

# Chapter 1

## General Introduction

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### Effects on birds of different land-uses in north-eastern Botswana

#### 1.1 Introduction

##### 1.1.1 Population

There are many challenges facing the world today, with population growth being one of the prime issues. The increasing number of people will have an impact on the environment for example deforestation and accelerated climate change. The world population reached 7 billion in 2011, with average life expectancy increasing from 48 years in the early 1950's to 68 at the turn of the century. Infant mortalities have dropped from 13% to 4.6% during the same period. Sub-Saharan Africa is the only remaining region of the world where population is set to double or treble in the next 40 years. Africa's population is growing at 2.3% per year, although the fertility rate will drop from 4.6 children to 3.0 children per woman. There are many parts of the world where economic growth is being outstripped by population growth; the consequence will be disparities within and between countries with an underlying common factor of poverty where these disparities are significant. The eradication of poverty will contribute to the slowing of population growth and eventually population stabilization (UNDP, 1997).

The evidence suggests that the target set in the United Nations Millennium Development Goals (MDGs) of the reduction of deaths in children below five years of age can be achieved. The highest levels of under-five year old deaths are found in sub-Saharan Africa with one in eight deaths recorded in this age group. There are a number of primary causes of death pneumonia, diarrhoeal diseases and malaria amongst others, but malnutrition is an underlying cause of a third of all deaths in children under the age of five. Although progress has been made in reducing child deaths in sub-Saharan Africa, children

from poorer homes and homes in rural communities are more prone to death before five years of age (UNICEF, June 2011)

Africa has a population that is growing at the highest rate in the world and much of this population is found in sub-Saharan Africa. Forty percent of the sub-Saharan population (270 million people) lives in arid, semi-arid and dry-humid regions of Africa, where the mean ratio of annual precipitation to evapo-transpiration ranges between 0.05 - 0.65 (Meadows & Hoffman, 2002; UNEP, 1997). Middleton (1991) describes arid zones as deserts, while semi-arid and sub-humid zones are called desert margins, with deserts and desert margins combining to form dry-lands. Dry-land covers 13 million km<sup>2</sup> which constitutes 43% on the African land mass (UNDP, 1997). The desert margins of sub-Saharan Africa include the area that stretches along the southern edge of the Sahara Desert, known as the Sahel, as well as some countries which are entirely dry-land, such as Botswana and Eritrea, which in total makes up 3.5 million km<sup>2</sup> (Gonzalez, 2002). The article by Meadows and Hoffman (2002) makes the point that half the surface of the earth can be classified as dry-land (which includes hyper-arid, arid, semi-arid and dry sub-humid areas), with a substantial portion of this dry-land being at various stages of degradation.

Dry-lands are noted for the scarcity of water which in turn affects both primary production and the cycling of nutrients. Precipitation is counter-balanced by evaporation and transpiration from plants in these dry land areas with a potential water deficit that will adversely affect the production of crops and will have a great impact on livestock and humans (Meadows & Hoffman, 2002).

### **1.1.2 Desertification and desert margins**

Population increase and the resultant pressure on deserts and particularly desert margins cause desertification which is currently affecting much of Africa's dry-lands. The United Nations Convention to Combat Desertification (UNCCD, 1994) concluded that desertification resulted in the degradation of arid, semi-arid and sub-humid areas as a consequence of various factors which include climate changes and human activities. Grove (1993) describes desertification as the reduction of the biological potential to reduced levels as a result of human activity. Warren and Agnew (1988) suggest that desertification is a process where the extent of desert (dry areas with few plants) is

increasing, usually into semi-arid lands. The net result is xeric areas with a few plants encroach into mesic habitats which a greater number of plants.

The regions of transition between typical deserts and areas of sufficient rainfall for plant growth during the warm time of the year are known as desert margins. These areas are characterized as having a climate of low and variable rainfall and high evaporation (Reich, *et al.*, 2000). Desert margins are under increasing pressure from a growing population that needs to produce food (Kellner, 2000; Middleton, 1991).

### 1.1.3 Causes of desertification

There is much debate on the causes of desertification with some authors suggesting that desertification is the result of man-induced factors and others suggesting that desertification is the result of natural causes, including climate change (Berry, *et al.*, 1983; Middleton, 1991). The publication by Berry, *et al.* (1983) makes reference to the Sahel region of sub-Saharan Africa and particularly the major drought of the late 1960's and 1970's. The effects of the drought are well documented with the loss of many lives and the displacement of 25 million people who were confronted by starvation and disease. The climatology of the Sahel region was noted for cyclical droughts and wet periods, recorded at regular intervals dating back to the earliest records. The made by Berry, *et al.* (1983) was that there has been little climate change over the last 2,500 years and that the devastating impact of the drought in late 1960's and 1970's was attributed primarily to the effects of man combined with the well recorded cyclical droughts of the region.

Desertification in Africa is not confined to the Sahel region but occurs south of the equator in a number of countries including South Africa, Botswana and Namibia, which all have borders with the Kalahari Desert (Gonzalez, 2002).

