivation on wetlands has more harm than good as habitats for birds are destroyed in the process. Most farmers burn vegetation to clear their farms and kill some animals caught unawares in the process, thus veld fires (35%) (Figure 5.14b) threatens the lives of many wetland animals. One interview respondent had this to say pertaining to wild animals:

> *We no longer see most of the wild animals we used to see on this wetland. There are few snakes and hare left. There used to be a lot of duikers on this Borrowdale wetland but now we only see three duikers. Some animals have been hunted and some have since migrated because of human activities such as deforestation, cultivation and building* (BR respondent 5).

5.2.11.3 Threats to wetland vegetation

Different human activities threaten wetland vegetation and amongst these, cultivation (25%), threatened wetland vegetation most (Figure 5.15). People clear land to grow their crops leaving wetlands bare (Figure 5.16).

Deforestation (2%) and veld fires (15%) destroy vegetation and lead to changes in wetland ecosystems. Different human activities have therefore modified wetlands. Commenting on the changes they observed one group said:

> *People are taking topsoil and some anthills have disappeared. Some people are cutting down trees to grow crops and build houses and there are few trees left. There*

is also little water in this wetland. The wetland is drying up. When we started using this wetland in 2000 some squatters used to come to do their laundry here because there was a lot of water but now they are not coming because of little water. (BR focus group 2).

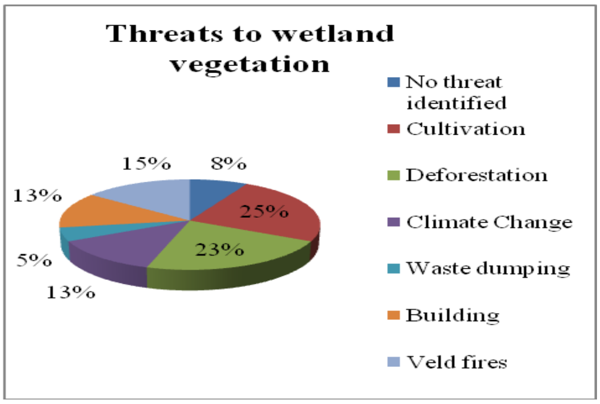


Figure 5.15: Threats to wetland vegetation

Figure 5.16: Part of Borrowdale wetland being cleared for agriculture

5.2.12 Effects of climate and climate change on the wetland

Borrowdale wetland has been affected by changes in climate**.** Commenting on the effects of climate change on wetlands, one respondent said:

Rainfall is no longer reliable and sometimes we receive very little and sometimes more than what we would expect. Sometimes we experience high temperatures. Since

2015 the meteorological department has been warning people about heat waves. Some wetland plants are drying up as a result of excessive heat. (BR respondent 8)

5.2.12 Ways of dealing with different threats to wetland elements

Some respondents indicated that there were not sure of what should be done (7.5 %) to deal with the different threats to wetland elements (Table 4). However, most respondents had similar perceptions on the need for policy and legislation implementation (75%). Respondents expressed the view that the city council should send people to protect wetlands and stop people from dumping waste. Some respondents argued that the government should have knowledge about the importance of wetlands so that they value them and stop allocating people stands on wetlands.

Table 4: Ways of dealing with threats to wetland elements

Ways of dealing with the threats	% of respondents
No idea	7.5
Policies and legislation implementation and enforcement	75
Educating people on the importance of wetlands and how to use them	10
Fencing them for protection	7.5

Some respondents suggested that residents of Harare should support the lobbying groups, lobbying against building on Borrowdale wetland. Issues pertaining to Borrowdale wetland have become so controversial and political such that residents lobbying against building on the wetland are not listened to by relevant authorities. Few respondents (10%) suggested that people should be educated on the importance of wetlands and how to use them (Table 4). Most respondents therefore pointed out that the government should act first to deal with these threats. One farmer pointed out that in 2000 there was a sign which prohibited people from dumping waste and cultivating on the wetland, but these signs have since been removed. Some respondents blamed the Harare city council for not monitoring the wetlands and one respondent on this issue said:

We once called the Environmental Management Agencies (EMA) to come and arrest people who were taking top soil but they did not come. They gave us their phone *numbers to report people who take top soil, dump waste and start veld fires but they don't act when we tell them. I want to protect and conserve this wetland, but, I don't have powers to stop people from people from abusing the wetland.* (BR respondent 3)

Some respondents indicated that they were aware of laws that guard against wetlands (41%). Although 48% of the people who responded to the questionnaire indicated that there is information given to them about wetlands, one respondent expressed his concern about lack of knowledge amongst other people who use wetlands:

There is serious lack of knowledge. I have always heard and read about the noise surrounding wetlands in Harare but no one has explained to me their purpose. Information about wetlands is still sketchy and the general public need to be informed about the importance of wetlands. (BR respondent 1)

5.2.13 Knowledge about laws and information that guard against wetlands

Out of 40 respondents, 45% indicated that they were aware of laws that guard against wetlands. Pertaining to information about wetlands, 60% indicated that there was no information given to them about wetlands.

5.2.14 Sustainable wetland use and conservation

Although respondents suggested different ways of using and conserving wetlands sustainably (Table 5) most of them blamed the government for not spearheading sustainable wetland use and conservation. Respondents felt that the government has a greater role to play in making sure that wetlands are used and conserved sustainably. Some respondents (40%) suggested that for wetlands to be used sustainably they should be fenced and used as recreational parks (Table 5). However, some respondents pointed out that fencing the wetlands will not solve the problem because:

Most young people here are not employed, so they will end up stealing the fence. If they put a fence around this area they should make sure that they also assign people to guard the fence. The other part of the wetland was once fenced but the fence was all stolen. (BR focus group 2)

Respondents also emphasised the importance of law enforcement and implementation in both using and conserving wetlands sustainably (25%). In suggesting challenges met in trying to use wetlands sustainably one group said:

> *As farmers we can use sustainable methods of farming such as applying organic manure. Those in power should impose laws and teach people how to use wetlands sustainably. Unfortunately these politicians are very greedy and they are taking wetlands and abuse them. We do not agree as farmers on which sustainable farming methods to use when growing our crops. We also don't know some of these sustainable farming methods. We want someone to teach us good farming methods but we do not want people from the government to teach us because they are corrupt. On one wetland in Chisipite here in Harare, farmers were given fertilisers by the government. Instead of teaching us sustainable farming methods the government (under ZANU PF) can lure us to vote for them by giving us fertilisers. It is better to be taught sustainable farming methods by people from seeds companies like Seed Co. Since they would want us to advertise their seeds, they can plough and give us seeds free of charge.* (BR focus group 1)

Table 5: Ways of using and conserving wetlands sustainably

Ways of using wetlands sustainably	**% of respondents**
No idea	5 %
Laws and legislation implementation and enforcement	25 %
Fence them and protect them to use as recreational places	40 %
Sustainable farming methods	20 %
Educating people on how to use wetlands	10 %

Some respondents (20%) were of the view that people should be taught to use sustainable farming methods (Table 5) such as zero tillage, use of organic fertilisers and crop rotation. Commenting on sustainability wetland use, one interview respondent said:

> *I think sustainability wetland use is not easy in Harare. We have different players with different agendas. People are not pulling in the same direction when it comes to sustainable wetland use and conservation of wetlands. We have the city council*

which want to address housing need at the same time conserve the wetlands. The environmentalists such as Environmental Management Agency (EMA) are advocating for wetland conservation at the same time people want to survive on these wetlands. There is too much pressure pertaining to these wetlands therefore it is difficult for wetlands to be used sustainably since the general public, city council and the (EMA) are not agreeing on how they should be used sustainably. (BR respondent 1)

5.3 Belvedere questionnaires, interviews and focus group data presentation

5.3.1 Age

Respondents to questionnaires in Belvedere included people of different ages and employment status who use wetlands in different ways (Table 6). Interviews in Belvedere were also administered to people of different age groups and these included 2 people above the age of 60, of which one male started using the wetland in 1978 for crop production. One focus group discussion of five males was also administered to people of Belvedere. Interviews were also administered to males (66.7%) and females (33.3%).

5.3.2 Education

Questionnaires were administered to people with different education qualifications. Although quite a number of respondents went to school up to tertiary level (43.6 %), some did not go to not go to school at all (2.6%) (Table 6). Interviews were also administered to respondents who had different education qualifications. Among these , 8% did not go to school, 17% went up to primary level, 67% up to secondary, 8%, went up to A level and none went up to tertiary level.

Table 6: Demographic characteristics of respondents to Belvedere questionnaires

Gender	**Male**			**Female**		
Number of respondents	25			14		
Percentage	64.1			35.9		
Age	**18-25 years**	**26-35 years**	**36-45 years**	**46-59 years**	**60 +**	
Number of respondents	7	13	9	8	2	
Percentage	17.9	33.3	23.1	20.5	5.1	
Education	**None**	**Primary**	**Secondary**	**A- level**	**Tertiary**	
Number of respondents	1	2	16	3	17	
Percentage	2.6	5.1	41	7.7	43.6	
Employment	**None**		**Employed**	**Self employed**		
Number of respondents	10		23	6		
Percentage	25.6		59	15.4		
Type of Employment	**None**	**Temporary**	**Permanent**	**Full-time**	**Part-time**	**Contract**
Number of respondents	10	1	11	10	3	4
Percentage	25.6	2.6	28.2	25.6	7.7	10.3
Distance from wetland	**Less than a km**	**1-2 km**		**3-5 km**	**More than 5 km**	
Number of respondents	8	12		3	16	
Percentage	20.5	30.8		7.7	41trar	

5.3.3 Employment

Although most respondents to Belvedere questionnaires were employed (59%), there were some who were not employed (25.6%) (Table 6). For interviews, 41.6% were unemployed, 41.6% were self-employed and 17% were employed. Wetlands in Harare are therefore used by both employed and unemployed people.

5.3.4 Distance from the wetland

Out of the 39 respondents to questionnaires, 41% stayed more than 5 km from the wetland (Table 6). Out of 12 respondents to individual interviews, 75% stayed less than a kilometre from the wetland, 8% stayed between 1-2 km from the wetland and 17% stayed more than 5 km from the wetland. All respondents to interviews had one child or more with the biggest family having five children. Some children from the 12 families were still going to school (67%). Out of 12 interview respondents, 42% had farms on the wetland and 58% who did not have farms failed to secure land for farming on the wetland after all the farms were taken. Interviews were also administered to some wetland users who had started using wetlands since 1972 and 1978, whilst some had used the wetlands for different length of time; 25, 5, 2, 6, 3 and 4 years. People came as far as Norton (40 km), Kambuzuma (5 km), Warren Park, (2 km) Mabvuku, (21 km) and Budiriro (8 km) to grow their crops on Belvedere wetlands.

5.3.5 Human perceptions and knowledge on wetlands

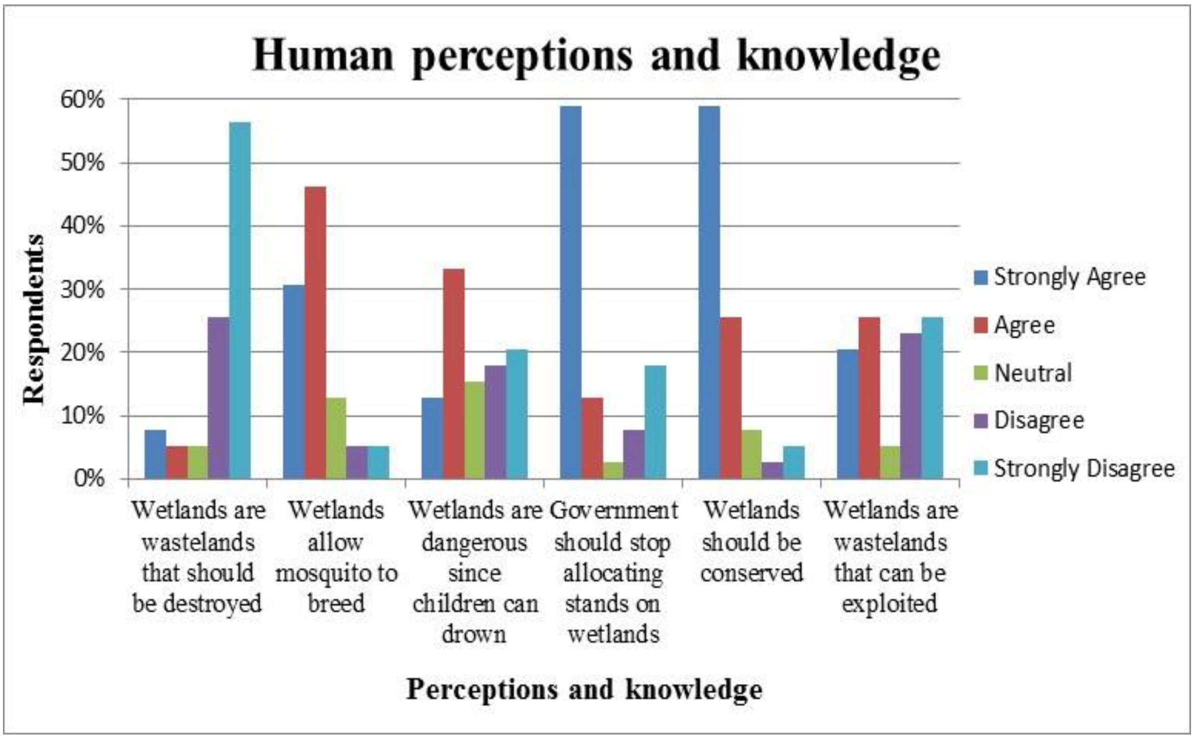


Figure 5.17: Human perceptions and knowledge about wetlands

Respondents had varied perceptions and knowledge about wetlands. Most respondents (82%) disagreed with the fact that wetlands are wastelands that should be destroyed (Figure 5.17). In support of this view, one interview respondent had this to say:

> *Wetlands should not be destroyed because they provide us with fresh air to breathe, allow our children to learn about different animals and plants and they also habitat homeless people.* (BV respondent 1)

Some respondents agreed with the fact that wetlands allow mosquito to breed (77%), and 46% supported the perception that wetlands are dangerous since children can drown (Figure 5. 17). Some respondents who commented on how dangerous wetlands are said:

> *Poisonous animals like snakes can be found on these wetland. Thieves can also hide in these wetlands and attack people at night.* (BV focus group 1)

Most respondents supported the view that government should stop allocating stands on wetlands (72%). Most respondents showed that they supported the conservation of wetlands (85%) and 49% disagreed with the view that wetlands are wastelands that should be exploited.

5.3.6 Wetland use and land use conflict

Belvedere wetland is used for different purposes by people from different areas (Figure 5.18). There has been conflict between different land use and interest of different stakeholders on Belvedere wetlands.

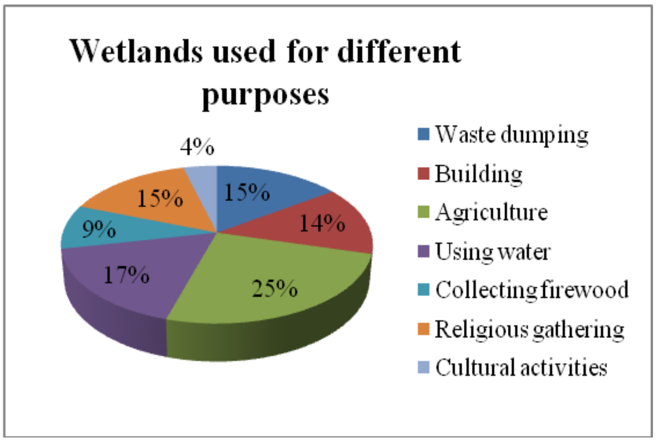


Figure 5.18: Wetlands used for different purposes

Although most respondents indicated that they were using Belvedere wetland for agriculture, some respondents were using the wetland for more than one purpose. Thus, out of 39 respondents, only 12 were using the wetland for one purpose and 27 were using it for more than one purpose. For example three people indicated that they were using the wetland for all the seven different purposes mentioned in Figure 5.18 (waste dumping, agriculture, building, using water, collecting firewood religious gathering and cultural activities). A further three people indicated that they were using the wetland for 6 different purposes and two of them were using the wetland for all the different purposes shown in Figure 5.18, except for cultural activities. More so, out of 39 respondents, 6 were using wetlands for 2 different purposes, 8 for 3 different purposes, 3 for 4 different purposes and 3 for 5 different purposes. Respondents had different reasons for using the wetland for agriculture such as availability of water (33%), fertile soils (3%), need for food (10%) and that it is the only open and idle land left (33%) (Table 7). Some respondents indicated that they were using wetlands to dump waste (15%) because of the failure by the city council to collect refuse regularly. Few people still use wetlands for cultural activities (4%).

Table 7: Reasons for using wetlands (n=39).

Reasons for choosing to use wetlands	**% respondents**
Not using wetlands	5
Water availability	33
Food security	10
Collect firewood because there is no electricity	3
Only open and idle space left	33
Fertile soils	3
No refuse collection by city council	8
Land was allocated to me by the government	5

Respondents who indicated that they have used the wetland to build their house (14%), (Figure 5.18), blamed the government for allocating them housing stands on wetlands (5%) (Table 7). Some interview respondents indicated that they get worms to sell to fisherman from the wetland and they also catch birds, rabbits and mice to eat, because these are the only places in urban areas where these creatures are still found.

Respondents indicated that there was conflict between wetland users, non-wetland users and the government. Most people who cultivated on Belvedere wetland were from other locations and some Belvedere residents complained about cultivation on the wetland, arguing that people were destroying the aesthetic value of these wetlands. When part of the wetland was sold to the Chinese by the city council to build the mall, most people lost their fields and the government continued selling the remaining part the wetland for housing construction. One farmer who complained about government’s actions said:

> *I don't have enough money to buy food so I get money from selling these fishing worms. Please send our grievances to the government. We are not consulted when the government is taking our fields for construction purposes. We know the land belongs to them, but we also want to be consulted because this year they have just stopped us from growing on this wetland. They have sold part of this wetland for building purposes and the wetland is going to be destroyed*. (BV respondent 2)

Selling of the wetland by the city council for building the mall was seen by residents as a political issue since the Environmental Management Agency (EMA) failed to convince the government to stop allocating the wetland for developmental purposes. Respondents also indicated that there was conflict between farmers and those people who were taking top soil from their farms. Wetlands have become a political and sensitive issue which most respondents were even scared of discussing. One respondent was therefore reluctant to give enough information in responding to the question of developmental and political pressure on Belvedere wetland. He stated that:

> *I don't want to say much about this because it is sensitive. I can't comment on this issue. I can only tell you that EMA had stopped the Chinese from building the mall on this wetland but the government intervened and the mall was built.* (BV respondent 7)

Another respondent who felt that Harare city council was being insensitive and inconsiderate by allocating wetlands for developmental purposes also aired his sentiments:

> *The government is greedy. This area used to be a very nice place. There are selling this wetland for building purposes because they want money and we will not all benefit.* (BV respondent 4)

However, some respondents were moved by the way wetlands like Belvedere were abused and degraded, and one respondent said:

> *I only wish these wetlands were enough to distribute them equally among families so that each family will look after its own wetland. People are destroying these wetlands and future generations will not see them. The government should do something before it's too late.* (BV respondent 12)

5.3.7 Economic benefits of wetlands

Respondents to Belvedere questionnaires, interviews and focus group discussion demonstrated how they benefited economically from using wetlands. Some respondents appreciated the fact that wetlands provide domestic water (62%) (Figure 5.19).

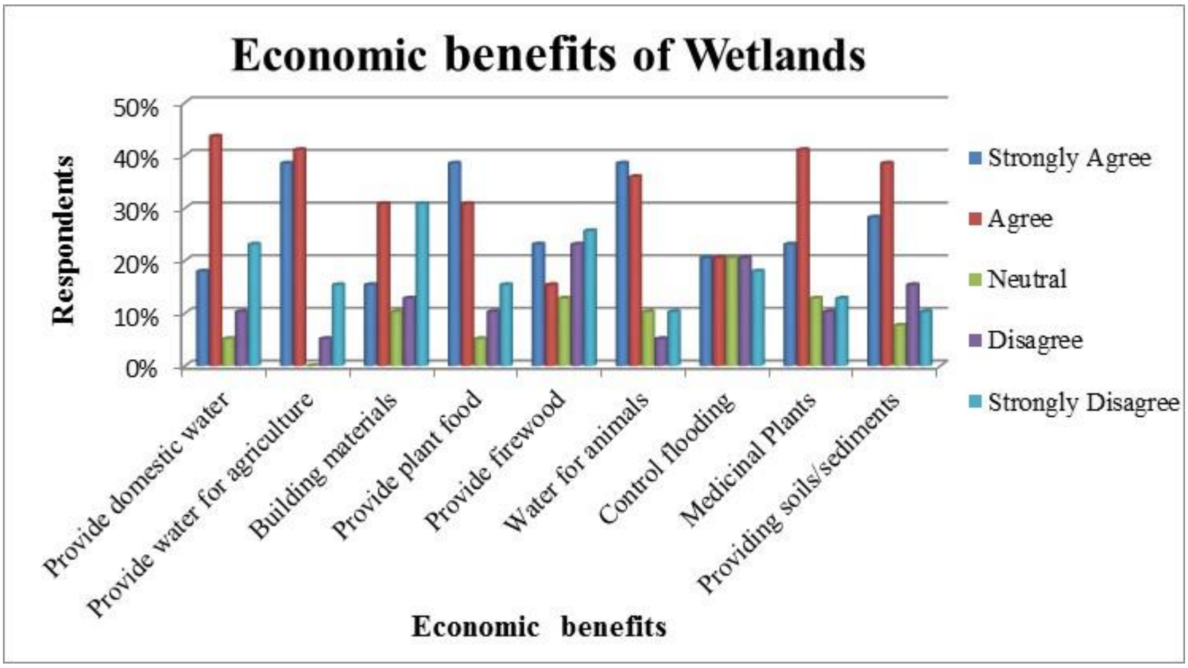


Figure 5.19: Economic benefit of wetlands

Most respondents (79%) supported the view that wetlands provide them with water for agriculture (Figure 5.19). Because of this, most respondents pointed out that they use the Belvedere wetland mainly for agriculture. One respondent said:

> *We grow crops such as pumpkins, bananas, beans, maize, sugarcane and a variety of vegetation for consumption and to sell* (BV respondents 1, 2 and 3)

Some respondents also indicated that they were getting reeds and natural vegetables one respondent commented on this:

> *We also get reeds to make mats to sell from this wetland. During the rainy season a unique natural vegetable called water curse (Kasunika in Shona) grows on this Belvedere wetland. A lot of people sell this vegetable to the Indians who stay here in Belvedere because it is one of their favourite vegetable.* (BV respondent 3)

Some respondents (46%) agreed with the fact that wetlands provide them with building materials and 69% also supported the view that wetlands provide plant food (Figure 5.19). Although some respondents (38%) agreed with the fact that wetlands provide them with firewood, others dismissed this economic benefit (49%) mainly because they are few trees left on the wetland. Most trees were cut down for firewood leaving the wetland bare. Most respondents (74%) agreed with the fact that animals get water from the wetlands and 42% supported the view that wetlands control flooding. In addition, 64% agreed with the view that they get medicinal plants from wetlands and 66% also supported the view that wetlands provide soils.

5.3.8 Social benefit of wetlands

Apart from benefiting economically, residents indicated that they were also benefiting socially from Belvedere wetlands. Most respondents agreed with the fact that wetlands are centres of recreation (61.5%), where people can view wild animals and birds and 74.4% of the respondents supported the fact that wetlands are centres of learning about birds, animals and plants found in the wetland. However some people (48.7%) disagreed with the fact that wetlands are places where people can stay (Table 8). Some people were therefore against building on wetlands.

Table 8: Social benefits of wetlands

Social benefits	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Centre of recreation for activities such as wildlife viewing and bird watching	33. 3%	28. 2%	7.7%	15.4%	15.4%
Centre of learning about birds, animals and plants found in wetlands	35.9%	38.5%	5.1%	12.8%	7.7%
Place where people can stay	15.4%	25.6%	10.3%	12.8%	35.9%

5.3.9 Environmental benefits of wetlands

Most respondents agreed that environmental benefits are provided by Belvedere wetland, indicating that they understood the environmental importance of wetlands (Figure 5.20). This is shown by the following percentage of respondents who agreed that wetlands modify climate

56%, are habitats for plants and animals (92%), improve water quality (52%), store carbon dioxide (59%) and enhancing ground water recharge (76%). Although a lot of people understood different environmental benefits, some respondents were neutral on the fact that wetlands modify climate (26%) and that they improve water quality (23%). This means that some were not aware of these environmental benefits of wetlands. Since some people were not sure how wetlands improve water quality, they also disagreed (25%) with this environmental benefit (Figure 5.20).

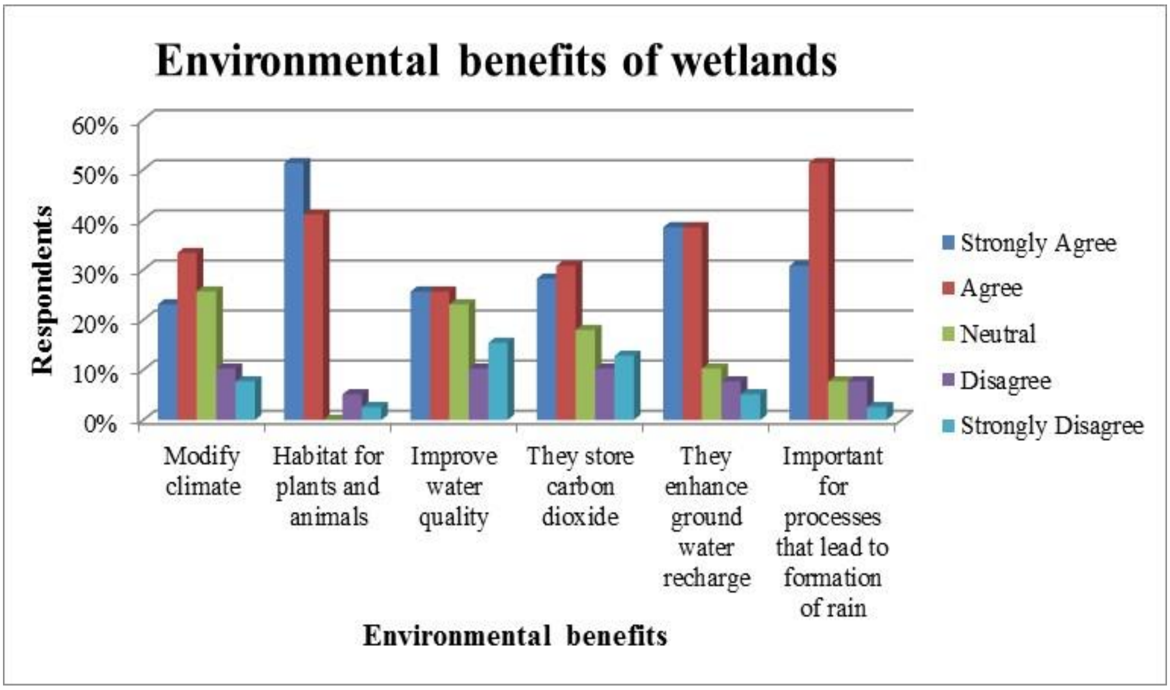


Figure 5.20: Environmental benefits of wetlands

5.3.10 Effects of different land use on wetlands

Different land uses have different impacts on wetland elements (Figure 5.21). Most respondents (97%) agreed that waste dumping pollutes wetland water. Some parts of Belvedere wetland water were seen to be polluted due to waste dumping (Figure 5.22).

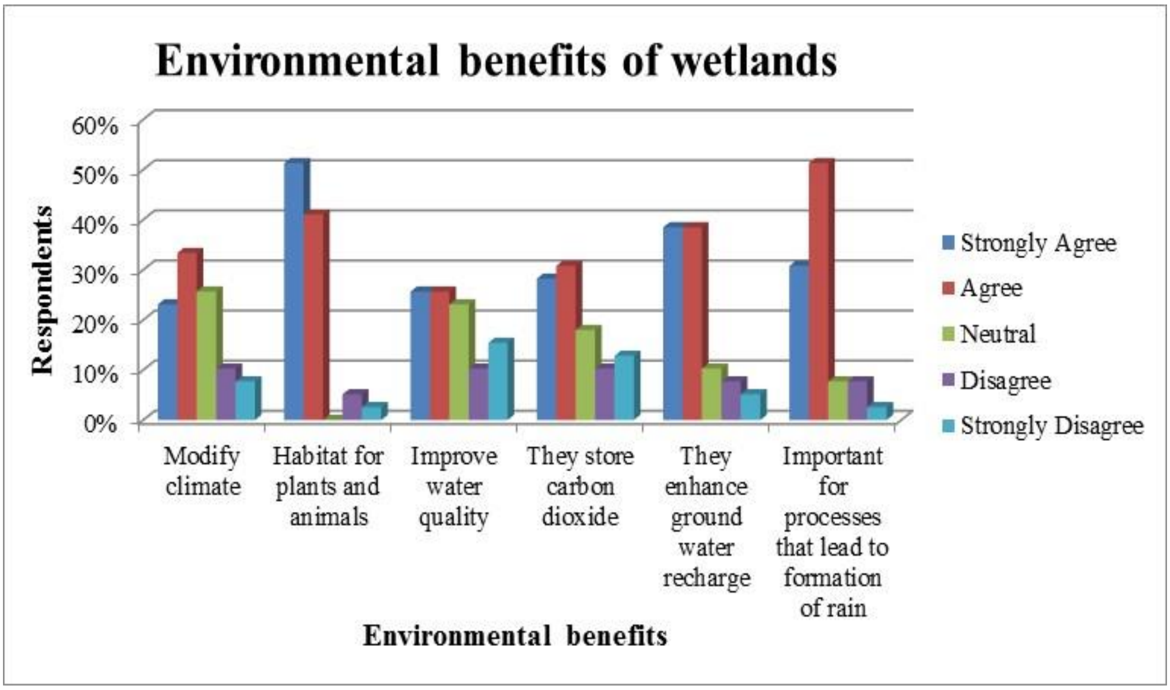


Figure 5.21: Effects of different land use on wetlands

Figure 5.22: (a) waste dumped into wetland water; (b) polluted wetland water

Most respondents (79%) agreed that cultivation on wetlands causes soil erosion. Belvedere wetland soils have been loosened and weakened due to intense cultivation. Some farmers believed that most of the top soil on Belvedere wetland was being eroded and they were left to grow crops on unfertile soils, compromising their harvest. Most respondents (90%) agreed with the fact that building houses and cultivation destroy the habitats of animals (Figure 5.21). One respondent said:

Most animals like warthogs have since left this wetland after the destruction of their habitats when this Chinese mall was built. We now see monkeys coming to feed on our maize (BV respondent 3).

Out of 39 respondents, 77% also agreed that birds have migrated since houses were built on the wetland and 72% supported the view that wetland soils lose fertility due to cultivation. Moreover, most respondents also agreed with the following effects of different land use on wetlands: some species die due to waste dumping on wetlands (82%), wetland cultivation destroys the beauty of wetlands (72%), and building houses on wetlands destroys the soil quality of wetlands (84%). Apart from the effects of different land uses, some farmers complained about people who were taking top soil from the wetland, leading to loss of fertile soil and leaving pits inside their fields and other parts of the wetland.

5.3.11 Threats to wetland elements

5.3.11.1 Threats to wetland soils and water

The main threat to Belvedere wetland soils was identified as cultivation (49%) since it loosens the soil, causing erosion and nutrient loss (21%) (Figure 5.23a). On some parts of Belvedere wetland the soil was so poor that some farmers were using artificial fertilisers to grow their crops (3%), further destroying soil quality.

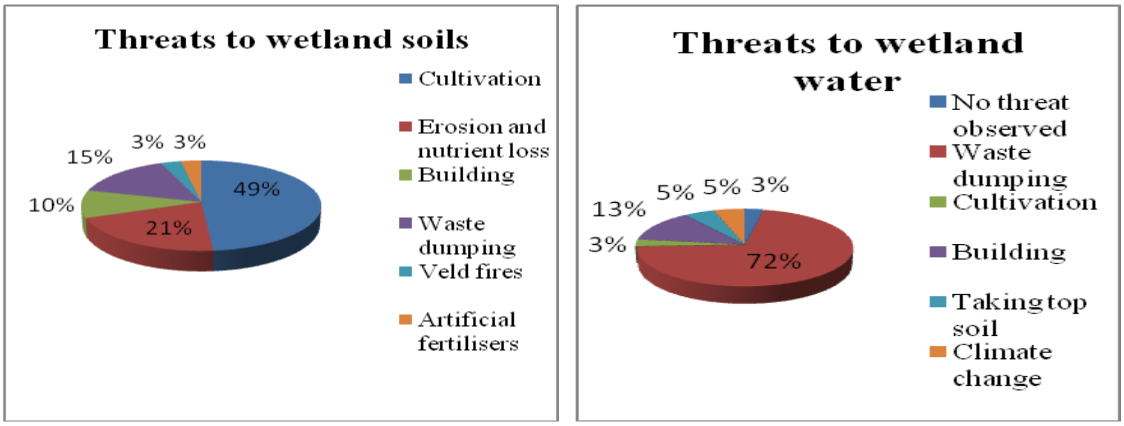


Figure 5.23: (a) Threats to wetland soils; (b) threats to wetland water

Belvedere wetland water is also being affected by waste dumping (72%) and algae has developed on some water areas due to pollution (Figure 5.24).

Figure 5.24: Polluted wetland water with water algae

Waste dumping also affects soil quality (15%) (Figure 5.23a). Some farmers complained that wetland soils in some parts were mixed with glasses and cans which are not biodegradable, making it difficult for them to grow their crops. Climate change (5%) was also identified as a threat to wetland water (Figure 5.23b). Little and unreliable rainfall and increased temperatures have caused some water loving plants to dry up. Buildings also affect wetland water (15%). Commenting on the amount of water found on the wetland, one farmer said:

> *In early 1970 when I started cultivating on this wetland there was a lot of water and this street was named Watermeyer because of too much water which was on this wetland. The wetland is now drying up because of these buildings (people's houses and the mall).* (BV respondent 3)

Building the Chinese mall and houses which most respondents complained about has resulted in draining of the surrounding wetland water. Banana trees were also planted around the mall to suck up some of the water from the wetland to make sure that buildings are not disturbed by wetland water (Figure 5.25).

Figure 5.25: (a, b) Pipes draining water from the wetland; (c, d) banana trees planted around the mall to drain water.

5.3.11.2 Threats to wetland birds and animals

Different human activities on wetland disturb habitats for animals and birds such that most of them have since disappeared (Figure 5.26). Building on Belvedere wetland has threatened wetland birds (39%) and animals (38%). People have destroyed habitats for birds and animals in the process of building, leaving most of them without shelter and food, forcing them to migrate. Some people also catch birds (13%) and animals (10%) for food, thereby reducing their numbers. Few animals such as monkeys and rabbits were still being seen in the wetland mainly during the rainy season when they come to feed on peoples' crops, especially maize. Some small animals such as mice, frogs and snakes were still found in the Belvedere wetland.

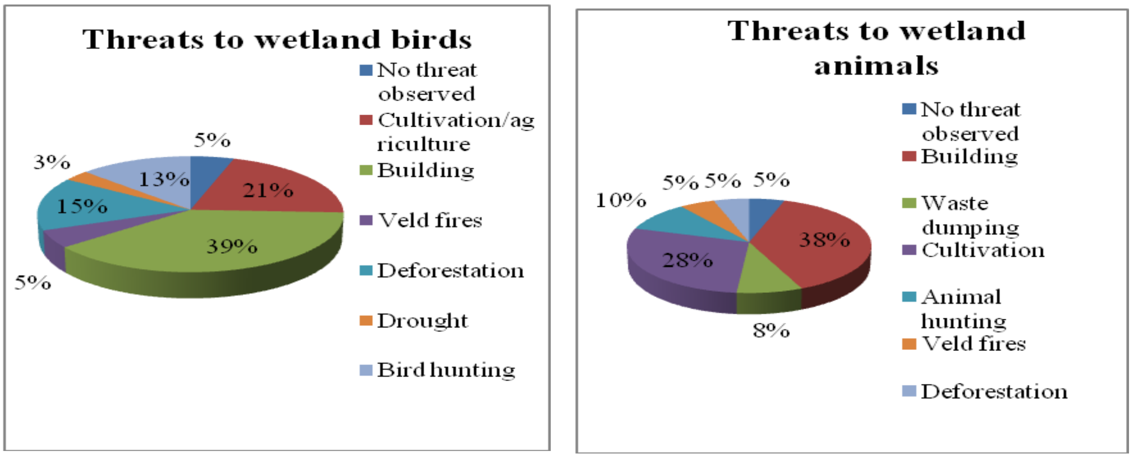


Figure 5.26: (a) Threats to wetland birds; (b) threats to wetland animals

5.3.11.3 Threats to wetland vegetation

Vegetation like any other wetland element in Belvedere wetland is being affected by different human activities (Figure 5.27). Deforestation (28%) was identified as the main threat to wetland vegetation. Trees were cut down during cultivation (23%), building (15%) and firewood collection. Some plants have disappeared due to cultivation and building, and some alien plants have emerged. One farmer said:

> *We no longer see some plants which used to see on this wetland and new plants such as black jack have emerged.* (BV respondent 2)

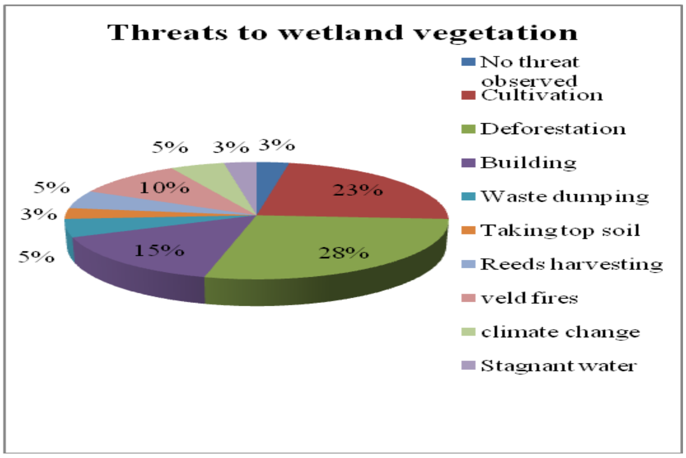


Figure 5.27: Threats to wetland vegetation

Increased deforestation which led to the destruction of many wetland trees was caused by most unemployed people who were cutting down trees to sell or burn. Figure 5.28 shows some of the human activities on Belvedere wetland, threatening wetland elements.

Figure 5.28: Human activities threatening Belvedere wetland: (a) top soil ready for collection; (b) top soil and pits left after removal of soil; (c) cultivation; (d) waste dumping; (e) public durawall (city sports centre) falling because it is built on the wetland; (f) durawall for a house built on the wetland; (g) collected fishing worms for sale, (h) sugarcane grown on wetland; (i) reeds cut from the wetland; (j) burnt part of the wetland (veld fires).

5.3.12 Ways of dealing with different threats to wetland elements

Most respondents (79%) suggested law implementation and enforcement as a way of dealing with different threats to wetland elements. This involves new laws that protect wetlands and enforcing those laws that already exist. Some respondents suggested that the government should arrest people who are seen abusing wetlands. The government should also stop people from building and cultivating on wetlands. People can also be educated about using wetlands without destroying them (10%). Economic crisis has caused the destruction of most wetlands as people see them as source of income to survive, therefore government should try to create jobs to avoid abuse of wetlands (5%). However, some respondents argued that wetlands should be fenced and protected (3%) in order to stop people from using them.

5.3.13 Knowledge about laws and information on wetlands

Respondents had varied views on the knowledge they had about laws that protect wetlands. Although 54% of the respondents agreed that there were laws that guard against abuse of wetlands, 46% argued that there were no such laws. Lack of knowledge on laws that guard against wetlands was based on the fact that some respondents argued that there was no information given to them about wetlands (49%). However, 51% of questionnaire respondents agreed that there was information given to them on wetlands, and some interviewed people pointed out that they were getting information about wetlands from the media (radio, newspapers, television and magazines).

5.3.14 Sustainable wetland use and conservation of wetlands

Fencing and protecting wetlands and use them as recreational parks (31%), was seen by some respondents as one of the most important ways of conserving and using wetlands sustainably (Table 9). Some respondents raised the issue of law implementation and enforcement (28%), since most felt that the government was reluctant to implement these laws for people to use and conserve wetlands sustainably.

Table 9: Ways of using and conserving wetlands sustainably

Methods	**% of respondents**
Implementation and enforcement of strict laws	28
Educating people about wetlands	18
Use sustainable farming methods	21
Fence them and protect them and use them as recreational parks in their natural state	31
Should continue to be owned by government not individuals	3

Some interview respondents argued that the government should involve local people in deciding how to use these wetlands. The way urban wetlands are managed in Zimbabwe is different from rural ones where local people are involved in the use of wetlands. Commenting on urban wetlands, one respondent said;

> *We don't have powers on these urban wetlands. If it was in rural areas we would advise the headman on how we would use the wetlands. No one listens to us even if we want to conserve wetlands in Harare. All the land in Harare like this wetland belongs to the city of Harare and they are making money with these wetlands selling them for construction. It's only in rural areas that people who abuse wetlands like cutting down trees in the wetland can be arrested.* (BV respondent 7)

Most respondents argued that building on wetlands was destructive and therefore the government should stop allocating stands on wetlands. Focus group respondents said:

> *We are not worried much about changes happening on the wetland due to cultivation. We are worried that the government is selling the wetland for developmental purposes and poverty is increasing because they are occupying our fields. This wetland is being destroyed and we will not have a wetland here years to come. We are afraid that our children will not be able to see these wetlands.* (BV focus group 1)

5.4 Data collection sites for soil samples

Soil samples for utilised parts of Borrowdale wetland were collected from different land uses such as agriculture, building, waste dumping and areas for religious practice, and samples from unutilised parts were randomly collected. Soil sample sites are shown on Figure 5.29. The same methodology was used for Belvedere wetland (Figure 5.30).