Meadows and Hoffman (2002) examine land tenure and drought on the effects of desertification in South Africa where a unique set of circumstances may have influenced this process. The climatic history of South Africa, like the Sahel, suggests that the region has been subject to arid conditions reflected in annual and decadal variability of the principle factor of precipitation. Combined with climate variability, a further contributing factor to desertification was the socio-economic conditions of the inhabitants of these marginal areas. The apartheid South Africa was governed principally with the aim of the

separation of ethnic groups with the consequence that there were two major land use types, namely commercial and communal. Commercial land was managed by the White population group, while the communal land was managed by the Black population group. Poverty played a pivotal role in the communal areas of apartheid South Africa. Commercial farmland was less susceptible to water run-off with shallow slopes while the communal areas had steeper slopes, which are more susceptible to erosion. The most relevant factor, when comparing these land uses, was that the livestock densities in the communal areas were as high as twice that of the commercial areas. When compared to the commercial land use areas, the communal land use had a higher population that was economically disadvantaged, and the land was more prone to erosion. Combined, these factors make areas more susceptible to degradation (Meadows & Hoffman, 2002; Fairbanks, 2004).

The point taken from the Meadows and Hoffman (2002) and Fairbanks (2004) articles is that poverty is associated with poor levels of education and plays a significant role in desertification. Land distribution in apartheid South Africa was a consequence of the government while the over-use of the land in the communal areas and desertification was a result of poverty and lower levels of education. The circumstances of land tenure during the apartheid years in South Africa can be viewed as a backdrop to the problem of desertification in this region.

The consideration that desertification could be the result of a combination of both human actions and natural causes, as proposed by Middleton (1991), is thereby also adopted as the background for desertification for this thesis. The following causes of desertification are suggested by Middleton (1991) and supported by other authors

### **1.1.3.1 Human activities that can cause desertification**

#### **a. Overgrazing**

- When the carrying capacity of a region is exceeded, overgrazing is the net result (Barnes, *et al.*, 2008; Berry, *et al.*, 1983).
- Soils become denuded and there is a reduction in vegetation species to species which are less palatable for livestock (Perkins & Thomas, 1993; Savory & Butterfield, 1999).

- The condition of the livestock then declines as a result of overgrazing (Abel & Blaikie, 1989).
- b. Over-cultivation
- When cultivated fields are not given a sufficient time to lay fallow, soil becomes exhausted with a degradation of soil structure (Berry, *et al.*, 1983).
  - Soil nutrients of desert margins are concentrated in the upper layers of soil because of the reduced rainfall, which reduces the leaching of soil nutrients to lower layers. Soil erosion by wind and water can then carry these nutrients away from desert margins (Nsinamwa, 2005; Perkins & Thomas, 1993).
  - Marginal lands are over-utilized because of a demand for food and cash crops (Middleton, 1991).
- c. Vegetation clearance
- This may occur for different reasons, including fuel for cooking and heating, construction and clearing fields for crops (du Plessis, 1995; Kalapula, 1989).
  - Exposed soil as a result of clearance is eroded more easily and the soil structure is degraded, as with overgrazing and over-cultivation (Elagib, 2011).
  - Removal of trees reduces the amount of shade in these marginal areas and also reduces the quantity of water reaching the water table (Pressland, 1973)
  - With a reduced number of trees for fuel and construction, inhabitants turn to dried dung for fuel. The removal of the dung contributes towards reduction of soil fertility (Elagib, 2011).
- d. Salinisation and water logging

- Irrigation should assist with crop production in marginal areas, but this is often not the case as over-irrigation can lead to a build up of salts and water logging (Berry *et al.*, 1983).
- Without effective drainage, salinisation and water logging reduce yields significantly, eventually resulting in irrigated fields being abandoned (Middleton, 1991).

### 1.1.3.2 Natural causes of desertification

- a. Lack of rainfall or drought
  - This is a natural phenomenon in dry-land areas which results in the wilting and death of plants, which will severely affect the inhabitants and livestock of the area (Meadows & Hoffman, 2002).
- b. Climate change
  - McClean *et al.* (2005) argue that this will have significant consequences for desert and desert margin areas. Middleton (1991), however, observes that, although there is evidence of climate change in many regions of the world, the effects on the dry lands of the world are uncertain.

### 1.1.4 Indicators of desertification

Middleton (1991) suggests that there are a number of possible indicators for desertification:

- Soil salinity increase (Abel & Blaikie, 1989; Berry, *et al.*, 1983)
- Increase in the number of dust storms (Elagib, 2011)
- Increase in the albedo effect, which is the fraction of solar radiation reflected back into space; the more reflective the surface the higher the albedo (Elagib, 2011)
- Soil compaction increase (Abel & Blaikie, 1989; Elagib, 2011)
- Reduced biological productivity and biomass (Altieri, 1999)

- Reduced organic matter in the soil (Abel & Blaikie, 1989; MacDonald, 1992)
- Increased sand dune movements (Elagib, 2011)
- Important plant species are reduced (Acocks, 1975; Nsinamwa, 2005)
- Important animal species are reduced (Arroyo, *et al.*, 1999; Barker, 1985; Blaum, *et al.*, 2007)
- Livestock lose condition and productivity (Nsinamwa, 2005)
- Decreased human wellbeing (Berry, *et al.*, 1983) with the land unable to support people and their livelihoods (Gonzalez, 2002)

Although there is a mosaic of factors that can contribute to desertification, this chapter has only looked at these factors in general. Climate change and livestock farming will be addressed in more detail as the former is currently very topical and influential in this study, and the latter is the main land use in the study area and therefore at the heart of this thesis.