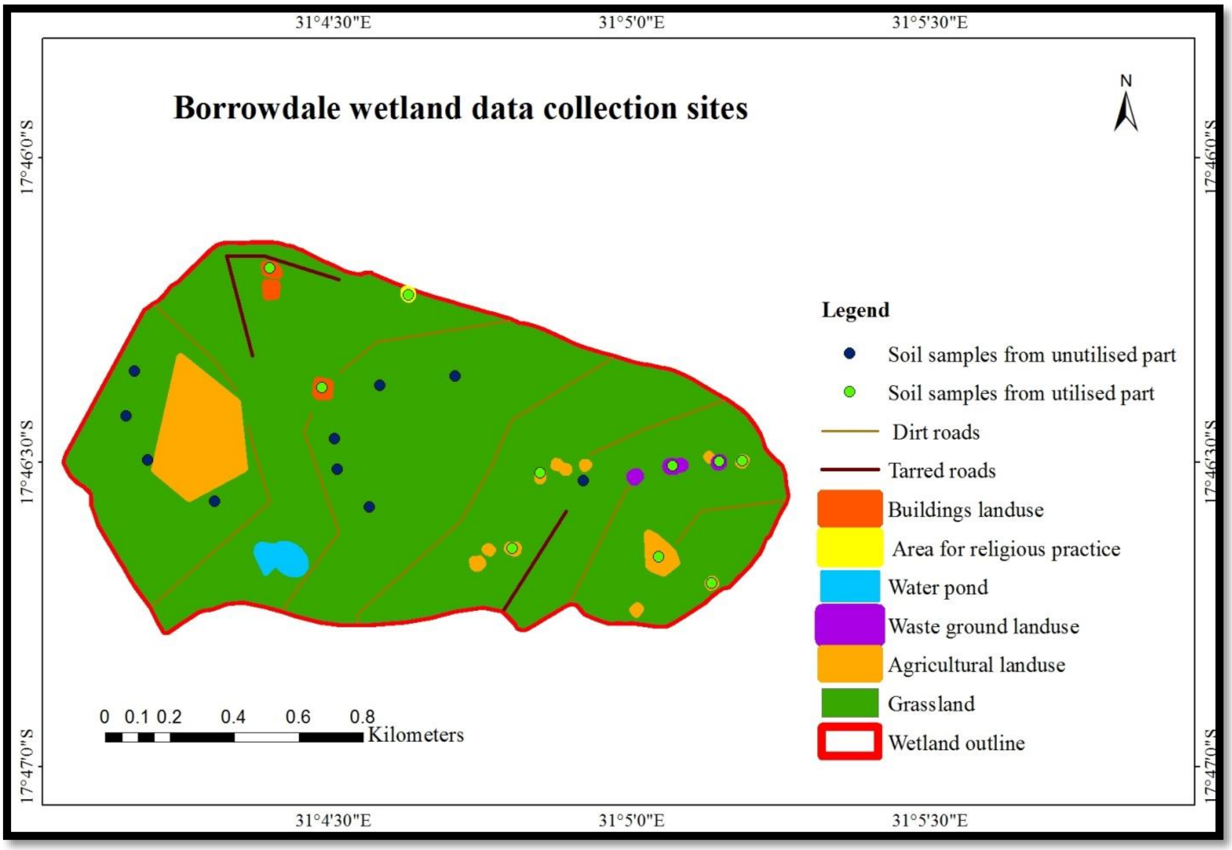


Figure 5.29: Data collection sites for Borrowdale wetland

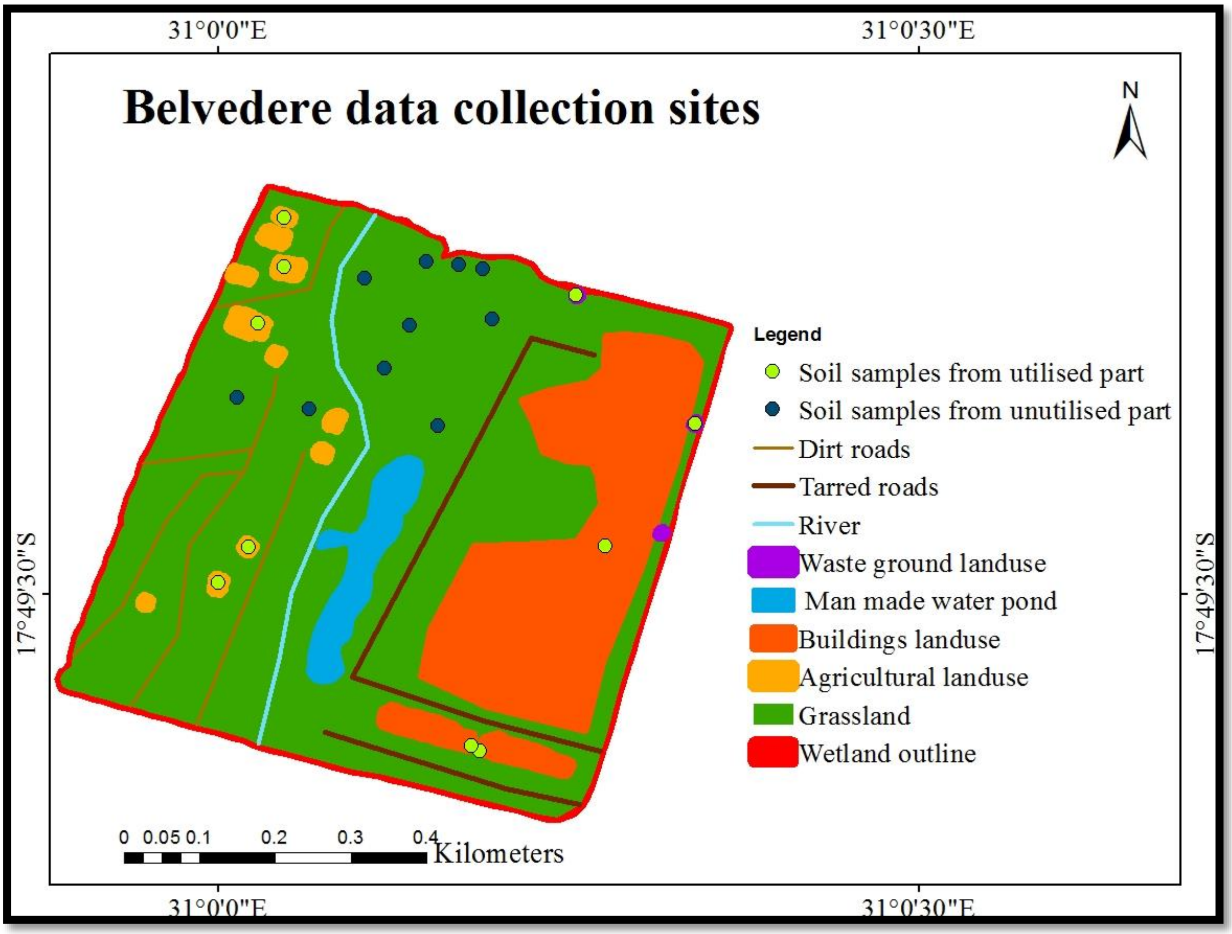


Figure 5.30: Belvedere data collection sites

5.5 Soil grain size analysis

The grain size of different soil samples collected from Borrowdale and Belvedere utilised and unutilised part of the wetlands analysed through the Gradistat programme (Blott and Pye, 2001) were presented using tables, graphs and maps. This was done before analysing organic carbon content in each soil sample. Grain size analysis was done to show how sediments from different sites differed in skewness, mean and kurtosis. Skewness and kurtosis values were interpreted according to Pye and Blott (2001). The sediments differed in skewness and kurtosis because of the different grain size distribution in each sample (Tables 10-13).

5.5.1 Grain size distribution for Borrowdale soil samples

Sediments from Borrowdale differed in mean, skewness and kurtosis values (Table 10 and 11).

Table 10: Borrowdale samples from utilised parts of the wetland

SAMPLE IDENTITY	SAMPLE TYPE	SEDIMENT NAME	MEAN (μm)	SKEWNESS	KURTOSIS
BR 1 utilised	Polymodal, poorly sorted	Poorly sorted medium sand	487.4	1.429 (symmetrical)	4.739 (Platykurtic)
BR 2 utilised	Polymodal, poorly sorted	Poorly sorted coarse send	578.8	1.058 (Fine skewed)	3.408 (Mesokurtic)
BR 3 utilised	Polymodal, poorly sorted	Poorly sorted coarse send	502.8	1.199 (Symmetrical)	3.796 (Platykurtic)
BR 4 utilised	Polymodal, poorly sorted	Poorly sorted coarse name	749.4	0,528 (Fine skewed)	2.324 (Mesokurtic)
BR 5 utilised	Polymodal, poorly sorted	Poorly sorted coarse sand	802.4	0.475 Fine skewed	2.255 (Mesokurtic)
BR 6 utilised	Polymodal, poorly sorted	Poorly sorted coarse sand	714.9	0.702 (Fine skewed)	2.574 (Mesokurtic)
BR 7 utilised	Polymodal, poorly sorted	Poorly sorted coarse sand	445.6	1.261 Symmetrical	4.320 (Platykurtic)
BR 8 utilised	Polymodal, poorly sorted	Poorly sorted coarse sand	619.0	0.883 (Fine skewed)	2.692 (Platykurtic)
BR 9 utilised	Polymodal, poorly sorted	Poorly sorted coarse sand	552.4	1.029 (Fine skewed)	3.069 Platykurtic
BR 10 utilised	Polymodal, poorly sorted	Poorly sorted coarse sand	664.4	0.714 (Fine skewed)	2.674 Mesokurtic

Table 11: Borrowdale samples from unutilised parts of the wetland

SAMPLE IDENTITY	SAMPLE TYPE	SEDIMENT NAME	MEAN (μm)	SKEWNESS	KURTOSIS
BR1 unutilised	Polymodal, poorly sorted	Poorly sorted very coarse sand	868.4	0.278 (Very fine skewed)	1.887 (Mesokurtic)
BR2 unutilised	Polymodal, poorly sorted	Poorly sorted very coarse sand	616.5	0.794 (Fine skewed)	2.436 (Platykurtic)
BR3 unutilised	Polymodal, poorly sorted	Poorly sorted very coarse sand	610.3	0.905 (Symmetrical)	2.651 Platykurtic
BR4 unutilised	Polymodal, poorly sorted	Poorly sorted very coarse sand	661.6	0.705 (Fine skewed)	2.322 (Platykurtic)
BR5 unutilised	Polymodal, poorly sorted	Poorly sorted very coarse sand	812.8	0.400 (Very fine skewed)	2.006 (Platykurtic)
BR6 unutilised	Polymodal, poorly sorted	Poorly sorted coarse sand	557	0.985 (Fine skewed)	3.119 (Platykurtic)
BR7 unutilised	Polymodal, poorly sorted	Poorly sorted coarse sand	700.7	0.633 (Fine skewed)	2.360 (Platykurtic)
BR8 unutilised	Polymodal, poorly sorted	Poorly sorted very coarse sand	783.3	0.419 (Very fine skewed)	2.025 (Mesokurtic)
BR9 unutilised	Polymodal, poorly sorted	Poorly sorted very coarse sand	793.5	0.453 (Fine skewed)	2.005 Platykurtic
BR10 unutilised	Polymodal, poorly sorted	Poorly sorted coarse sand	674.1	0.730 (Fine (skewed)	2.598 (Platykurtic)

One sample collected from the unutilised part of Borrowdale wetland (BR 3 unutilised) shows a normal distribution (symmetrical) whilst the other nine were positively skewed (fine skewed) and some were very fine skewed. This indicates there are more data points concentrated to the right than the left of the distribution. However there is also low concentration in the positive side therefore there is low concentration of silt and clay grains in all the sediments (Figures 5.31 and 5.32). Soil particles from utilised and unutilised parts of the wetland have different grain size distribution (Figures 5.31 and 5.32). Soils from unutilised parts have coarser sand particles as compared to the utilised parts.

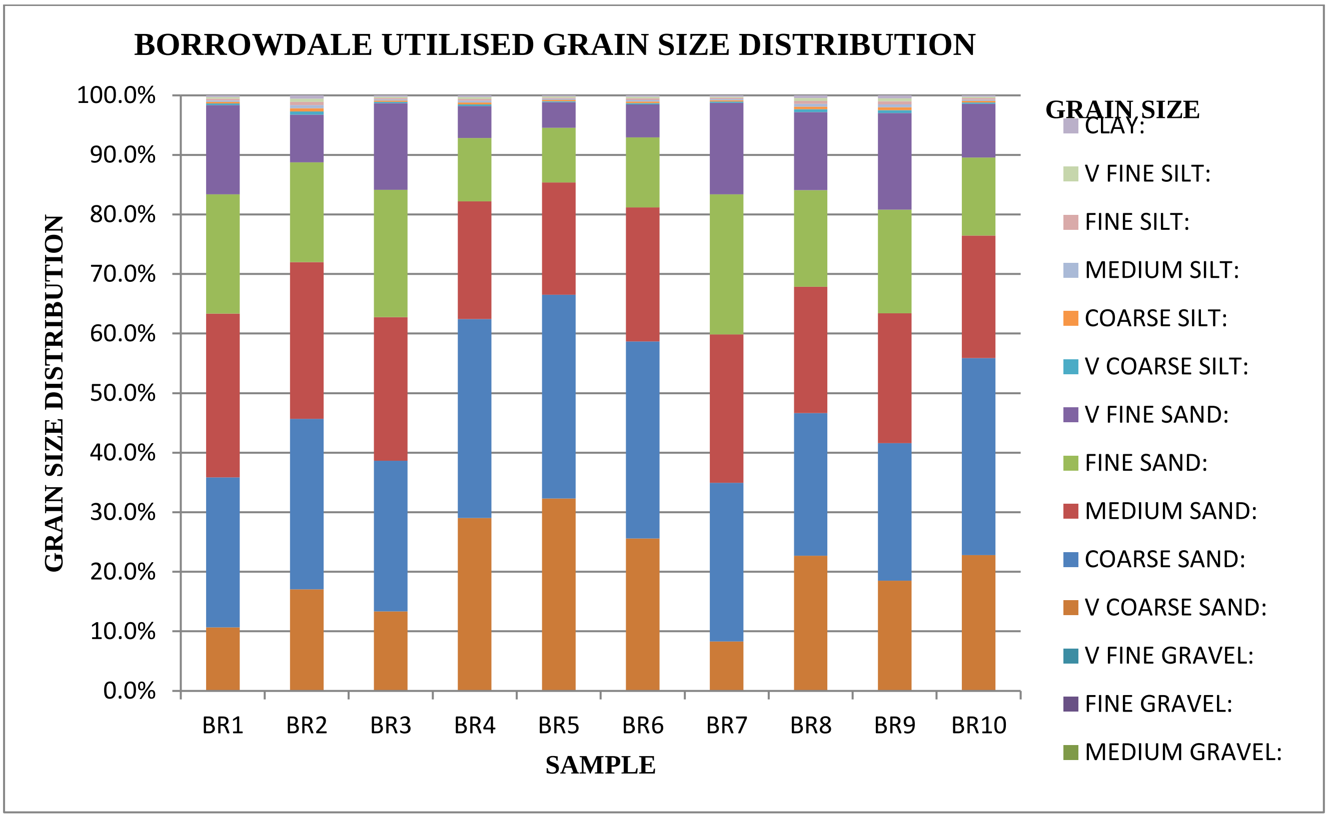


Figure 5.31: Borrowdale utilised area grain size distribution

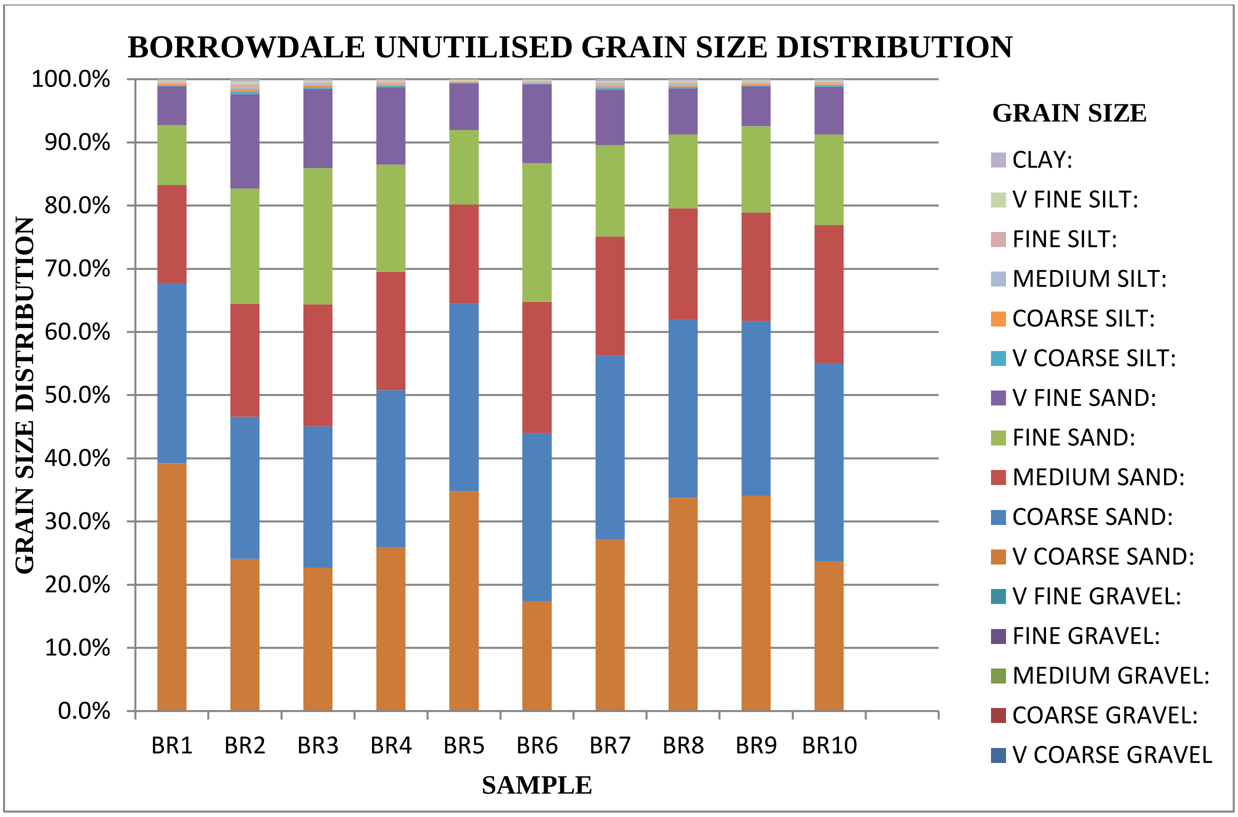


Figure 5.32: Borrowdale unutilised area grain size distribution

Sediments from utilised parts of Borrowdale wetland had less very coarse sand as compared to the unutilised part. Moreover, sediments from unutilised parts of Borrowdale wetland had coarse and very coarse particles which were not found in samples from utilised parts (Figures 5.31 and 5.32).

5.5.1.1 Mean size distribution for Borrowdale soils

Highest mean grain size of soil samples from Borrowdale was recorded from soil samples collected from unutilised parts of the wetland. The highest recorded mean was therefore 868.4 µm, corresponding to poorly sorted very coarse sand (Figure 5.33).

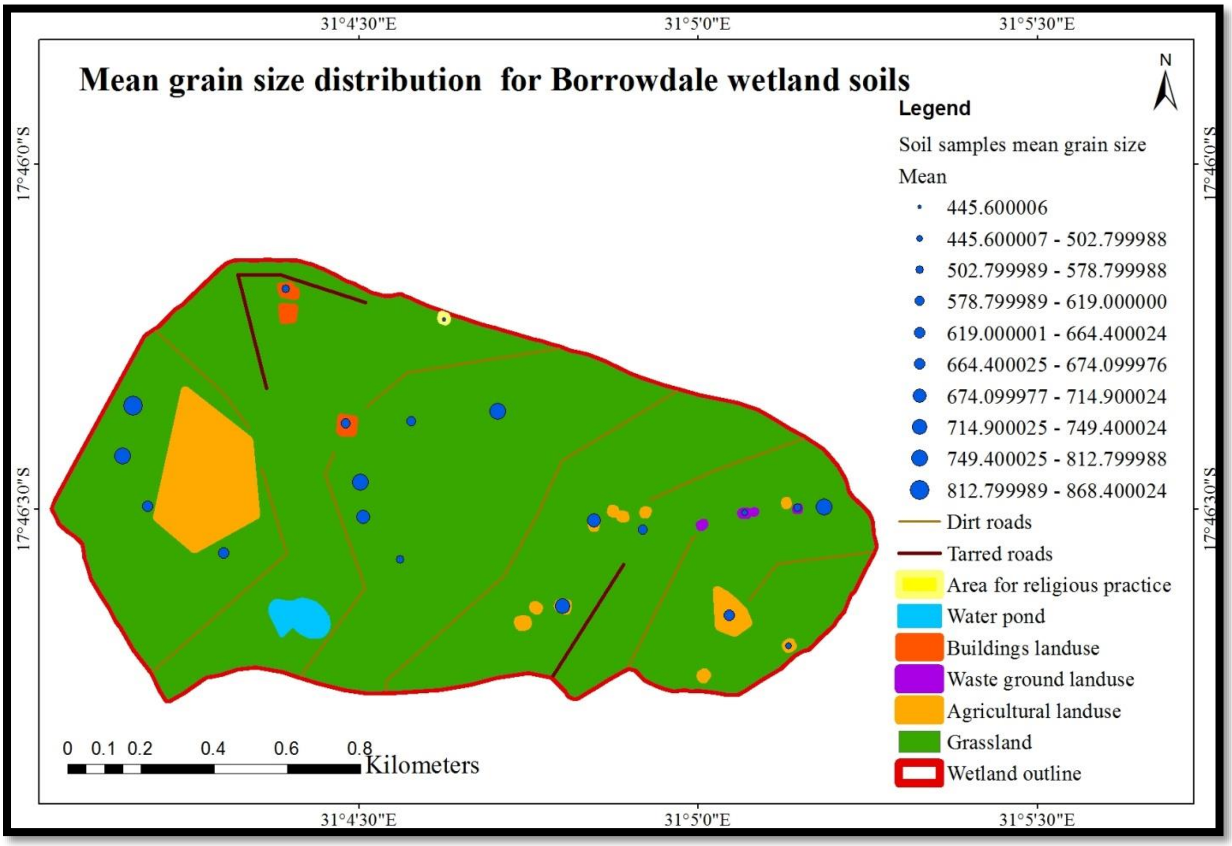


Figure 5.33: Mean grain size distribution for Borrowdale wetland soils

Coarsest sediments were collected from unutilised middle part and the far southern part of the wetland (Figure 5.33). Finest sediments were found on utilised parts of the wetland on cultivated land, area used for religious practice and on waste ground. Although all sediments from Borrowdale wetland are poorly sorted (Tables 10 and 11), poorly sorted very coarse sand sediments were only found in unutilised parts of the wetland. Poorly sorted medium sand sediments were only collected from the utilised part of the wetland and were not found on the unutilised part.

5.5.1.2 Grain size distribution (skewness) for Borrowdale wetland soils

Skewness and kurtosis values describes attributes of the grain size distribution (Joanes. and Gill, 1998). Out of 10 samples collected from the utilised part of Borrowdale wetland, 7 showed fine skewedness or positively skewed meaning that the mean is to the right of the peak. Therefore, soil from the utilised part of the wetland had higher skewness values compared to those from the unutilised part (Figure 5.34, Tables, 10 and 11). The highest skewness value of 1.429 was recorded from the utilised part of the wetland. Only 3 soil samples from the utilised part of the wetland had a symmetrical distribution, showing data which was normally distributed.

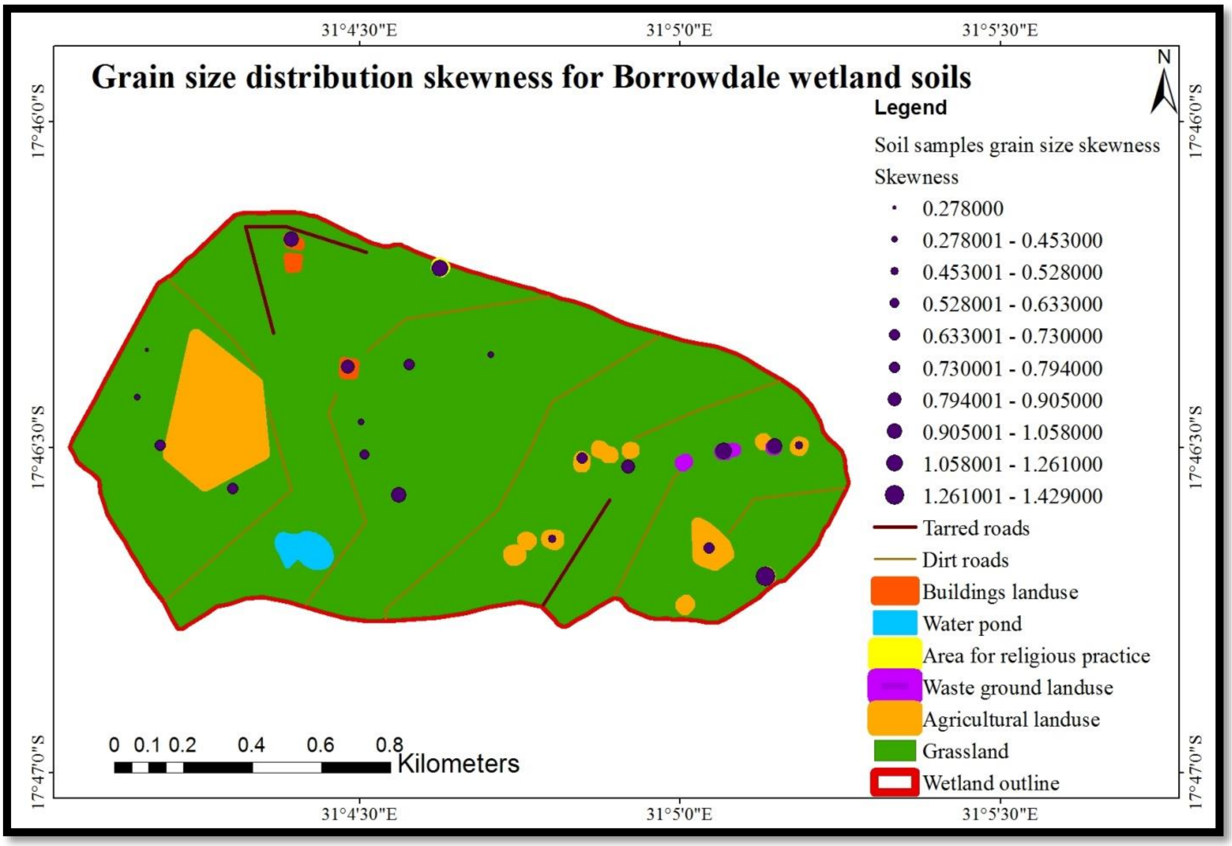


Figure 5.34: Grain size distribution skewness for Borrowdale wetland soils

Out of ten sediments samples collected from the unutilised part of the wetland, only one sample showed a normal distribution of grains (symmetrical skewed).

5.5.1.3 Kurtosis for Borrowdale wetland soils

Kurtosis describe the trends in data distribution (how high or flat the distribution of data points are). Mesokurtic distributions are normally distributed and leptokurtic distributions are those with a high peak. Platykurtic distributions have a broad flat peak. Out of ten sediment samples from the utilised part of the wetland, five samples showed mesokurtic distributions (normal distribution) and five other samples showed a platykurtic distribution (negative flat, wide distribution), with values greater than mesokurtic values (Table 10). The highest recorded kurtosis value (4.739) with platykurtic distribution was from the utilised part of the wetland (Figure 5.35).

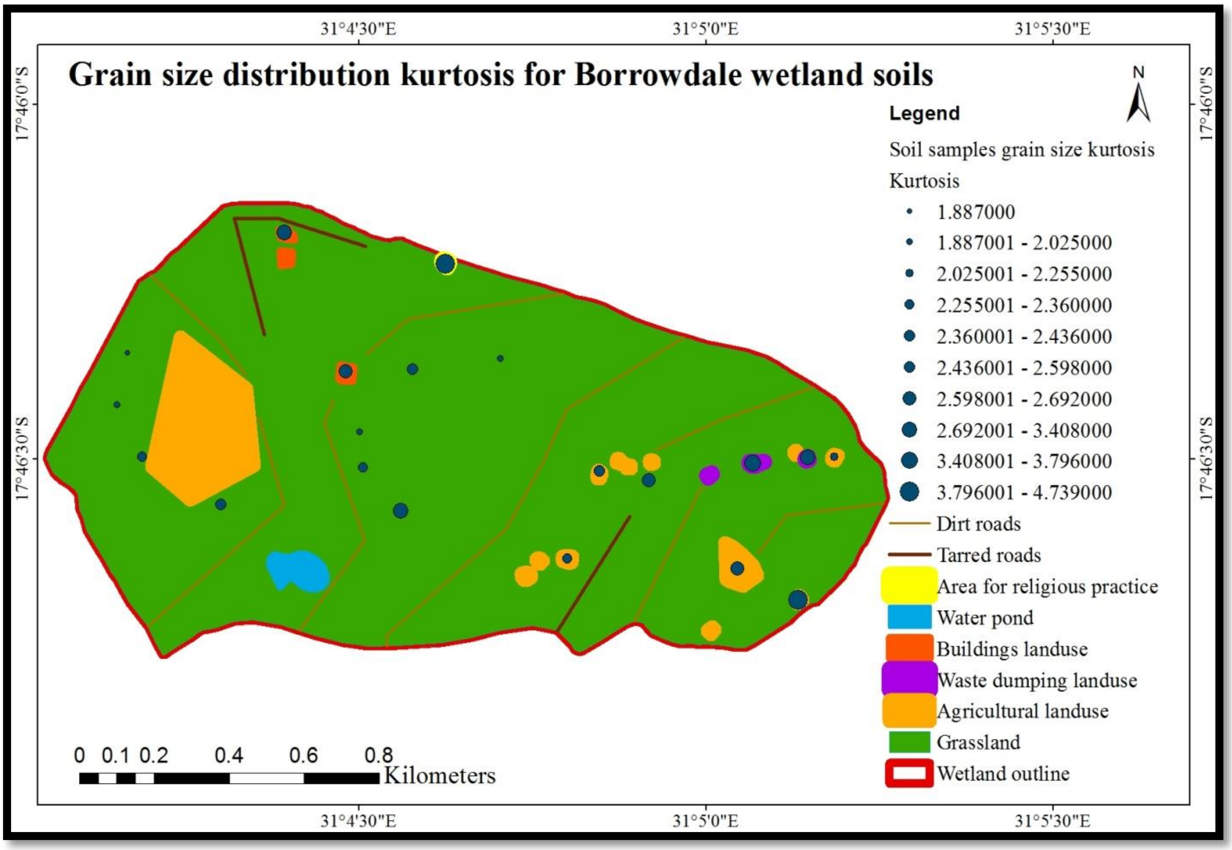


Figure 5.35: Kurtosis for Borrowdale wetland soils

Kurtosis values of sediment samples from the unutilised part of the wetland differed from those from the utilised part. Only two sediment samples from the unutilised part showed normal distributions (mesokurtic) and the other 8 sediment samples showed platykurtic distributions (Table 11).

5.5.2 Grain size distribution for Belvedere wetland soils

Soil samples had different grain size distribution depending on where they where collected. Samples from the utilised and the unutilised parts of the wetland, differ in mean skewness and kurtosis (Tables 12 and 13).

Table 12: Belvedere samples from utilised part of the wetland

SAMPLE IDENTITY	SAMPLE TYPE	SEDIMENT NAME	MEAN (μm)	SKEWNESS	KURTOSIS
BV1 utilised	Polymodal, poorly sorted	Poorly sorted coarse sand	676.5	0.543 (Very fine skewed	2.595 (Mesokurtic)
BV2 utilised	Polymodal, poorly sorted	Poorly sorted coarse sand	824.3	0.406 (Fine skewed)	2.232 (Mesokurtic)
BV3 utilised	Polymodal, poorly sorted	Poorly sorted very coarse sand	1000.4	-0.041 (Very fine skewed)	1.824 (Leptokurtic)
BV4 utilised	Polymodal, poorly sorted	Poorly sorted coarse sand	628.3	0.877 (Fine skewed)	3.010 (Mesokurtic)
BV5 utilised	Polymodal, poorly sorted	Poorly sorted coarse sand	772.8	0.498 (Very fine skewed)	2.401 (Leptokurtic
BV6 utilised	Polymodal, poorly sorted	Poorly sorted coarse sand	716.5	0.583 (Very fine skewed)	2.708 (Mesokurtic)
BV7 utilised	Polymodal, poorly sorted	Poorly sorted very coarse sand	759.4	0.527 (Fine skewed)	2.213 (Mesokurtic)
BV8 utilised	Polymodal, poorly sorted	Poorly sorted very coarse sand	838.1	0.398 (Fine skewed)	1.959 (Mesokurtic)
BV9 utilised	Polymodal, poorly sorted	Poorly sorted coarse sand	538.9	1.079 (Fine skewed)	3.538 (Platykurtic)
BV10 utilised	Polymodal, poorly sorted	Poorly sorted coarse sand	655.6	0.680 (Fine skewed)	2.606 (Platykurtic)

Table 13: Belvedere samples from unutilised part of the wetlands

SAMPLE IDENTITY	SAMPLE TYPE	SEDIMENT NAME	MEAN (μm)	SKEWNESS	KURTOSIS
BV1 unutilised	Polymodal, poorly sorted	Poorly sorted coarse sand	591.3	0.752 (Fine Skewed)	2.772 (Platykurtic)
BV2 unutilised	Polymodal, poorly sorted	Poorly sorted coarse sand	562.8	0.766 (Very Fine Skewed)	2.920 (Mesokurtic)
BV3 unutilised	Polymodal, poorly sorted	Poorly sorted coarse sand	588	0.785 (Fine Skewed)	2.710 (Platykurtic)
BV4 unutilised	Polymodal, poorly sorted	Poorly sorted coarse sand	546.2	0.851 (Fine skewed)	3.045 Platykurtic
BV5 unutilised	Polymodal, poorly sorted	Poorly sorted coarse sand	518.6	1.085 (Symmetrical)	3.293 (Very Platykurtic)
BV6 unutilised	Polymodal, poorly sorted	Poorly sorted coarse sand	598.2	0.819 (Fine skewed)	2.789 (Very Platykurtic
BV7 unutilised	Polymodal, poorly sorted	Poorly sorted coarse sand	534.9	1.032 (Fine skewed)	3.411 (Mesokurtic)
BV8 unutilised	Polymodal, poorly sorted	Poorly sorted coarse sand	570.7	0.833 (Fine skewed)	2.940 Platykurtic
BV9 unutilised	Polymodal, poorly sorted	Poorly sorted coarse sand	575.7	0.815 (Fine skewed)	2.571 (Very Platykurtic)
BV10 unutilised	Polymodal, poorly sorted	Poorly sorted coarse sand	575.7	1.022 (Fine skewed)	3.373 (Platykurtic)

Grain size distributions from both the utilised and the unutilised parts of Belvedere wetland show a positive skewness (fine skewed) showing more data concentrated to the right (Figures 5.36 and 5.37). Therefore there are limited silt and clay grains in all of these samples.

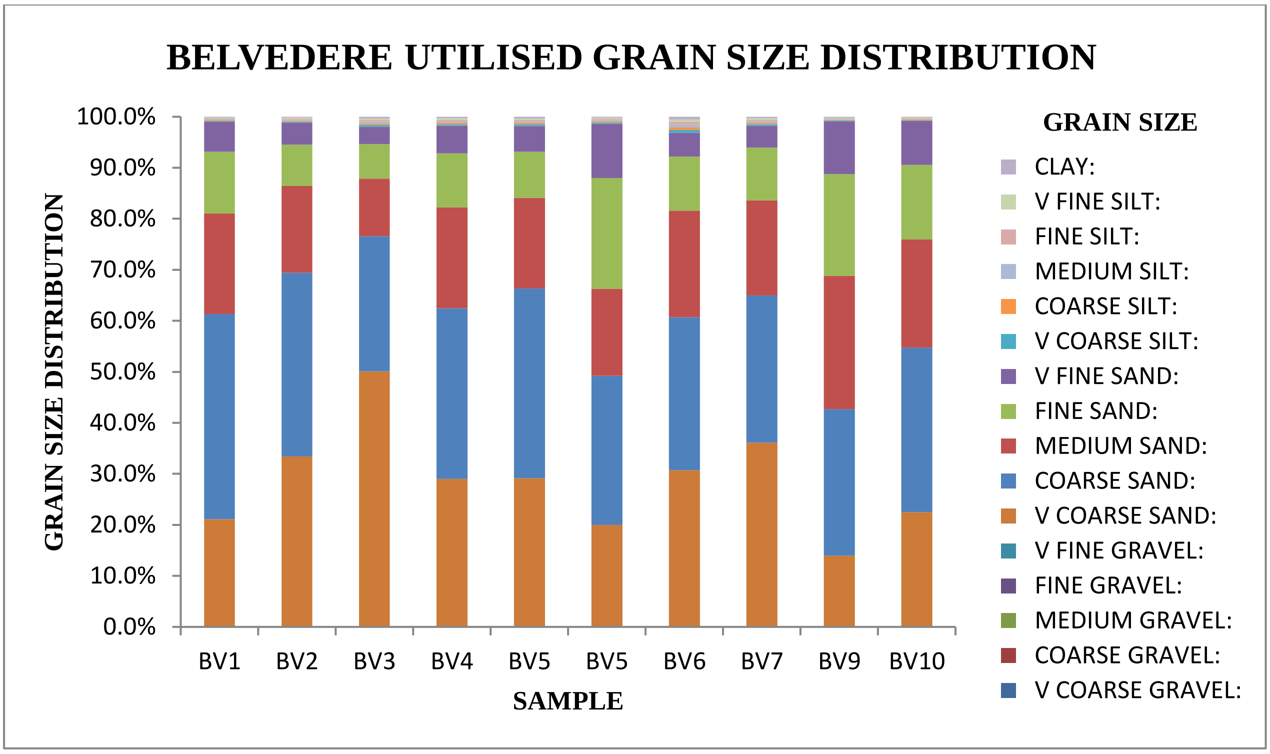


Figure 5.36: Belvedere utilised area grain size distribution

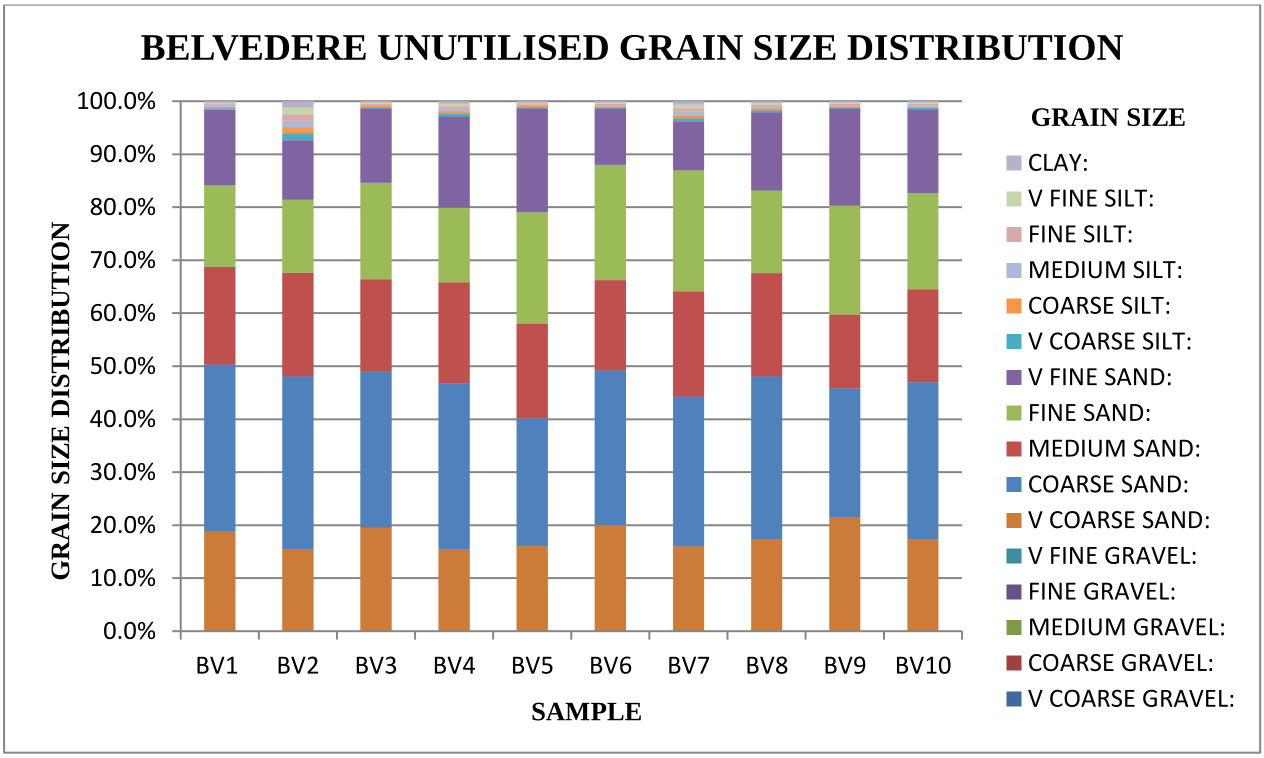


Figure 5.37: Belvedere unutilised area grain size distribution

Grain size distributions of sediments from the utilised parts of the wetland had more very coarse sand grained particles as compared to those from the unutilised parts (Figures 5.36 and 5.37). Some soil samples from the unutilised parts had more fine grained particles (clay, very fine silt, fine silt and medium silt) as compared to those from the utilised parts of the wetland.

5.5.2.1 Mean grain size distribution for Belvedere wetland soils

The highest mean grain size for Belvedere wetland soils was recorded from the utilised parts of the wetland **(**1000 µm) (Figure 5.38). Coarsest particles were from the utilised parts of the wetland with different land use (cultivation, waste ground and building). Sediment samples collected from the northern unutilised part of the wetland had the lowest mean values (finest particles) (Figure 5.38).

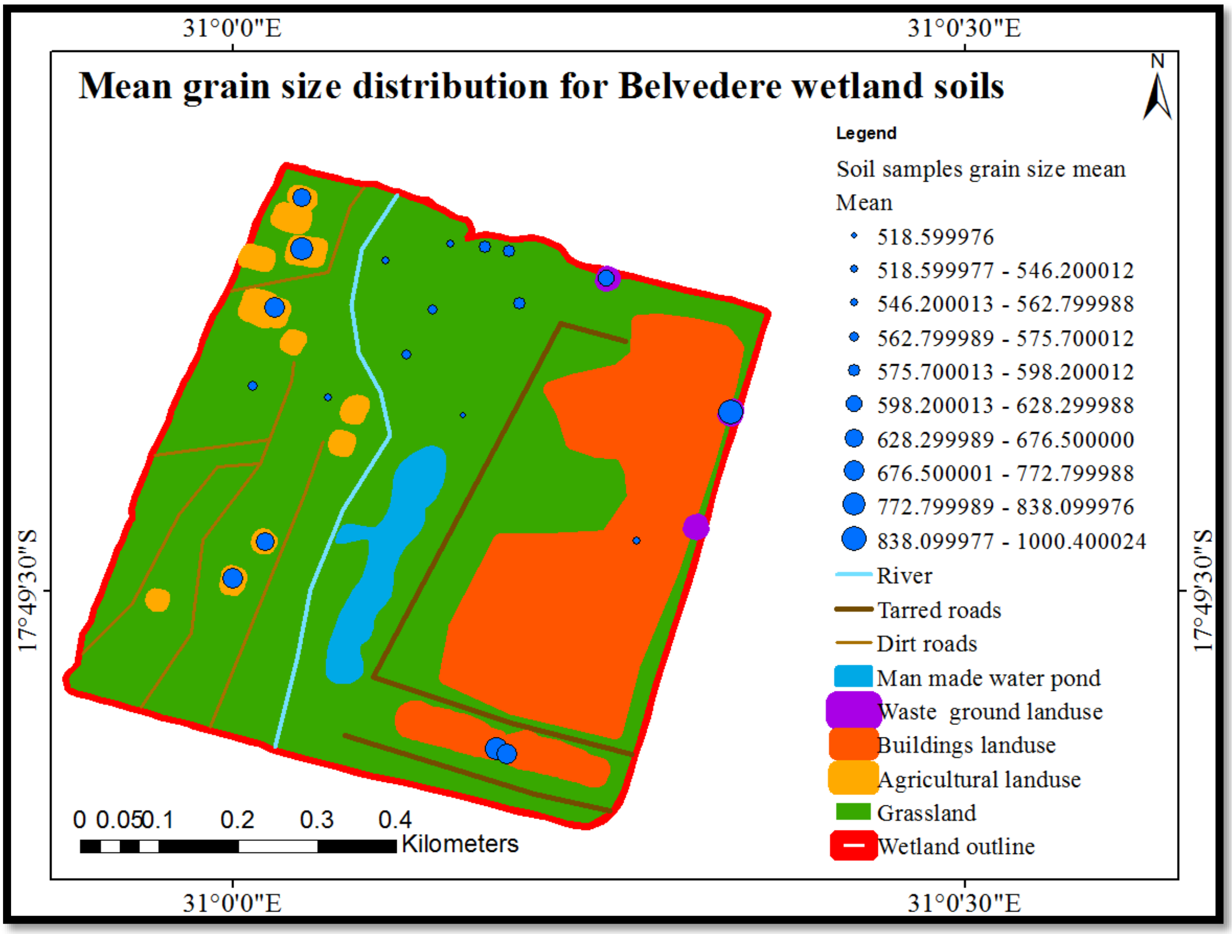


Figure 5.38: Mean grain size distribution for Belvedere wetland soils

Sediment samples from cultivation and waste ground land uses had the highest mean values (coarsest grain size).

5.5.2.2 Grain size distribution skewness for Belvedere wetland soils

Samples from the utilised part and the unutilised parts of the wetland had different skewness values (Figure 5.39). Highest skewness values were recorded from the unutilised parts of the wetland (1.085) and the lowest value was recorded from the utilised parts (- 0.041) (Tables 12 and 13).

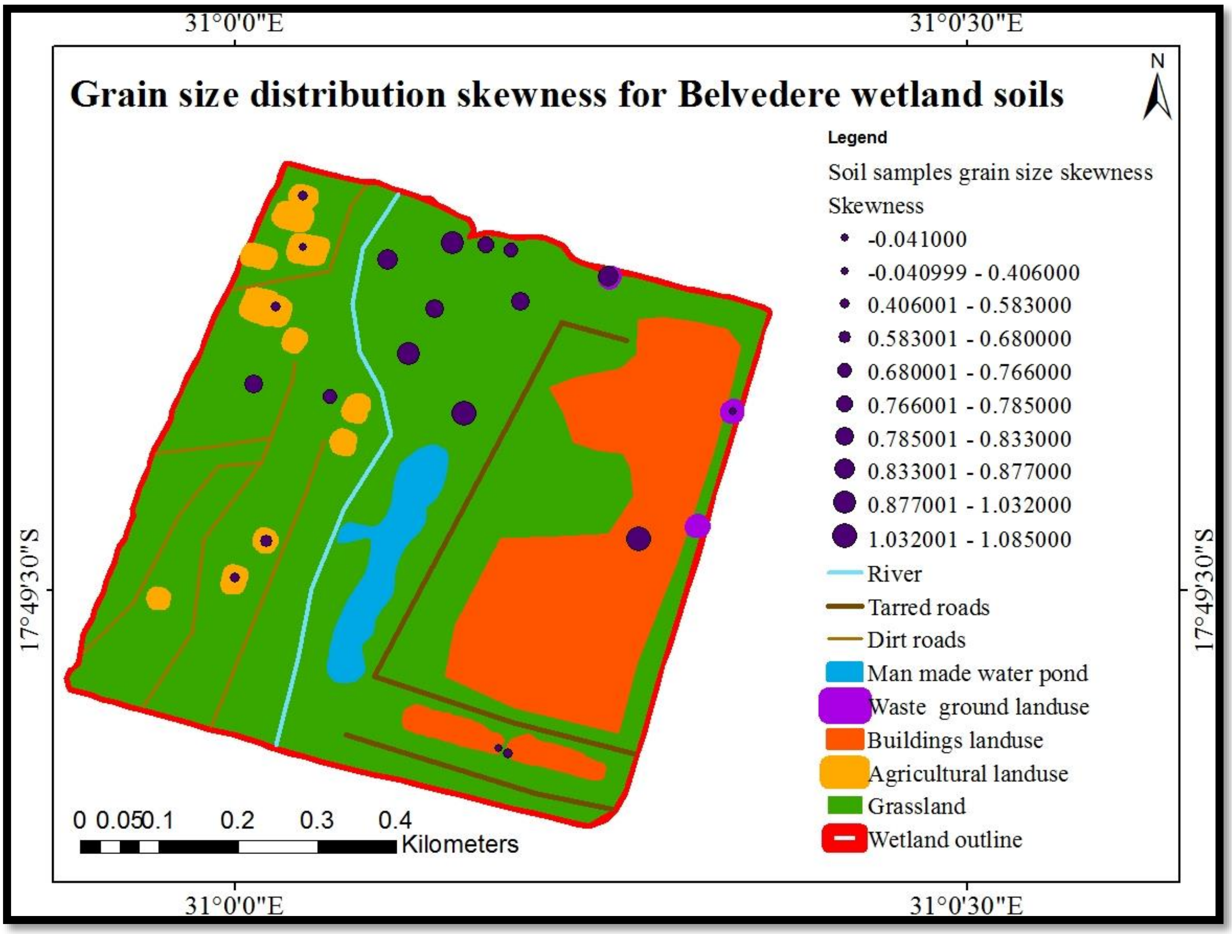


Figure 5.39: Grain size distribution skewness for Belvedere wetland soils

One sediment sample from the unutilised part of the wetland (BV5 unutilised), showed a symmetrical (normal distribution) meaning that the mean (518.2 µm) is in the centre of the graph. However, sediment samples from both the utilised and the unutilised parts showed positively skewed asymmetrical distributions where their mean values are greater than the median (Tables 12 and 13).

5.5.2.3 Kurtosis for Belvedere wetland soils

Soil samples from the utilised and unutilised parts of the wetland had different kurtosis values (Figure 5.40). Out of 10 sediment samples from the utilised parts, 6 samples were mesokurtic (with graphs showing the same tail size both sides) and 3 samples were platykurtic (with flat, wide distributed thin tails).

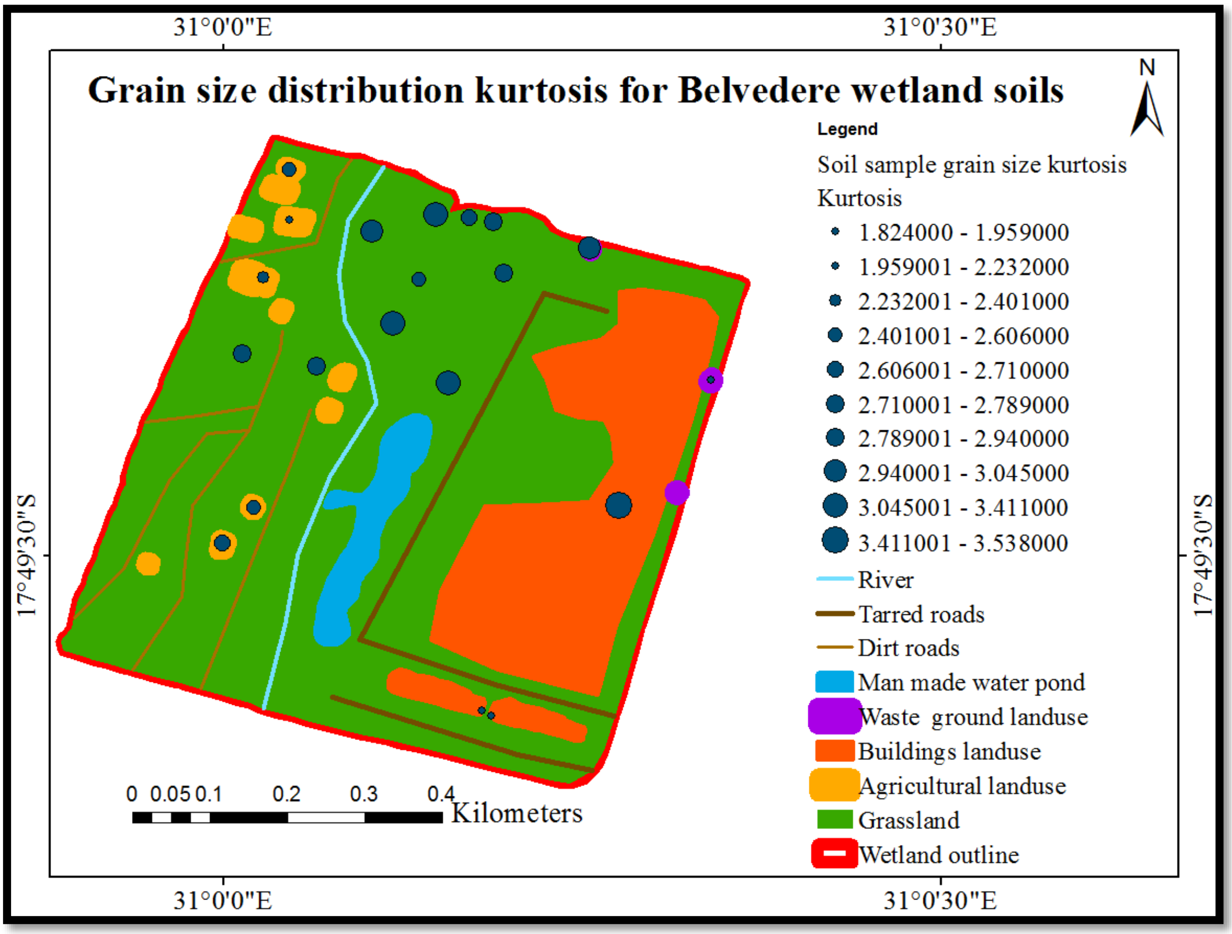


Figure 5.40: Kurtosis for Belvedere wetland soils

Only one sample from the utilised parts of the wetland was leptokurtic (positive tall and thin distribution). Of sediments from the unutilised parts of the wetland, 8 out of ten samples were platykurtic and 2 were mesokurtic (Table 13). Highest kurtosis values were recorded from the unutilised parts of the wetland (Figure 5.40).

5.6 Organic carbon content

5.6.1 Borrowdale wetland soils organic carbon content.

Results of calculated soil organic carbon content were presented using tables and maps (Figure 5.41). For Borrowdale, wetland high percentages of organics were recorded from the unutilised parts of the wetland and low from the utilised parts (Table 14). One soil sample from unutilised part of the wetland had the highest percentages of organic carbon (24.73%). The lowest organic carbon percentage (7.95%) was found from one sediment sample collected from the utilised parts of the wetland (Table 14).

Table 14: Organic carbon content for Borrowdale wetland soils

Soil samples from utilised part	% organics	Soil samples from unutilised part	% organics
BR1 utilised	7.95	BR1 unutilised	20.98
BR2 utilised	10.76	BR2 unutilised	19.76
BR3 utilised	15.02	BR3 unutilised	24.73
BR4 utilised	16.54	BR4 unutilised	19.43
BR5 utilised	18.23	BR5 unutilised	20.36
BR6 utilised	16.05	BR6 unutilised	19.80
BR7 utilised	15.66	BR7 unutilised	16.10
BR8 utilised	7.91	BR8 unutilised	21.85
BR9 utilised	10.68	BR9 unutilised	20.53
BR utilised	13.46	BR10 unutilised	19.98

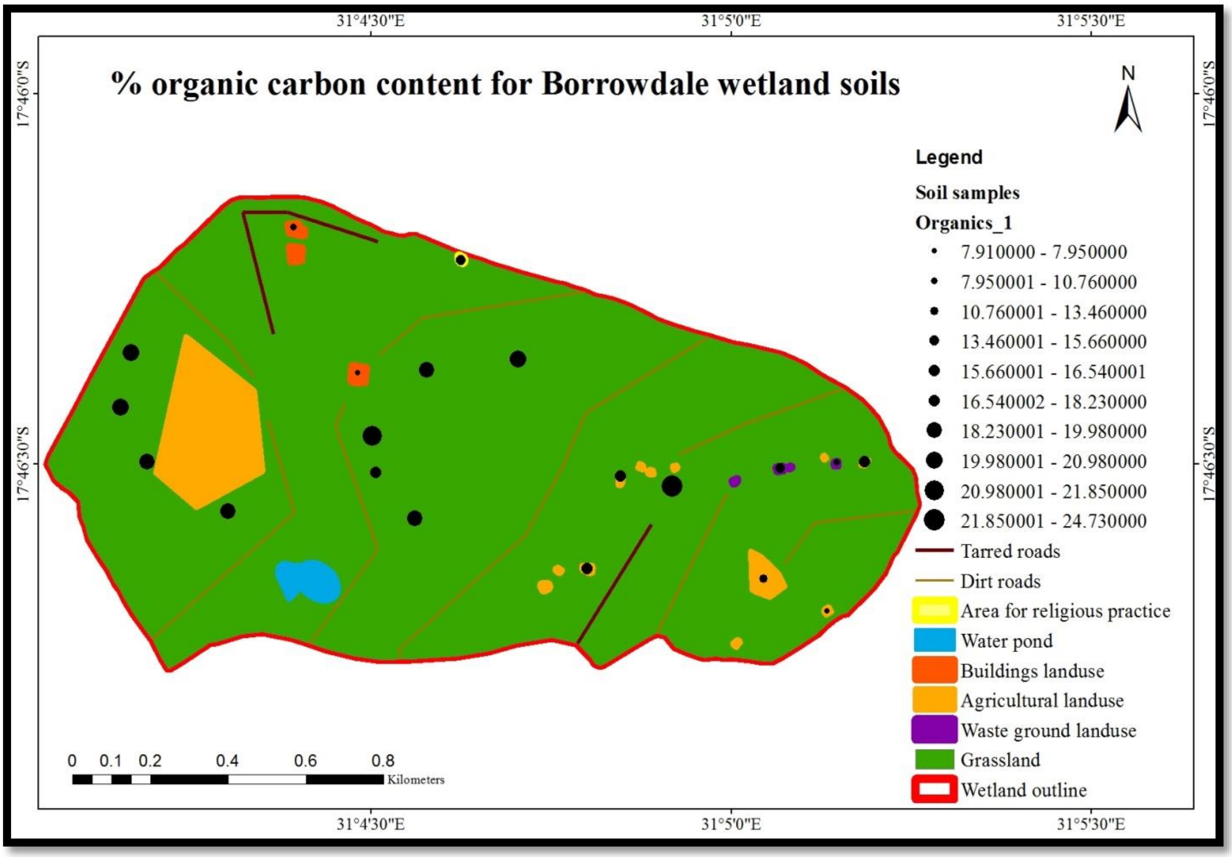


Figure 5.41: Percentage organic carbon content for Borrowdale wetland soils.

Table 15: Mean, standard deviation and range for organic carbon content of Borrowdale wetland soils.

Borrowdale wetland	Number of samples	Mean %	95% CL Mean		Standard Deviation	Min %	Max %
Utilised part	10	13.226	10.593	15.858	3.6796	7.91	18.23
Unutilised part	10	20.352	18.814	21.495	2.1489	16.10	24.73

Organic carbon content mean, standard deviation and range of sediments, differed between the utilised parts and unutilised parts (Table 15).

5.6.2. A comparison of Borrowdale wetland utilised and unutilised sediments

Four different methods which are Shapiro-Wilk, Kolmogorov-Smirnov, Cramer-von Mises and Anderson-Darling were used to test normality in organic carbon content data for both samples (Tables 16 and 17).

Table 16: Borrowdale sediments from utilised part of the wetland, normality tests results

Tests for Normality for Borrowdale soils from utilised part				
Test				
Shapiro-Wilk	**W**	0.915459	**Pr < W**	0.3206
Kolmogorov-Smirnov	**D**	0.187067	**Pr > D**	>0.1500
Cramer-von Mises	**W-Sq**	0.061168	**Pr > W-Sq**	>0.2500
Anderson-Darling	**A-Sq**	0.379649	**Pr > A-Sq**	>0.2500

Table 17: Borrowdale sediments from unutilised part of the wetland normality tests results

Tests for Normality for Borrowdale soils from unutilised part				
Test				
Shapiro-Wilk	**W**	0.899338	**Pr < W**	0.2155
Kolmogorov-Smirnov	**D**	0.233941	**Pr > D**	0.1212
Cramer-von Mises	**W-Sq**	0.109334	**Pr > W-Sq**	0.0755
Anderson-Darling	**A-Sq**	0.603727	**Pr > A-Sq**	0.0869

The results showed that organic carbon content was not normally distributed in sediments from the utilised and the unutilised parts of the wetland at p>0.05 (Shapiro-Wilk the utilised parts p= 0.3). All the methods depicted a similar pattern with p-values greater than 0.05 (Tables 16 and 17). Thus, a non-parametric Wilcoxon Two–Sample Test was computed to compare the amount of organic carbon content between the utilised the unutilised sites. The results indicated a statistically significant difference in organic carbon content at p=0.002 (one-sided t-test) and 0.002 (2-sided t-test) (Table 18).

Table 18. Wilcoxon Two sample Test (Borrowdale wetland soils)

Wilcoxon Two- Sample Test	
t Approximation	
One-sided Pr< Z	**0.002**
Two sided Pr > |Z|	**0.002**

5.6.3 Belvedere wetland soils organic carbon content

Results for organic carbon content in soils from the utilised and the unutilised parts of Belvedere wetland were also presented using tables and a map (Tables 16 and 17, Figure 5.42). Sediment samples from the unutilised parts of the wetland showed highest percentages of organic carbon content, with one sample having 46.61% (Table 19, Figure 5.42), of organics within it. However, soil samples from the utilised parts of the wetland had the lowest levels of organic carbon compared to those from the unutilised (Table 19, Figure 5.42) mainly because of the differences in landuse from both sites. Different land uses that can alter organic carbon content include cultivation, building and waste dumping.

Table 19: Belvedere wetland soils organic carbon content

Soil samples from utilised part	% organics	Soil samples from unutilised part	% organics
Bv1 utilised	14.07	BV1 unutilised	46.61
BV2 utilised	13.96	BV 2 unutilised	18.11
Bv3 utilised	20.65	BV3 unutilised	18.27
BV4 utilised	16.13	BV4 unutilised	44.03
BV5utilised	14.97	BV5 unutilised	39.42
BV6 utilised	16.26	BV6 unutilised	39.50
Bv7 utilised	21.89	BV7 unutilised	34.43
Bv8 utilised	22.97	BV8 unutilised	39.50
Bv9 utilised	25.21	BV9 unutilised	27.26
BV10 utilised	15.20	BV 10 unutilised	40.95

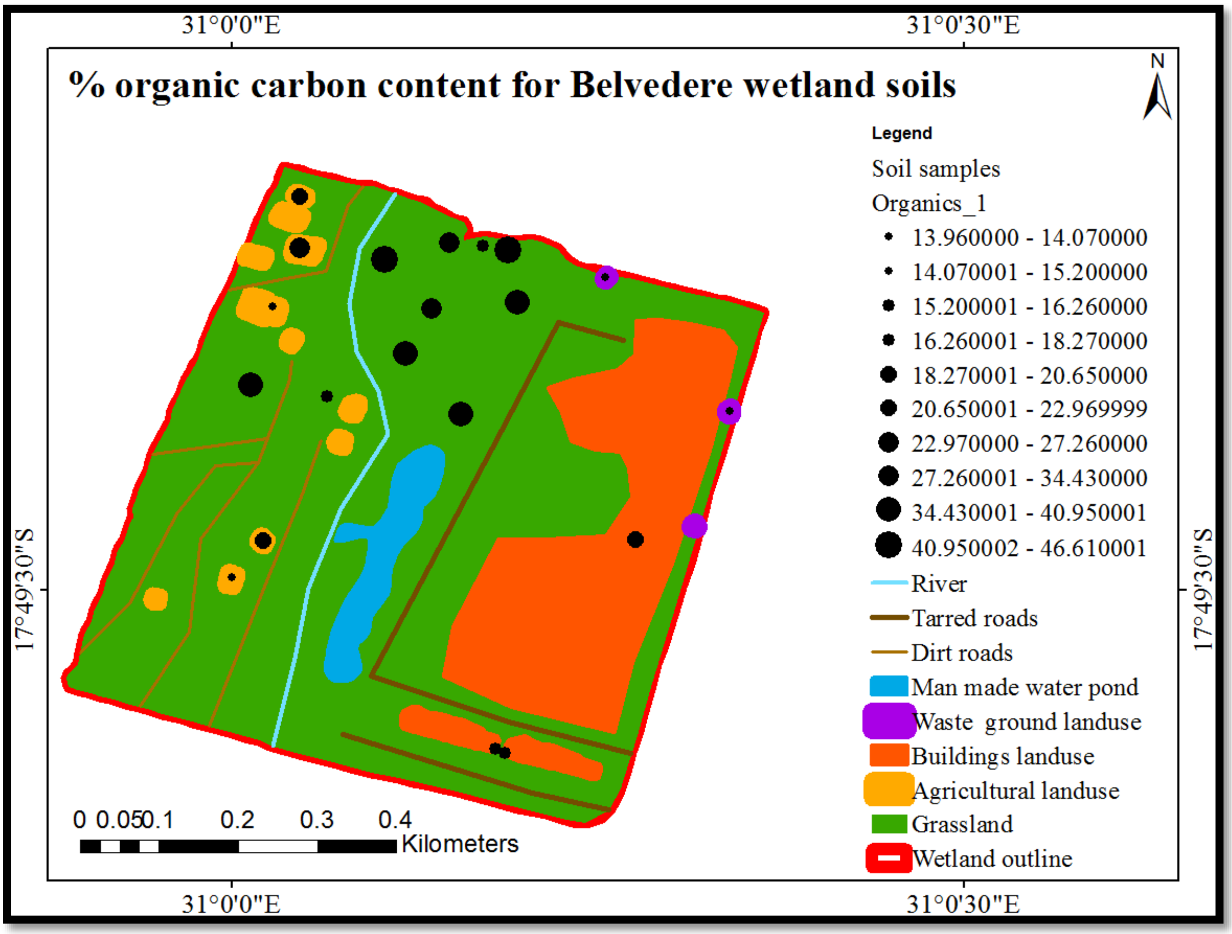


Figure 5.42: Percentage organic carbon content for Belvedere wetland soils

Table 20: Mean, standard deviation and range for organic carbon content of Belvedere wetland soils.

Belvedere wetland	Number of samples	Mean %	95% CL Mean		Standard Deviation	Minimun %	Maximum %
Utilised part	10	18.609	15.7226	21.4954	4.0349	13.96	25.21
Unutlised part	10	34.808	27.5096		10.2024	18.11	46.61

Organic carbon content mean, standard deviation and range of sediments, differed between the utilised parts and unutilised parts (Table 20).

5.6.4 A comparison of Belvedere wetland utilised and unutilised sediments

Four different methods which are Shapiro-Wilk, Kolmogorov-Smirnov, Cramer-von Mises and Anderson-Darling were used to test normality in organic carbon content data for both samples (Tables 21 and 22).

Table 21: Belvedere sediments from utilised part of the wetland normality tests results

Tests for Normality for Belvedere soils from utilised part				
Test				
Shapiro-Wilk	**W**	0.913541	**Pr < W**	0.3062
Kolmogorov-Smirnov	**D**	0.219775	**Pr > D**	>0.1500
Cramer-von Mises	**W-Sq**	0.064653	**Pr > W-Sq**	>0.2500
Anderson-Darling	**A-Sq**	0.381288	**Pr > A-Sq**	>0.2500

Table 22: Belvedere sediments from utilised part of the wetland normality tests results

Tests for Normality for Belvedere soils from unutilised part				
Test				
Shapiro-Wilk	**W**	0.860084	**Pr < W**	0.0765
Kolmogorov-Smirnov	**D**	0.274384	**Pr > D**	0.0318
Cramer-von Mises	**W-Sq**	0.11088	**Pr > W-Sq**	0.0718
Anderson-Darling	**A-Sq**	0.643064	**Pr > A-Sq**	0.0691

The results showed that organic carbon content was not normally distributed in sediments from the utilised and the unutlised parts of the wetland at p>0.05 (Kolmogorov-Smirnov,the unutilised parts p= 0.3). All the methods depicted a similar pattern with p-values greater than 0.05.(Table 21 and 22). Thus, a non-parametric Wilcoxon Two–Sample Test was computed to compare the amount of organic carbon content between the utilised and the unutilised sites. The results indicated a statistically significant difference in organic carbon content at p=0.004 (one-sided t-test) and 0.008 (two-sided t-test) (Table 23).

Table 23: Wilcoxon Two sample Test (Belvedere wetland soils)

Wilcoxon Two- Sample Test	
t Approximation	
One-sided Pr< Z	**0.004**
Two sided Pr > |Z|	**0.008**

5.7 Conclusions

Through findings from questionnaires, interviews and focus group discusions, different aspects pertaining to human environment were presented in this chapter. Results from soil grain size distribution and soil organic carbon content helped in substantiating the physical environment. Emperical findings from this chapter will be used to discuss different aspects of this studyin the next chapter (Chapter 6) and draw conclusions in Chapter 7.

Chapter 6: Analysis and discussion

6.1 Introduction

This chapter analyses and discusses the results and findings presented in Chapter 5.

6.2 Land uses and biotic threats

Results for land use mapping of Belvedere and Borrowdale showed the conversion of the other parts of the wetlands from natural or nonuse land use to human-induced land uses, such as cultivation, building, waste ground and areas for religious practices man-made ponds and dirt roads (Figures 5.1 and 5.2). For Borrowdale wetland, cultivation was the most common human-induced land use covering 4.4% of total land uses and for Belvedere building was the common human-induced land use covering 19.70% of total land uses. The conversion of the other parts of the wetlands to different land uses has been influenced by different factors. One interviewee revealed that he could not afford to buy food because he was unemployed and had to rely on the wetland for food (BV respondent 2). Some people were also generating income through selling their produce from the wetland (BR respondent, 4). Studies by Rebelo *et al*. (2010) and Marambanyika and Beckedahl (2016) revealed that some wetland values were being lost as pressure due to agriculture was exerted on the wetlands. In support of this view, Feresu (2010) argued that the rate of wetland use for agriculture in urban areas has increased due to food insecurity, unemployment, and poverty.

Economic challenges have compelled residents in Harare to rely on wetlands for survival (BR respondent 4). The number of people growing crops on Borrowdale wetlands has increased due to poverty and hunger (BR focus group 2). Rogerson (1993) and Mudimu (1997) pointed out that Government economic reforms such as the Economic Structural Adjustment Programme (ESAP) in the 1990s increased the rate of unemployment, since most people were retrenched from their jobs. A lot of people have therefore turned to urban agriculture on wetlands to produce food to sustain their livelihoods (Binns and Lynch, 1998; Feresu, 2010). Land use conversion is the major cause of wetland ecological function loss. Findings from this research reveal that vegetation on the wetlands was destroyed or changed as people cleared land for cultivation using veld fires and hoes (Figures 5.28j and 5.16). A similar study by

Marambanyika and Beckedahl (2016) on rural wetlands in Zimbabwe revealed reduction in vegetation cover due to land clearance and increased cultivation on wetlands.

The presence of new non-native plants, such as blackjack (BV respondent 2) which were not expected to be seen growing in wetlands, and the extinction of other plants like different flowers people used to harvest for sell on Borrowdale wetland (BR respondent 3), indicated that change of land use affected wetland ecological processes which also affected vegetation as a whole. Wetland users also identified threats to wetland vegetation as cultivation, buildings, deforestation, waste dumping veld fires, reed harvesting, stagnant water and taking of top soil (Figures 5.15 and 5.16). Taking of top soil from both wetlands to sell was a threat to wetland soil, since pits were created leaving the soil susceptible to erosion (Figures 5.13a and k; 5.28a and b). Top soil is equated to fertile soil, therefore, removing it means decreased soil fertility. On both wetlands, deforestation was also a threat to vegetation as people were clearing the land for cultivation and building (Figures 5.16 and 5.27). When wetlands are left alone they have the ability to support a variety of plant and animal species. This is because decayed vegetation matter and animal droppings can be recycled back into the wetland. However, one interviewee believed that if he was to be stopped from using the wetland he would die of hunger (BV Respondent 2). Thus some people were solely relying on wetlands for their survival. This same position was shared by Mlanga *et al*. (2014) who allude to the lack of alternatives for livelihoods apart from the use of urban wetlands for agriculture. Farmers were therefore growing different crops such as pumpkins, sugarcane, beans, maize and a variety of vegetables (BV respondents 1, 2 and 3) to feed their families and sell surplus (BR respondent 4).

Apart from cultivation, waste dumping and building, wetland users also reveal other threats such as taking of top soil, artificial fertilisers, soil erosion and veld fires (Figures 5.11a and 5.23a). One interviewee revealed that he had to leave the field he started using in 2000 and looked for a new field on Borrowdale wetland because the soil was no longer fertile and the harvest had deteriorated (BR respondent 3). Unsustainable farming methods have led to the deterioration of the quality of wetland soils. Similar results were confirmed by Rebelo *et al*. (2010) in which people revealed that the soil was losing its fertility due to cultivation and they were opting to use fertilisers to improve their harvest. Intensive use of urban wetlands for agriculture has threatened environmental sustainability, caused biodiversity and wetlands ecological function loss (Silvius *et al*., 2000). Schuyt (2005) showed that similar problems such as overuse of wetland resources due to poverty and overpopulation have affected Nakivumbo urban wetland in urban Uganda wetlands, and land was left bare since farmers cleared the land to grow their crops.

Cultivation, building, waste dumping and taking of top soil were also affecting Borrowdale and Belvedere wetland water (Figures 5.11b and 5.23b). This has affected the amount of water available such that some parts of the wetlands were drying up (Figure 5.12a and b; BV respondent 2). Limited water on major vleis in Harare such as Borrowdale and Belvedere has affected the amount of water then going into major rivers such as Manyame and Mukuvisi. One interviewee pointed out that they were buying water in Borrowdale West because their boreholes which relied on the wetland for water supply were drying up due to construction (BR respondent 3). However, boreholes in Borrowdale West were also affecting the amount of water on Borrowdale wetland, as they were all drawing water from the wetland (BR focus group 1). People from one focus group revealed that they never used to grow crops on the wetland because of too much water (BR focus group 1). Land use changes and different human activities were, therefore, modifying the ecological functioning of the wetlands. Limited water on the wetlands destroyed the aesthetic value of wetlands (Figure 5.12a and b). A similar study by Murungweni (2013) on Monavale wetland in Harare revealed loss of biodiversity, habitat and aesthetic value of wetlands due to land use changes (cultivation and building). One Belvedere interviewee also revealed that building of houses and the Chinese Mall on Belvedere wetland impacted negatively on the water (BV respondent 2). He confirmed that when he started using the wetland in early 1970 there was a lot of water on Belvedere wetland and Watermeyer Street was named so because of too much water that was on the wetland (BV respondent 2). A similar study by Rebelo *et al*. (2010) on human use of two rural wetlands in Tanzania (Zanzibar and Kilombero Valley) revealed wetland users attributing the drying of the wetland to different human land uses such as cultivation.

Destruction of animal and habitats through veld fires and deforestation (Figures 5.14a and b; 5.26a and b) have caused the migration of many animals and birds from both wetlands. Bird catching and animal hunting for meat have also threatened the remaining birds and animals found in Borrowdale and Belvedere wetlands (Figures 5.14a and b; 5.26a and b). One interviewed farmer said that they were seeing few hares and snakes on Borrowdale wetland and only three duikers were left (BR respondent 5). An interview for Belvedere wetland with one farmer revealed that most animals such as warthogs left the wetland when the Chinese mall was built and monkeys were seen coming to feed on their crops (BV respondent 3). In support of this view Thompson and Hamilton (1983) argued that unsustainable use of wetlands can affect animal species since the change of water regimes changes the composition of invertebrates that provide food for other animals. In a bid to survive, the urban poor have employed unsustainable ways of extracting wetland benefits thereby increasing environmental degradation.

Tarred roads and buildings on both wetlands (Figures 5.13d and e; 3.3k) have resulted in impervious concrete surfaces. Urbanisation has therefore increased the drying up of wetlands ecosystems since they are being replaced by concrete pavements and buildings (Bowyer-Bower *et al*., 1996; Paucharda *et al*., 2006). Land use changes on both wetlands have therefore affected the potential of the wetlands to perform their nutrient and water retention functions. According to Mushamba (2010), Harare local government has generated a lot of money from selling land for housing development and as a result, most wetlands are occupied. A study by Schuyt (2005) also revealed that most African governments have given value to economic projects that generate more money rather than protecting wetlands.

Waste dumps have become an eyesore on Belvedere and Borrowdale wetlands (Figures 5.6c, 5.13b and l, 5.28d), because of most of the solid waste such as plastics and bottles are not biodegradable. Waste dumped on these wetlands has threatened wetland vegetation, water, soil, and animals (Figures 5.11, 5.14b, 5.15, 5.23, 5.26b and 5.27). Water quality on both wetlands was also being affected by waste dumping and sewage. Bursting of sewer on Borrowdale wetland and waste dumping polluted the water (Figure 5.13g and i; BR respondent 3). More so, sewage disposal and solid waste dumping on Belvedere wetland led to water pollution such that algae developed on the water (Figures 5.22 and 5.24). Algae develops where there are sufficient nutrients mostly phosphorous and nitrogen. Therefore algae on Belvedere wetland water reflected the presence of phosphates and nitrates within the water. This showed that the water was contaminated and of poor quality. In support of this view, Norton (1992) argues that algae have grown in some wetlands as a result of pollution in wetland soils. Urban residents dump waste on wetlands because wetlands in Harare just like in most urban areas in developing countries are sometimes treated like common property open for access to all urban dwellers. Replacement of the natural land use by waste dumps has also affected the flow of water within the wetland (Figures 5.22 and 5.24) and led to habitat loss and altered wetland soil structure. Studies by Bowyer-Bower and Drakakis-Smith (1996) and Mlanga *et al*. (2014) revealed that land use change in urban areas has resulted in the alteration of the chemical components of water, destruction of biodiversity, habitat loss and soil erosion in most wetlands. The increase of Harare population has resulted in the increase of residential areas and the city council has failed to offer proper services to these areas. According to Feresu (2010), the Harare city council does not have sufficient resources to cater for the growing population. Thus, it lacks the capacity to collect waste generated by residents. Borrowdale wetland was also being used for religious practice and dirt roads developed as people were visiting the wetlands (Figures 5.1 and 5.2). Trampling on wetland soil during the religious gathering and using dirt roads have led to soil compaction. This has affected the rate of infiltration in these areas. Dirt roads have destroyed vegetation on both wetlands (Figures 3.3n; 3.5i and j).

6.3. Anthropogenic uses of wetlands and their values

Residents were using Belvedere and Borrowdale wetland for different purposes and some were depended on wetlands to sustain them since they were using them for more than one purpose (Figures 5.5 and 5.18). For example for Borrowdale wetland, 3 people were using the wetland for six different purposes whilst for Belvedere 3 were using the wetland for all seven different purposes (waste dumping, agriculture, building, using water, collecting firewood, religious gathering and cultural activities). Out of 40 respondents to Borrowdale questionnaires, 24 were using wetlands for more than one purpose and for Belvedere, out of 39 respondents, 27 were also using wetlands for more than one purpose. Mitsch and Gosselink (2000) argue that using wetlands for different purposes have made them become valuable as they are utilised by people for their wider combined benefits.

Many respondents pointed out that they were using the wetlands for agriculture (Borrowdale 28%; Belvedere 25%) (Figures 5.5 and 5.18). Studies by Mbereko *et al*. (2007) and Marambanyika and Beckedahl (2016) on rural wetlands in Zimbabwe also revealed that people were using the wetlands for different purposes (rituals, fishing, cultivation, fishing, hunting, livestock grazing and medical purposes). Borrowdale and Belvedere wetlands were used for agriculture because of water availability, fertile soil, and that they are open places left in the urban areas (Tables 2 and 7; BR respondent 4). Mbereko *et al*. (2007) and Marambanyika and Beckedahl (2016) revealed similar results, that a lot of people were using the rural wetlands for agriculture. Most of these people had farms within the wetlands (Borrowdale, 80%) and those who did not have farms (Belvedere, 58%) failed to secure farms because of the shortage of space. Respondents with families were therefore compelled to resort to agriculture to feed their children. Since wetlands have become a source of income and food (BR respondent 4) for urban residents there was competition in securing farms within wetlands. As reported by Scoones (1991), wetlands are the only natural ecosystems left in arid and semi-arid areas which are reliable and readily available to everyone. Those who were using the wetland for building purposes pointed out that the land was allocated to them by the government and those who were dumping waste on the wetlands blamed the government for not collecting refuse (Tables 2 and 7). Accommodation problems in Harare have forced government planners and land developers sell open spaces occupied by wetlands for residential development. Some people were also using wetland water for domestic purposes and some were collecting firewood (Figures 5.5 and 5.18). Some people were, therefore, being forced to rely on wetlands for water and fuel. This shows the failure of the Harare city council to meet the demands of the people due to population pressure. This position was also shared by Manzungu *et al*. (2016) who argued that failure by the Harare city council to provide clean water to residents has forced some residents to resort to wetland water.

Employed people were also found using wetlands. Hyperinflation might have forced employed people to use wetlands to supplement their income, since food was expensive (BR focus group, 2). Thus questionnaires were administered to employed people who were also using these two wetlands for different purposes (Tables 1 and 6). Some people who were interviewed were also employed (Borrowdale 60%; Belvedere 68.6%). Binns and Lynch (1998) argued that people from poor households were using wetlands mostly for agriculture to produce food to sustain their families. Some people who were employed could not rely on their salaries for food let alone pay fees for their children. Borrowdale and Belvedere wetlands were therefore used for different purposes to solve some of the problems which were faced by Harare residents. Urban life in developing countries such as Zimbabwe has become very expensive such that some employed people cannot survive without supplements to their incomes. Some people were coming from more than 5 km to use Borrowdale and Belvedere wetlands (Tables 1 and 6). For Belvedere wetland some people were coming from Norton (40 km) and Mabvuku (21 km). The same problems that people in Harare were facing that required them to use wetlands were also faced by people who were not staying close to the wetlands. Some people are forced to travel long distances to Belvedere wetlands because few wetlands are still found in some areas around Harare. Most of these wetlands have been destroyed and people were depending on the few left.

Findings from this research showed that men were equally involved than women in using wetlands for urban agriculture (Tables 1 and 6). This is contrary to Mudimu (1997)'s study which revealed that women in sub-Saharan Africa were more actively involved in urban farming on wetlands than their men since they were compelled to bear the essential responsibility of making sure that their families are fed. Unlike in the past where women only would participate in urban agriculture, men have also become active participants in using wetlands. Economic challenges such as unemployment and hyperinflation discussed above compelled some males to use wetlands to survive and also feed their families. Despite using wetlands to solve problems of food insecurity, wetland users in urban areas also see wetlands as the only available cheap source of solving their financial problems (BR respondent 4, BV respondent 3).

6.4 Human perceptions and understanding of the importance and use of wetlands

Despite a few who were not aware of the importance of wetlands, most Borrowdale and Belvedere wetland users understood the importance of wetlands. Most respondents did not support the view that wetlands are wastelands that should be destroyed (Borrowdale, 78%; Belvedere, 82%) (Figures 5.4 and 5.17). Wetland users treasured the continual existence of wetlands. This is because they appreciated the fresh air they would continue to get from wetlands and that their children would also learn about animals, birds and plants from wetlands (BV respondent 1, BR respondent 3). These results were contrary to Matiza (1994)'s argument which states that people perceived wetlands as wastelands that should be destroyed. Although residents had different attitudes pertaining to wetland existence, a few perceived them as wastelands (Borrowdale 10%; Belvedere 13%) (Figures 5.4 and 5.17). More so, a lot of people were against the view that wetlands are wastelands that can be exploited (Figures 5.4 and 5.17).

People indicated that they understood the dangers which were associated with wetlands. Most people supported the view that wetlands allow mosquito to breed (Borrowdale 69%; Belvedere 77%) (Figures 5.4 and 5.17). One focus group indicated that Borrowdale wetland was dangerous to residents since thieves were hiding behind the tall grass and some people have been robbed by these thieves, and they also habitat poisonous snakes (BR focus groups 1 and 2). Farmers believed that by cultivating on the wetland they were clearing the wetland to avoid thieves from hiding (BR focus group 2). Although wetland users indicated that they were aware of the dangers associated with wetlands, few people supported the view that wetlands are dangerous since children can drown (Borrowdale, 43%; Belvedere, 46%). Cases of drowning on vleis such as Borrowdale and Belvedere were, therefore, rare since these are seasonally waterlogged vleis. The view that government should stop allocating stands on wetlands was supported by a lot of people (Borrowdale 83%; Belvedere 72%) (Figures 5.4 and 5.17). Farmers believed that building was more dangerous to wetland ecosystems and it was better that they would be used for cultivation (BR respondent 9). One interviewed farmer argued that allocating wetlands for developmental purposes would only benefit a few and they were to lose their fields (BR respondent 4). A lot of people were, therefore, concerned about food security. Thus they strongly supported the view that wetlands should be conserved (Borrowdale 93%; Belvedere 85%) (Figures 5.4 and 5.17) so that they would continue to have land to grow their crops. A similar study by Marambanyika and Beckedahl (2016) also revealed that people supported conservation of wetlands to protect benefits from cultivation such as food and income generation.

6.4.1 Human perceptions on socio-economic benefits of wetlands

Respondents confirmed that they were benefiting economically and socially from, Borrowdale and Belvedere wetlands. Most respondents were getting domestic water from the wetland (Borrowdale 61%; Belvedere 62%) (Figures 5.7 and 5.19). Boreholes in Borrowdale West were drawing water from Borrowdale wetland (BR focus group 1). A similar study by Rebelo *et al*. (2010) reveals that people were also getting water for domestic use from the wetlands. Respondents confirmed that wetlands provided water for agriculture (Borrowdale 76%; Belvedere 79%) (Figures 5.7 and 5.19). One farmer who was interviewed confirmed that she was harvesting a lot of maize because of the availability of water on Borrowdale wetland (BR respondent 4). Studies by Mbereko *et al*. (2007), Svotwa *et al*. (2008), Rebelo *et al*. (2010) and Marambanyika and Beckedahl (2016) also revealed that people opted to grow crops on wetlands because of water availability since dry land agriculture was no longer productive. Some farmers were also able to send the maize they harvested from the wetlands to their relatives in rural areas (BR respondent 4, BR focus group 2). Besides being sources of food for urban dwellers only, urban wetlands have also become a source of food for rural people. Respondents were also generating income through selling fishing worms and mats made from reeds collected from wetlands (BV respondent 2, BV respondent 3). One interview respondent indicated that she was able to pay her child's school fees with the money she gets after selling her harvest (BR respondent 4). Studies by Mbereko *et al*. (2007) and Marambanyika and Beckedahl (2016), revealed that people were also benefiting economically from using wetlands since they collected reeds to make baskets to sell and also selling fishing worms. One interview respondent pointed out that they were harvesting a unique vegetable called water curse (*Kasunika* in Shona) from Belvedere wetland and sell it. Mbereko *et al*. (2007) and Marambanyika and Beckedahl (2016)'s studies also shared the same position, revealing that people were harvesting and eating traditional vegetables from wetlands in rural areas. Few respondents agreed with some of the economic benefits of Borrowdale and Belvedere wetlands. Some respondents disagreed that Borrowdale wetland was providing them with building material (46%). For Belvedere wetland, 46% agreed that they were getting building material. Although some respondents from Belvedere indicated that wetlands provided them with firewood (Figure 5.19) some dismissed this benefit. For Borrowdale wetland, 53% (Figure 5.7) denied collecting firewood from the wetland. Most people could not rely on both wetlands for the provision of firewood and building materials because of the absence of trees within the wetlands. However, a similar study by Rebelo *et al*. (2010) revealed contrary results since people in Kilombero Valley, Tanzania were using grass from the wetland for thatching and timber and other plant species for building. Uncontrolled cultivation and urbanisation on urban wetlands have therefore removed some of these economic benefits.

Respondents appreciated the recreational values of wetlands such that a lot of them agreed that wetlands were centres of recreational activities such as wildlife viewing and birdwatching (Borrowdale 67.5%; Belvedere 61.5%) (Tables 3 and 8). Wildlife viewing and birdwatching were also considered as important recreational activities attracting tourists at Monavale vlei in Harare (Murungweni, 2013). More so, respondents acknowledged that wetlands like Borrowdale and Belvedere were centres of learning whereby people would learn about different birds, animals and plants found in the wetlands (Borrowdale 62%; Belvedere 74.4%) (Tables 3 and 9). However, by disagreeing with the view that wetlands should be a place where people should stay (Borrowdale 67.5%; Belvedere 48.7%) respondents were concerned about the continual existence of the wetlands because of their direct benefits since they believed that building on wetlands would totally destroy the wetlands. One interviewed user was against wetland destruction since she feared that her children would not be able to see wild animals, birds and plants found in the wetlands (BR respondent 3). This is because unique plants, mammals, reptiles and amphibians which are not found on the other parts of the landscape are only available on these wetlands (Hugget *et al*., 2004).

6.4.2 Human perceptions and understanding of the environmental benefits of wetlands

Although respondents had varied perceptions about environmental benefits of wetlands, most of them indicated that they were conversant with most of the environmental benefits of wetlands. This is revealed by the number of people who supported different environmental benefits. Most respondents supported the following environmental benefits: wetlands modify climate (Borrowdale 68%; Belvedere 56%), habitat for plants and animals (Borrowdale 85% Belvedere 92%), and that they enhance groundwater recharge (Borrowdale 75%; Belvedere 76%) (Figures 5.9 and 5.20). For Borrowdale, few respondents (43%) agreed with the view that wetlands store carbon dioxide. Some were skeptical about this environmental benefit (38%) and some disagreed with it (20%). Although there were some respondents who were not sure about the view that wetlands store carbon dioxide (18%) and some who disagreed (23%), most respondents for Belvedere questionnaire supported this view (59%).

More so, some respondents were not sure about how wetlands improve water quality and therefore did not support this view (Borrowdale 23%; Belvedere 25%) and some remained neutral (Borrowdale 30%; Belvedere 23%). Although a lot of respondents were conversant with some of the environmental benefits of wetlands, they did not have sufficient knowledge about some of the functions of wetlands. As revealed by one interview respondent, information about wetlands was still sketchy and their purpose and importance were not explained to the general public (BR respondent 1). Knowledge about the environmental benefits of wetlands was not disseminated to the people effectively by Harare city council and EMA officials, such that some people were not aware of their importance. The same position was also shared by Rebelo *et al*. (2010) who pointed out that wetland users do not have sufficient knowledge about all the varied benefits of wetlands and therefore they end up using wetlands unsustainably in most cases.

6.4.3 Human perceptions and understanding of the effects of different land use on wetlands

Respondents were certainly conversant with the impacts of different land uses on wetlands as revealed by how respondents from both wetlands agreed with the different land uses impacts on wetland ecosystems. Changes brought about by different land uses on both wetlands have been observed by wetland users. Respondents supported the view that waste dumping pollutes wetland water (Borrowdale 88%; Belvedere 97%) (Figures 5.10 and 5.21) and waste dumped on wetland water was clearly visible on Belvedere wetland (Figure 5.22). Respondents were aware of the negative impacts of different land uses: cultivation on wetlands causes soil erosion (Borrowdale 68%; Belvedere 79%), building houses and cultivation destroy habitats for animals (Borrowdale 76%; Belvedere 90), birds have migrated since houses were built here (Borrowdale 73% Belvedere 77%), and wetland soils loose fertility due to cultivation (Borrowdale 75%; Belvedere 72%). Some species die due to waste dumping on wetlands (Borrowdale 88%; Belvedere 82%) wetland cultivation destroys the beauty of wetlands (Borrowdale 88%; Belvedere 72%), and building houses on wetlands destroys the soil quality of wetlands (Borrowdale 68%; Belvedere 82%). Despite the community's awareness of the effects of different land uses on wetlands, they continue to use wetlands unsustainably.

6.5 Land use conflict

In both case studies, respondents revealed varied land use conflicts between different stakeholders. The Harare city council views wetlands as a profit-making resource through selling wetlands for developmental purposes. However, respondents especially farmers were grieved about how wetland ecological integrity was being compromised through allocating wetlands for developmental purposes. One interview respondent suggested that the government should stop allocating stands on wetlands since they would end up losing their fields (BR respondent 4). Contrary to the Harare city council and government officials' intentions, most respondents from both case studies supported the use of wetland for agriculture. Another interview respondent said that there were disagreements among government officials on whether to build on Borrowdale wetland or not, and part of wetland was fenced for four years after it had been sold to foreign investors for building a mall (BR respondent 4). However, residents complained that they were not consulted when decisions to use wetlands for construction purposes were taken. One interviewed farmer felt that by allocating stands on wetlands the government was ignorant of future generations since this would degrade wetlands (BR respondent 3).

Although residents of Harare were lobbying against building on wetlands, construction on Borrowdale and Belvedere could continue with the support of the government. Land use conflicts on Borrowdale and Belvedere wetlands had become a sensitive issue which some respondents were scared to talk about (BV respondent 2). As was revealed by one interviewed farmer, there was also conflict between environmental agencies and government on how wetlands in Harare should be used. He said that EMA tried in vain to stop the Chinese from building the mall on Belvedere wetland but corrupt politicians intervened and the mall was built. Although Section 113 (1) of the Environmental Management Act (Chapter 20:27) states that the minister may stop or limit development on ecologically sensitive areas (EMA ACT, 2003), developments on Borrowdale and Belvedere wetlands have continued. Some politicians have therefore promoted their interests by approving construction on Belvedere and Borrowdale wetlands without the minister objecting. According to Schuyt (2005), decision makers in most developing countries are not concerned about environmental issues pertaining to wetlands, since to them protecting wetlands may not be very important. A study by Mushamba (2010) revealed that Harare local government generated a lot of revenue from selling land, and as a result, most wetlands are occupied. In addition, Section 4 (d) of the Environmental Management Act (Chapter 20:27), also assigns the minister to monitor the environment and trends in the utilisation of natural resources and the impact of such utilisation on the environment. However, utilisation of Borrowdale and Belvedere wetland was not being monitored and these wetlands were under pressure. Mlanga *et al*. (2014) observed that wetland utilisation was continuing uncontrollably and construction in Harare was taking place on most wetlands at a high rate.

Respondents argued that allocating wetlands for developmental purposes was not fair as it would only benefit a few (BR respondent 4, BV respondent 4). One focus group said that they were not worried much about changes happening on the wetland due to cultivation, but were most concerned about losing wetlands to housing development since this would increase poverty because their fields would have been occupied (BV focus group 1). Apart from land use conflict between people and the government (Harare city council), there was also conflict between the farmers and people who were taking top soil. One interviewed farmer said that they were fighting with people who were taking top soil from their farms since they were taking fertile soil leaving them to grow crops on unfertile land (BR respondent 6). Contrary to these results, a similar study by Mbereko *et al*. (2007) revealed wetland management conflicts between traditional leaders and the government, whereby headmen blamed modern wetland management systems for overriding the traditional systems. Land use conflicts on both Borrowdale and Belvedere wetlands were mainly between the government and the general public based on wetland use rather than on management.

6.6 Wetlands and climate change

Apart from anthropogenic uses threatening wetlands, Borrowdale and Belvedere wetlands were also affected by natural phenomena such as climate change. Belvedere respondents suggested climate change as a threat to wetland water (5%) and vegetation (5%) (Figures 5.23b and 5.27 respectively). Droughts caused by unreliable rainfall have also affected wetland birds (Figure 5.26a). The same position was shared by Mortsch (1998) who argues that apart from the pressure that wetlands can experience from urbanisation, agriculture and waste dumping, wetlands are also experiencing additional stress from climate change. Some respondents confirmed that rainfall was no longer reliable and sometimes they received little and sometimes more than expected, and the meteorological department have been warning people about heat waves since 2015 (BR respondent 8, BR focus group 2). The increase in temperatures in 2015 and 2016 in Zimbabwe affected the ecological quality of Borrowdale and Belvedere wetlands (BR respondent 8). In evaluating the effects of climate change on ecosystems, Leemans and Eickhout (2004) found that the rapid increase in global mean temperatures limits the adaptive capacity of wetland species, and the decline in biodiversity affects many valuable and functional characteristics of wetlands.

Change in temperatures and rainfall reliability due to climate change has therefore induced stress on wetland soil temperatures, hydrology, wetland species, and also posed a threat to species habitats on wetlands (Bridgham *et al*., 1995; Dawson *et al*., 2003). Rain-fed agriculture on dry land in Harare has proved to be unsustainable due to unreliable rainfall and people have opted to grow crops on wetlands since they retain moisture for a long time. This has increased agricultural land use on wetlands thereby affecting their ecological integrity. This position was also shared by Hartig *et al*. (1997) who argued that climate change has increased the encroachment of agricultural activities on wetlands thereby degrading them. The increase in the number of people growing crops on wetlands indicated that dry land agriculture was no longer profitable due to climate change which affected peoples' harvests.

6.7 Comparison of grain size distribution of wetland sediments

Borrowdale wetland sediments grain size distribution from the utilised parts of the wetland varied considerably with that from the unutilised parts. The mean grain size distribution for sediments from the utilised parts of Borrowdale wetland ranged from 445.6-802.8 μm (Table 10) and for those from the unutilised parts ranged from 557.0-868.4 μm (Table 11). The mean range of the grain sizes of Borrowdale sediment samples from the utilised parts was higher (357. 2 μm) than from the unutilised parts (311.4 μm). This shows that coarser sized grains were present in the unutilised samples. The abundance of coarser grain sizes in sediments from the unutilised part of the wetland was due to the slope catena since most of the sediments from the unutilised part were collected from a lowland area. The elevation for sediments sites from the unutilised parts of the wetland ranged from 1524-1532 m and for those from the utilised parts of the wetland ranged from 1515-1527 m. Coarser grain sizes would have been eroded from bare, high and utilised (agricultural, waste ground, building and area for religious practice land uses) land and trapped to the low lying areas of the unutilised parts of the wetland because of the presence of vegetation.

The abundance of coarser sediments on the unutilised parts of Borrowdale wetland was also reflected by the presence of most poorly sorted very coarse sand (7) (Table 12) compared to the sediments from the utilised parts which had more poorly sorted coarse sand (9 sediment samples) (Table 10). According to Bell and Roberts (1991) most of the vlei in Zimbabwe are ‘sandvleis’ dominated mainly by sand sediments with little clay and are non-calcic. However, sometimes soil tillage can put the soil under stress and this can lead to some particles breaking down into smaller particles forming more fine grain size particles in the utilised parts of the wetlands. Only 1 sediment sample from the unutilised part of the wetland had equal concentration of both coarse grain sizes and fine grain sizes (symmetrical or normal distribution) whilst (3 sediment samples) from the utilised parts of the wetland showed symmetrical (normal) distribution (Tables 10 and 11). Although most sediments from the unutilised part of the wetland were positively skewed (fine skewed), skewness values for the unutilised sediments were lower than those from the utilised side. Skewness of sediments from utilised part of the wetland ranged from 0.475-1.429 for those from unutilised part ranged from 0.278-0.985 (Tables 10 and 11). More so, this reflected presence of more course grain sized particles on the unutilised parts of the wetlands than the utilised parts.

The range of skewness values of sediments from the utilised parts of the wetland was 0.954 whilst the one for the unutilised sediments was 0.707. Thus, more sediments from utilised parts of the wetlands were, therefore, more positively skewed than those from unutilised parts reflecting coarser grain sized particles on the unutilised part. More so, high kurtosis values were recorded from the utilised parts of the wetland with half of the samples showing mesokurtic (normal distribution) and the other half platykurtic (flat peaked curve) (Table 10). However, majority of the sediments from the unutilised parts were platykurtic (flat peaked) (8) whilst a few sediments were (mesokurtic) (2). The kurtosis value range was 2.884 from the utilised parts and 1.232 from the unutilised parts. As people were taking top soil from the wetlands, most fine grain sized particles could have been carried away leaving coarse sized particles which were eroded and deposited to the unutilised parts of the wetland.

Grain size mean, skewness and kurtosis for sediments from Belvedere wetland also varied. Belvedere sediments from the utilised parts of the wetlands had the highest mean range (538.9 μm) compared to sediments from the unutilised parts of the wetland (72.7 μm) (Tables 12 and 13). Some sediments from the utilised parts were poorly sorted very sand coarse and these included 2 samples collected from building land use (BV 3 utilised and BV 7 utilised) and 1 from waste dumping land use. Building and waste dumping land use, therefore disturbed the aggregates of the soil, making them coarser (Table 12). All sediment samples from the unutilised parts of the wetland were poorly sorted coarse sand because they were not tampered with (Table 13).

Exceptional observations were recorded from one sediment sample from the utilised part of the wetland which had values which indicated negatively skewed (-0.041) meaning that the sample had more coarse grains (Table 12). However, Leptokurtic (peaked curved) were also recorded from some sediments (2) from the utilised parts indicating the presence of more fine grains than in samples from the unnutlised parts of the wetlands (Table 12). High skewness range (1.12) was recorded from the utilised parts compared to the unutilised parts (0.333). Although these samples had coarse grain sized particles, coarse grains were more common from the unutilised parts of the wetlands than the utilised parts. Although sediment samples from the unutilised parts of the wetland were all positively skewed, kurtosis ranged from mesokurtic distribution to platykurtic (Table 13). The kurtosis values for sediments from the utilised parts ranged from mesokurtic, platykurtic to leptokutic (Tables 12). Fine grained sediments were, therefore, available in sediments from the unutilised part of the wetlands but in limited amounts. However, the abundance of coarse grain sizes from the unutilised part of the wetland reflects deposition from high-land (outside the wetland) to low-land (the unutilised parts of the wetland) and trapped by vegetation. Coarser grains were not eroded from the utilised parts of the wetlands because the slope angles of the sites (the utilised parts and the unutilised parts) were uniform since the topography was quite flat.

6.8 Comparison of organic carbon concentration in different wetland sediments

As a result of different land uses on both wetlands, the variability of organic carbon content percentages within sediment samples from the utilised parts and the unutilised parts were shown. The mean percentages of organic carbon content for soils from the utilised parts of Borrowdale ranged between 10.59% and 15.86% whilst for soils from the unutilised parts ranged from 18.81% to 21.50% (Table 14). For Belvedere wetland the mean organic carbon content of sediments from utilised parts of the wetlands ranged from 15.72% to 21.50% whilst for sediments from the unutilised parts ranged from 27.51% to 42.11% (Table 29). Wilcoxon Two-Sample Test for both wetlands indicated statically differences in organic carbon content for soil samples from the utilised and the unutilised parts of wetlands at p=0.002 (one-sided t-test and 2-sided t-test) for Borrowdale and p= 0.004 (one-sided t-test) and p=0.008 for 2-sided t-test) (Tables 18 and 23). This reflected that sediments from the utilised parts of both wetlands were losing their quality (fertility) due to different land uses such as waste ground, building and waste dumping. Organic carbon content from the utilised parts of Borrowdale wetland showed a wider range (10.28%) of values compared to sediments from the unutilised parts (8.63%) (Table 14). Although there was a wide range of values within sediment samples from unutilised part of Belvedere wetland (28.5%) compared to sediments from the utilised parts of the wetlands (11.25%), highest percentage concentrations of organic carbon content were recorded from the unutilised sediments.

Some farmers have been using the wetlands for a long time (BR respondent 3) and soil organic matter has since been exhaustively used for crop production. This has lowered the amount of organic carbon content in sediments from the utilised parts of the wetlands thereby reducing the quality of the soil. In some cases, high values of organic carbon percentages were recorded from the utilised parts of the wetlands (Tables 14 and 19), and this revealed that some of the fields were still new. A study by Niaz *et al*. (2017) reveals similar results in which different land uses lowered soil organic carbon content concentrations within the soils since they were affecting the amount of carbon that would be flowing in and out. Some sediment samples were collected from building land uses (Figures 5.29 and 5.30) and showed low organic carbon concentration because these soil were mixed up with different building materials like cement. Different human activities such as cultivation, building and waste dumping on Borrowdale wetland have affected the soil quality thereby lowering the organic carbon content of the soils. Bronson *et al*. (2004) observed that organic carbon content has long been considered as a reflector of the productivity of the soil and loss of organic carbon content, therefore reflect that the soil quality is deteriorating.

6.9 Ways of dealing with wetland threats, sustainable wetland use and conservation

Evidence from both case studies also showed that respondents supported conservation of wetlands (Borrowdale 93%; Belvedere 85%) (Figures 5.4 and 5.17). However, wetlands in Harare do not have collective ownership like those in rural areas, whereby every member of the community participates in the conservation of wetlands spearheaded by traditional leaders. One interview respondent said even if they wanted to conserve wetlands they did not have powers to stop people from abusing wetlands because the wetlands are owned by the city of Harare, but if it was in rural areas they would advise the headman on how to use wetlands (BV respondent 7). Respondents suggested different ways of dealing with wetlands threats, using wetlands sustainably and conserve them (Tables 4, 5 and 9). Law implementation and enforcement was suggested by many respondents as the main way of dealing with threats to wetland elements (Borrowdale 75%; Belvedere 79%), and using and conserving wetlands sustainably (Borrowdale 25%; Belvedere 28%). Most respondents from Borrowdale indicated that they were not aware of wetland laws (55%). Zimbabwe does not have a national wetland policy but only wetland legislation which some people are not aware of. Section 4 of the Zimbabwe Environmental Management Act (EMA) (Chapter 20:27), 2002, bestows to every citizen the right to live in a clean environment that is not harmful to their health, with access to environmental information, the right to protect the environment for the benefit of present and future generations, and the right to participate in the implementation of legislation and policies that prevent pollution, environmental degradation and sustainable management and use of natural resources, while promoting justifiable economic and social development (EMA ACT, 2002).

However, information pertaining to wetlands is scarce among people and 60% of the respondents from Borrowdale indicated that there was no information given to them about wetlands. Information on how wetlands should be used is not effectively disseminated to people by EMA officials and the Harare city council environmental officers. This contradicts a study by Marambanyika and Beckedahl (2016) which reveals different methods such as workshops, meetings and interactions which were used to spread information about different laws that protect wetlands. Although 54% of Belvedere respondents indicated that they were aware of the laws which guard against wetlands and 51% indicated that information was given to them about wetlands, they were only getting the information about wetlands from the media (radio, newspapers, television and magazines). Information on wetland laws is not properly communicated to all people, leaving most people unaware.

Respondents from both wetlands also suggested implementing sustainable methods of farming as a way of using and conserving wetlands sustainably (Borrowdale 20%; Belvedere 21%). However, sustainable farming methods can only be implemented if people are taught on how to use wetlands (Borrowdale 10%; Belvedere 18%) in order to conserve them sustainably. Wetlands should benefit people but they should be used wisely to enhance economic and social development. Some farmers showed that they did not trust the government officials and EMA officials and therefore were not comfortable to be taught sustainable farming methods by them. Discussion with one focus group revealed that farmers do not agree on sustainable ways of using wetlands and some farmers were not aware of sustainable farming methods. However, farmers preferred to be taught good farming methods by seed companies such as Seed Co because they give people seeds and teach them how to grow them using sustainable ways. They feared that the government would only lure them into voting for them (BR focus group 1). Farmers gave an example of some farmers growing crops on one wetland in Chisipite who were given fertilisers by the government and were never taught sustainable farming methods.

Although the Environmental Act (CAP: 20:27) and Statutory Instrument 7 of 2007, the Environmental Management and Ecosystem Protection Regulation, govern wetland utilisation in Zimbabwe (EMA Act, 2007), Borrowdale and Belvedere wetlands are under threat. The Environmental Management Agency (EMA) and the Harare city council are very corrupt and sometimes they take bribes instead of acting on wetland abusers and offenders. One interview respondent said that on one occasion he informed EMA to come and arrest people who were taking top soil from the wetland but they failed to come (BR respondent 3). The same position was shared by Marambanyika and Beckedahl (2016)'s results which reported the corrupt nature of some environmental officers who were accepting bribes from wetland abusers. EMA officers and Harare city council environmental officers are therefore reluctant and inconsistent in enforcing laws. They lack political intention to carry through wetland laws and deal with offenders (Nhapi, 2009).

Despite being a signatory to the Ramsar Convention on wetlands which encourage countries to advocate for sustainable use and conservation of wetlands, Zimbabwe is failing to monitor wetland use. One interviewee complained about the city council failing to take action after they reported several times about the sewage system which was bursting and polluting Borrowdale wetland (BR respondent, 5). Section 9 (b) (v) of the Environmental Management Act (Chapter 20:27) compels environmental officers to regulate and monitor the discharge or emission of any pollutant or hazardous substance into the environment. However, EMA and the Harare city council environmental officers were, therefore, failing to abide by this law.

Respondents from Belvedere (5%) also suggested that the government should create jobs as a way of dealing with threats to wetlands and some proposed fencing of the wetlands and use them as recreational areas (Borrowdale 40%; Belvedere 31%). However, fencing the wetland proved to be problematic because young people who are not employed would end up stealing the fence, as pointed out by some farmers (BR focus group 2). Focus group respondents suggested that after fencing the wetland, the Harare city council should assign people to guard the fence. However, the government of Zimbabwe like most developing countries lacks resources (financial capacity) to make sure that wetlands are fully protected against abusers.

6.10 Sustainability evaluation

Sustainability indicators such as economic, environmental quality and social use were used in this study to evaluate wetland sustainability. Economic, social and environmental indicators have been used widely to evaluate the sustainability of wetlands because they show how the wetlands resource is performing as compared to what is expected (Balteiro and Romero, 2004; Nassuer, 2004; Waas *et al*., 2014). Results showed that severe economic challenges such as unemployment and hyperinflation have resulted in social problems of poverty and food insecurity among many Harare residents and these problems have forced people to turn to urban wetlands for livelihood sustenance.

The conflict between the government and people pertaining to how wetlands should be used has hindered environmental sustainability when it comes to wetlands in Harare. One interview respondent said that sustainable wetland use was not possible in Harare since people were not agreeing on how to use wetlands (BR respondent 1). Wetlands in Harare were therefore under pressure from the city council who wanted to address housing needs, EMA officers who advocated for the conservation of wetlands, and the general public who relied on wetlands for their survival (BR respondent 1). Government officials were using their political muscles to promote their interests on wetlands and the general public was not consulted in the process. Regardless of having knowledge on the importance of wetlands and their value, people continue to use wetlands unsustainably to meet their needs. Failure of the Zimbabwean government, just like most developing countries to cater for the basic needs of the people (such as jobs) (BR focus group 2; BV respondent 2) has led to wetland degradation in Harare. By contrast a study by Mistch and Gosselink (2000) reveals that most developed countries have managed to provide basic needs to their citizens and therefore are now concerned with the management and conservation of fragile ecosystems such as wetlands.

Conversion of Borrowdale and Belvedere wetlands to different land uses has caused biodiversity loss and altered the integrity of both wetlands, as confirmed by respondents and organic carbon content variations. Thus wetland degradation was compromising environmental sustainability. A study by Svotwa and Manyanhaire (2008) revealed contradicting results since it showed that farmers employed sustainable farming methods on wetlands in Mwaonazvawo rural area in Zimbabwe. Therefore wetland integrity was not compromised. Traditional institutions have played an important role in ensuring sustainable wetland use and conservation in rural areas (Mbereko *et al*., 2007; Ndlovu and Manjeru, 2014; Marambanyika *et al*., 2016). Unlike urban wetlands most rural wetlands in Zimbabwe are used for agriculture, livestock grazing and burying children (Scoones, 1991; Ndlovu and Manjeru, 2014; Marambanyika and Beckedahl, 2016). However, unsustainable use of Borrowdale and Belvedere wetlands has degraded the health of these valuable ecosystems. Deterioration of the soil quality on Borrowdale and Belvedere wetlands reflected by low organic carbon content in the utilised parts of the wetland indicated that land was less productive. According to Borghesi and Vercelli (2003) loss of ecological integrity can result in the land becoming less productive making the condition of the poor worse and they tend to utilise natural resources more to sustain their livelihoods. This can finally lead to the loss of fragile ecosystems like wetlands.

Unplanned and unsustainable use of Borrowdale and Belvedere wetlands has compromised environmental sustainability due to inadequate wetland management strategies (BR respondent 3). Studies by Svotwa and Manyanhaire (2008) and Marambanyika *et al*. (2016) reveal different results which indicated that rural wetlands were used sustainably with the help of Agricultural Extension (AREX) officers educating people about conservative farming methods. However, there challenges for AREX officers to do the same with Borrowdale and Belvedere wetland users, since it is difficult to co-ordinate all users. Results from this study show that wetland users were not from the same location. However, once wetland values and functions are lost through different land uses such as building they cannot be reversed (Mitsch and Gosselink 2000). In 2015 Zimbabwe adopted the United Nations Sustainable development goals and goal number 15 compels countries to protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation, and halt biodiversity loss (ICSU, 2015). In contrast results from this study show that wetlands (terrestrial ecosystems) are used unsustainably without prohibitive measures taken.

6.11 Conclusions

As discussed in this chapter, similarities and difference with other previous studies were drawn from empirical finding of this study. This chapter will therefore lead to the next chapter where conclusions for this study are presented.

Chapter 7: Conclusions

This study aimed at investigating human understanding and perceptions on wetlands and assessing environmental effects of human utilisation of the wetlands as a way of evaluating their sustainability. The following were the main results drawn from this study.

- Both Belvedere and Borrowdale wetlands are being converted from natural land use to human-induced land uses such as agriculture, building, waste ground, and areas for religious gathering. The two wetlands had similar land uses except for areas of religious practice which were only found on Borrowdale wetland. Top soil was also being collected from the wetlands to sell.
- Increased urban agriculture on wetland was mainly due to economic challenges (inflation and unemployment) and social problems (food insecurity). Building land use on wetlands in Harare was mainly due to the need for money by the Harare city council and government officials who wanted to pursue their interests.

- Respondents had mixed responses pertaining to the value and importance of wetlands. Although the majority were aware of the economic and social benefits of the wetlands, some were skeptical about the environmental benefits of wetlands.
- More grain sized particles were found in sediments from the utilised parts of the two wetlands compared to the unutilised parts.
- There was evidence of biodiversity loss mainly due to human use and partly due to climate change. Furthermore, low percentages of organic carbon content in sediments from the utilised parts of the wetlands showed unsustainable utilisation of the two wetlands.
- The research noted that there are flaws in the management of urban wetlands in Harare.

7.1 Implications of the study to wetland evaluation and management

On a wider perspective findings from this research relate to the general status of small urban wetlands in developing countries. This study concludes that having knowledge about the importance and values of wetlands does not necessarily guarantee wise use of wetlands by users. Responsible authorities are not taking part in the management of wetlands in urban areas. Furthermore, land use conflicts can cause wetland degradation since this can lead to poor coordination pertaining to wetland management. Conflicts of interest on urban wetlands between stakeholders have led to complexity on wetland management strategies. As a result wetland integrity is compromised. Opportunistic manipulation of wetlands can result in unplanned use leading to wetland destruction.

The unwillingness of government officials and environmentalists to monitor wetland use can undermine the general public efforts to protect and restore wetlands. Responsible authorities should take a pro-active approach to reduce wetland degradation. Findings from this research can inform environmentalists to constantly evaluate wetland health and peoples' environmental attitudes to improvise wetland management strategies. Thus wetland evaluation and management should entail assessing the integrity of these valuable ecosystems. To curtail wetland use developing countries' governments should address economic challenges (for example unemployment and hyperinflation in Zimbabwe) which have resulted into food insecurity. The urban peoples' low standards of living can threaten the ecological integrity of wetlands when their values and functions are lost to different land uses. Thus results from this study bring awareness to developing countries' governments on the status of urban vleis so that they take immediate action to protect and restore their functions and values before they are lost completely.

7.2 Local community involvement in wetland management

Wetland management authorities should adopt the bottom-up approach in improvising management strategies (Fraser *et al*., 2006) Thus local communities should be consulted first so that they participate and contribute in wetland policy making. Wetland management strategies should be centred on the local communities' views and contributions. Responsible authorities should also create wetland management committees made up of communities who can work in facilitating wetland awareness campaigns and educating people on the wise use of wetlands. The local wetland committees can network with other committees from rural areas to enhance proper management of wetland resources to identify and share good practice. Government and environmentalists should involve the local communities when making decisions pertaining to wetland use.

7.3 Priorities in terms of wetland use

Although wetlands like other natural resources should continue to be used to sustain livelihoods, not all land uses are wetland friendly. More so, most wetland users use unsound methods (for example use of veld fires to clear land for cultivation) to exploit wetland benefits. However, human needs have to be catered for through wetland use without compromising the integrity of these ecosystems. It is, therefore, important to avoid using wetland for building purposes but rather use them for agriculture. Although sustainable methods can be used during cultivation, it is difficult to do the same when building on wetlands. Hence, development on wetlands is more destructive to wetlands than cultivation. However, if people decide to use wetlands for crop production it is advisable to adopt sustainable farming methods such as crop rotation and zero tillage to ensure the continual existence of wetlands. It is therefore wise to teach wetland users all these sustainable methods beforehand and monitor their implementation, provide support and training.

7.4 What the government of Zimbabwe should do

There has been lack of practical implementation and consistency of wetland legislation (Schuyt, 2005) in Zimbabwe. The city fathers need to avoid wetlands when allocating land for developmental purposes. Wetland management legislation for Zimbabwe is weak and more theoretical rather than practical. Zimbabwe's Environmental Management Act has unclear sections which need to be revised. For example section 4 (d) of the Environmental Management Act (Chapter 20:27), also assigns the minister to monitor the environment and trends in the utilisation of natural resources and the impact of such utilisation on the environment. However, this act does explain how the minister is supposed to monitor utilisation of natural resources and the impact of utilisation. Wetland legislation also needs to be reviewed and a national wetland policy needs to be structured with the involvement of all stakeholders. A national wetland policy based on the consensus of all stakeholders should, therefore, be passed for wetland management and sustainable use. However, before allowing any land use on wetlands Environmental Impact Assessment (EIA) should be done effectively. Inefficiency in policy management has increased unsustainable use of wetlands in Zimbabwe (Matiza and Crafter, 1994) has resulted into wetland degradation. The Zimbabwean government should also look into institutions responsible for wetland management and investigate whether they are monitoring wetland use within urban areas. The Government should, therefore, encourage collaboration of different stakeholders in wetlands management and implementation of revised wetland laws. Thus the government of Zimbabwe should ensure transparency in the ways wetland are used and managed. In addition, the government should ensure inclusion of wetland studies in primary level curricula. Primary school environmental education syllabi should include issues pertaining to wetland values and functions. The government should also make sure that effective channels are used to disseminate information pertaining to wetland use and management.

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APPENDICES

Appendix 1: Questionnaire schedule

QUESTIONNAIRE SCHEDULE FOR RESIDENCE OF BELVEDERE AND BORROWDALE

Section A: Background information

(Please tick where applicable)

1. Gender: Male ☐ Female ☐

2. Age: 18-25 years ☐ 26-35 years ☐ 36-45 years ☐ 46-59 years ☐

3. Education qualification: None ☐ Primary ☐ Secondary ☐ A-level ☐ Tertiary ☐

Other specify………………………………………………………………………………………………………

4. Employment Status: None ☐ Employed ☐ Self employed ☐

5. If employed, what type of employment? temporary ☐ permanent ☐ full time ☐ part time ☐ contract ☐

6. Where do you stay from this wetland? Less than a km ☐ 1-2km ☐ 3-5km ☐ more than 5km ☐

Section B

Please indicate to what extent you agree or disagree with each of these statements. Tick in the box.

Strongly Agree- **SA**, Agree- **A,** Neutral- **N**, Disagree- **D,** Strongly Disagree-**SD**

7. Human Perceptions and knowledge about wetlands

	SA	A	N	D	SD
Wetlands are wastelands that should be destroyed					
Wetlands allow mosquito to breed					
Wetlands are dangerous since children can drawn					
Are you aware of any laws that guard against wetlands					

Is there any information given to you about wetlands					
Government should stop allocating stands on wetlands					
Wetlands should be conserved					
Wetlands are wastelands that can be exploited					

8. Wetlands used for other purposes

If you use wetlands in any of the following ways please tick in the box

Waste dumping ☐

Building ☐

Agriculture ☐

Using water ☐

Collecting firewood ☐

Religious gathering ☐

Cultural activities ☐

If so name it …………………………………………………………………..

Explain why you have chosen to use wetlands in the ways you have chosen above
…………………………………………………………………………………………………
………………………………………………………………………………………………….

9. In the way that you have been using wetlands do you think you benefited economically in any of the following ways;

	SA	A	N	D	SD
Provide domestic water					
Provide water for agriculture					
Building materials					
Provide plant food					
Provide firewood					
Water for animals					
Control flooding					
Medicinal plants					

Providing soils /Sediments					

Other……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………

10. Considering how you have used wetlands, do you think you have benefited socially in any of the following ways?

	SA	A	N	D	SD
Centre of recreation					
Centre of learning					
Place were people can stay					

Other……………………………………………………………………………………………
…………………………………………………………………………………………….

11. In the way that you have been using wetlands, what do you think about the following environmental benefits of wetlands?

	SA	A	N	D	SD
Modify climate					
Habitat for plants and animals					
Improve water quality					
They store carbon dioxide					
They enhance ground water recharge					
Important for processes that lead to formation of rain					

Other……………………………………………………………………………………………
…………………………………………………………………………………………….

12. To what extent do you agree with the following effects of the different landuses on wetlands?

	SA	A	N	D	SD
Waste dumping pollutes wetland water					
Cultivation on wetlands causes soil erosion					
Building houses and cultivation destroy habitats for animals					
Birds have migrated since houses were built here					
Wetland soils loose fertility due to cultivation					
Some species die due to waste dumping on wetlands					
Wetland cultivation destroys the beauty of wetlands					
Building houses on wetlands destroys the soil quality of wetlands					

Other…………………………………………………………………………………………
……………………………………………………………………………………………….

13. What do you think are the main threats to the following wetland elements?

a) Soil………………………………………………………………………………

b) Water……………………………………………………………………………..

c) Vegetation………………………………………………………………………

d) Birds……………………………………………………………………………….

e) Animals …………………………………………………………………………

14. What do you think should be done to deal with these threats?..

…………………………………………………………………………………………

15. Are there any laws that guard against wetlands…………………………………………….

16. Is there any information given to you about wetlands ……………………………….....

……………………………………………………………………………………………….

17. What do you think can be done to use these wetlands sustainably?....................................

………………………………………………………………………………………………..

18. What do you think can be done to conserve these wetlands in a sustainable way………….

……………………………………………………………………………………

Appendix 2: Individual interview schedule

INTERVIEW SCHEDULE FOR IN-DEPTH INDIVIDUAL INTERVIEW WITH RESIDENCE OF BELVEDERE AND BORROWDALE

Section A: Background information

(Please tick where applicable)

1. Gender: Male ☐ Female ☐

2. Age: Below 18- 25 years ☐ 26-35 years ☐ 36-45 years ☐ 46- 59 years ☐ 60+ years ☐

3. Education qualification: None ☐ Primary ☐ Secondary ☐ A-level ☐ Tertiary ☐ other (specify)…………………………………………………………………………………………

4. Employment Status: None ☐ Employed ☐ Self employed ☐

5. Where do you stay from this wetland? Less than a km ☐ 1-2km ☐ 3-5km ☐ more than 5km ☐

6. Do you have a family? ☐ ☐

7. If yes how big is your family? ☐ ☐

8. Do your children go to school? ☐ ☐

9. How old are your children? ☐ ☐

10. Do you have a farm? ☐ ☐

11. If no where do you grow your crops? ☐ ☐

13. Do you ever send your children to cultivate the fields? ☐ ☐

Section B

14. How long have you been using this wetland?

15. In what ways have you been using this wetland?

16. Have you ever observed any changes on the wetland:

a) soil?

b) water?

c) vegetation?

17. If yes what changes have you observed?

18. What do wetlands provide to different animals?

19. How do different plants benefit from the wetlands?

20. What are your perceptions on the changes over time of the wetland:

a) soil quality, soil fertility and soil erosion?

b) vegetation type, biodiversity, new plants and deforestation?

c) water quality, water pollution and water availability?

d) animals on wetland, wild or domestic animals?

21. What changes have you observed over time of the wetland due to:

a) climate?

b) economic and social pressures?

c) development and political pressure?

22) Do you believe that it is important that wetlands continue to exist present (current) and future?

23) If yes why do you think it is important for them to continue to exist present and future?

24) What should be done to avoid destruction of wetlands?

25) Have you ever heard of sustainability?

26) What can you say about sustainability in relation to wetland use?

27) Have you observed any elements of climate change?

28) If yes how has climate change affected the wetland?

Appendix 3: Focus group Interview schedule

INTERVIEW SCHEDULE FOR FOCUS GROUP INTERVIEWS WITH RESIDENCE OF BELVEDERE AND BORROWDALE

1. Are there conflicts between different landuses on this wetland?

2. How do you use wetlands in this area?

3. How are wetlands important to the soil?

4. What effects does the spread of the city on wetlands have on the following;

a) wetland soil ?

b) wetland water?

c) wetland animals and plants?

5) What effects does waste dumping on wetlands have on the following;

a) wetland soil?

b) wetland water?

c) wetland plants and animals?

6) How are the following elements affected by cultivation on wetlands?
a) wetland soils?

b) wetland water?

c) wetland plants and animals?

7) How has borehole drilling on wetlands affected the following;

a) wetland water and water table?

b) wetland soils ?

c) plants and animals?

8) Why do you use these wetlands for agriculture?

9) What type of crops do you grow at this wetland?

10) Why do you favour to grow such types of crops on these wetlands?

11) Do you grow these crops for consumption or for sale?

12) What have you observed on the number of people growing crops on wetlands since you started staying here?

13) What are the changes you have observed on this wetland since you settled here?

14) What challenges are there in living on wetlands (flooding)?

14) What are the major threats to this wetland?

15) Suggest what can be done to deal with these threats?

16) Suggest ways of conserving these wetlands?

Appendix 4: Consent forms

Consent form for completing a questionnaire

Human utilisation and environmental quality of wetlands, The case of Harare, Zimbabwe.

I………………………………… agree to participate in this research project. The research has been explained to me and I understand what my participation will involve.

I agree that my participation will remain anonymous YES NO (please circle)

I agree that the researcher may use anonymous quotes in his research report YES NO

I agree that the I am going to complete the questionnaire YES NO

Researcher……………………………………………………….. (signature)

………………………………………………………………….(name of participant)

…………………………………………………………………….date

Consent form for Participating in an interview

Human utilisation and environmental quality of wetlands, The case of Harare, Zimbabwe

I………………………………… agree to participate in this research project. The research has been explained to me and I understand what my participation will involve.

I agree that my participation will remain anonymous YES NO (please circle)

I agree that the researcher may use anonymous quotes
in his research report YES NO

I agree that the interview may be audio recorded YES NO

Researcher……………………………………………………….. (signature)

…………………………………………………………………(name of participant)

…………………………………………………………………….date

Consent form for participating in focus group discussion

Human utilisation and environmental quality of wetlands, The case of Harare, Zimbabwe.

I………………………………… agree to participate in this research project. The research has been explained to me and I understand what my participation will involve.

I agree that my participation will neither remain anonymous

nor confidential YES NO (please circle)

I agree that the researcher may use anonymous quotes

in his research report YES NO

I agree that the I am going to complete the questionnaire YES NO

Researcher……………………………………………………….. (signature)

…………………………………………………………………(name of participant)

……………………………………………………………………..date

Appendix 5: Information sheets

Participant Information Sheet (Questionnaire)

Good day
My name is Emmah Mandishona and I am a Masters student in Geography at Wits University. In fulfillment of my studies I have to undertake a research project and I am investigating on; Human utilisation and environmental quality of wetlands, The case of Harare, Zimbabwe. The aim of this research is to investigate human understanding and perceptions on wetlands and assessing environmental effects of human utilisation of the wetlands as a way of monitoring their sustainability.

As part of this project I would like to invite you to take part in answering this questionnaire. This process will involve writing your responses on the spaces provided on the questionnaire and will take around 50 minutes.

You will not receive any direct benefits from participating in this study, and there are no disadvantages or penalties for not participating. You may withdraw at any time or not answer any question if you do not want to. The questionnaire will be completely confidential and anonymous as I will not be asking for your name or any identifying information, and the information you give to me will be held securely and not disclosed to anyone else. If you experience any distress or discomfort we will stop the completing the questionnaire or resume another time.

If you have questions afterwards feel free to contact me. This study will be written up as research report. If you wish to receive summary of this report I will be happy to send you.

Yours sincerely,
Emmah Mandishona emandishona@gmail.com cell number+27845526223

Prof Jasper Knight Jasper.Knight@wits.ac.za phone number +271177176508
Lucille Mooragan lucille.mooragan@wits.ac.za phone number +271171714

Participant Information Sheet (Interview)

Good day

My name is Emmah Mandishona and I am a Masters student in Geography at Wits University. In fulfillment of my studies I have to undertake a research project and I am investigating on; Human utilisation and environmental quality of wetlands, The case of Harare, Zimbabwe. The aim of this research is to investigate human understanding and perceptions on wetlands and assessing environmental effects of human utilisation of the wetlands as a way of monitoring their sustainability.

As part of this project I would like to invite you to take part in an interview asking about you and your use of wetlands. This activity will involve verbal communication and will take around 1 hour. With your permission I would also like to record the interview using a digital device and I may take photos of your house or farm for use in my research report.

You will not receive any direct benefits from participating in this study, and there are no disadvantages or penalties for not participating. You may withdraw at any time or not answer any question if you do not want to. The interview will be completely confidential and anonymous as I will not be asking for your name or any identifying information, and the information you give to me will be held securely and not disclosed to anyone else. If you experience any distress or discomfort we will stop the interview or resume another time.

If you have questions afterwards feel free to contact me. This study will be written up as research report. If you wish to receive summary of this report I will be happy to send you.

Yours sincerely,

Emmah Mandishona emandishona@gmail.com cell number +27845526223

Prof Jasper Knight Jasper.Knight@wits.ac.za phone number +271177176508

Lucille Mooragan lucille.mooragan@wits.ac.za phone number +27117171408

Participant Information Sheet (Focus group discussions)

Good day

My name is Emmah Mandishona and I am a Masters student in Geography at Wits University. In fulfilment of my studies I have to undertake a research project and I am investigating on; Human utilisation and environmental quality of wetlands, The case of Harare, Zimbabwe. The aim of this research is to investigate human understanding and perceptions on wetlands and assessing environmental effects of human utilisation of the wetlands as a way of monitoring their sustainability. As part of this project I would like to invite you to take part in a focus group discussion. This discussion will involve three people. This research will take place at any place convenient to participants where you are all comfortable with. This focus group will be done in the afternoon. This activity will involve verbal communication and will take around 2 hours. With your permission I would also like to record the discussion using a digital device.

You will not receive any direct benefits from participating in this study, and there are no disadvantages or penalties for not participating. You may withdraw at any time or not answer any question if you do not want to. Confidentiality and anonymity cannot be guaranteed since these are focus groups discussions with more than one person but will be guaranteed for all participants when findings are made available in a public forum since pseudonyms will be used. I kindly ask you to keep information discussed in this group to yourself. I will not be asking your name or any identifying information, and the information you give to me will be held securely and not disclosed to anyone else. If you experience any distress or discomfort we will stop the group discussions or resume another time. If you have questions afterwards feel free to contact me. This study will be written up as research report. If you wish to receive summary of this report I will be happy to send you.

Yours sincerely,

Emmah Mandishona emandishona@gmail.com cell number +27845526223

Prof Jasper Knight Jasper.Knight@wits.ac.za phone number +271177176508
Lucille Mooragan lucille.mooragan@wits.ac.za phone number +27117171408

Appendix 6: Calculations of grain size distribution

SAMPLE STATISTICS

SAMPLE IDENTITY: **BV 5 unutilised** ANALYST & DATE: ,

SAMPLE TYPE: Polymodal, Poorly Sorted TEXTURAL GROUP: Sand

SEDIMENT NAME: Poorly Sorted Coarse Sand

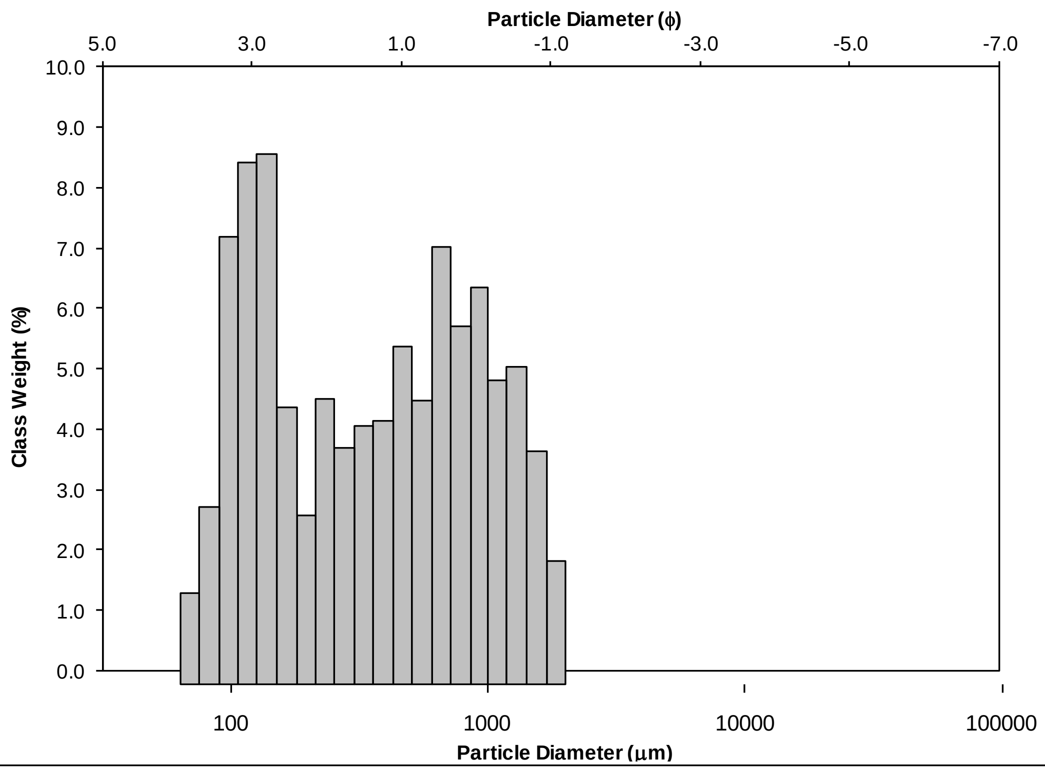
	μm	φ
MODE 1:	137.5	2.868
MODE 2:	655.0	0.616
MODE 3:	925.0	0.117
D_{10}:	99.20	-0.302
MEDIAN or D_{50}:	352.7	1.504
D_{90}:	1232.8	3.334
(D_{90} / D_{10}):	12.43	-11.039
$(D_{90} - D_{10})$:	1133.6	3.636
(D_{75} / D_{25}):	5.773	8.127
$(D_{75} - D_{25})$:	646.5	2.529

GRAIN SIZE DISTRIBUTION

GRAVEL:	0.0%	COARSE SAND:	24.1%
SAND:	98.7%	MEDIUM SAND:	17.9%
MUD:	1.3%	FINE SAND:	21.0%
		V FINE SAND:	19.6%
V COARSE GRAVEL:	0.0%	V COARSE SILT:	0.2%
COARSE GRAVEL:	0.0%	COARSE SILT:	0.2%
MEDIUM GRAVEL:	0.0%	MEDIUM SILT:	0.2%
FINE GRAVEL:	0.0%	FINE SILT:	0.2%
V FINE GRAVEL:	0.0%	V FINE SILT:	0.2%
V COARSE SAND:	16.1%	CLAY:	0.2%

	METHOD OF MOMENTS			FOLK & WARD METHOD		
	Arithmetic μm	Geometric μm	Logarithmic φ	Geometric μm	Logarithmic φ	Description
MEAN ($\bar{x}$):	518.6	329.8	1.600	341.9	1.548	Medium Sand
SORTING (σ):	457.1	2.808	1.490	2.658	1.410	Poorly Sorted
SKEWNESS (Sk):	1.085	-0.495	0.495	-0.019	0.019	Symmetrical
KURTOSIS (K):	3.293	3.469	3.469	0.666	0.666	Very Platykurtic

GRAIN SIZE DISTRIBUTION



Appendix 7: Ethics clearance certificate

Research Office

HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)
R14/49 Mandishona

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER: H16/06/19**
PROJECT TITLE	Human utilisation and environmental quality of wetland: The case of Harare, Zimbabwe
INVESTIGATOR(S)	Ms E Mandishona
SCHOOL/DEPARTMENT	GAES/
DATE CONSIDERED	24 June 2016
DECISION OF THE COMMITTEE	Approved unconditionally
EXPIRY DATE	12 July 2019

DATE 13 July 2016 **CHAIRPERSON** ______________ (Professor J Knight)

cc: Supervisor : Professor J Knight

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10005, 10th Floor, Senate House, University.

I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to completion of a yearly progress report.**

____
Signature

_____/_____/_____
Date