#### **1.1.5 Climate and climate change**

In his publication, Karadong (2005) makes the point that nothing lasts forever, including species, with the extinction of species being a prominent feature in the history of the earth. Species should not be seen in isolation but as part of the environment, as well as having an interaction with the environment; the net result being that species must adapt to the environment, move to a more suitable area, or die out as a species (Karadong, 2005). There have been climate changes in the past and living organisms - both plant and animal - have had to adapt to these changes and it is this adaptability that has created the vast array of living organisms in the world today (Karadong, 2005).

McClellan, *et al.*, (2005) addressed the consequences of climate change on the environment with the use of models. The article concludes that there are some limitations when using models, including the overemphasis of the extinction rate when compared to extinction rates of previous climate changes. However, there are many similarities between the results of the models used and the history of climate change.

One of the most pressing problems facing mankind at present is a change in climate, which is a phenomenon that has occurred throughout ancient history. The

exacerbating factor of the current cycle is the contribution of man in speeding up the change to such an extent that species will be unable to adapt fast enough with the result that there may be mass extinction of species and a collapse of ecosystems (McClellan *et al.*, 2005). The principle contributing factor to climate change is the alteration in the composition of the atmosphere, which then causes changes in temperature and other meteorological conditions. The change of the gas composition of the atmosphere prevents heat reflected from the earth leaving the atmosphere with consequential temperature increases in the atmosphere (Gonzalez, 2002). This cycle is known as the Greenhouse Effect, which is a major contributor to climate change. Carbon dioxide (CO<sub>2</sub>) inputs into the atmosphere by man are continually increasing, becoming a major accelerator of the Greenhouse Effect and consequently contributing significantly to the rate of climate change.

Gonzalez (2002) addresses the possible effects of the increased rate of climate change with specific reference to desert margins. The rainfall patterns over time and space will be affected by climate change, which, when combined with temperature changes and solar isolation, will have significant effects on desertification (Gonzalez, 2002). Elagib (2011) suggests that rainfall is the most complex and influential of climatic factors over space and time. An understanding of the influence of rainfall and its impacts on the soil in dry-land, arid and hyper-arid regions are an issue that needs to be addressed.

If we examine the rainfall patterns of southern Africa and Botswana in particular, there are similarities when compared to the Elagib (2011) study mentioned in the preceding paragraph. There is a pattern of a reduction in rainfall from east-to-west in southern Africa, which is a region of generally erratic rainfall with drought cycles every 18 years (Bhalotra, 1985; Tyson, 1979).

Rainfall in Botswana is described by Tietema, *et al.*, (1991) as being low and erratic with seasonal co-efficient of variation as high as 100% being common. Elagib, (2011) refers to the rainfall events of his study area of Sudan as often having devastating results on soil erosion because the intensity of storms.

Climatic rainfall patterns provide a good explanation for the distribution of woody plant species over time and space (O'Brien, 1993). The east-to-west pattern of distribution of southern Africa's woody vegetation can be attributed primarily to climate and the

variation in climate - in particular to rainfall. There is an increase in woody species in an easterly direction, from the lowest number of woody species in the dry-arid to semi-arid areas of the west, with the highest number of woody species found in the more mesic to humid areas in the east. The erratic rainfall of Botswana between and within seasons has a major seasonal influence on the vegetation and, as a result, on the distribution of avifauna (Penry, 1994).

Elagib, (2011) noted in his study of the hyper-arid areas of Sudan that there is a similar high co-efficient of variation when analysing rainfall when compared to the rainfall conditions in Botswana. The virtual non-existence of vegetation cover in the dry areas of Sudan makes the soils of this area highly vulnerable to direct impact of rain and therefore erosion.

There needs to be a greater understanding of the sensitivity of biodiversity to climate change as there is great demand on species to alter their habitats to accommodate climate change. Efforts are being made to reduce the catalyst-type effects of man, which accelerate or force climate change. The efforts to reduce these impacts on the environment appear to be too slow as many species are unable to adapt to the current rate of climate change (McClellan, *et al.*, 2005). What does emerge from the article by McClellan, *et al.* (2005) is that there will be some areas of refuge, such as mountain ranges, for plant and animal species sensitive to climate to colonise these cooler areas. McClellan, *et al.* (2005) also suggest that there will be other areas of refuge offering small pockets of suitable microclimates, which will permit some populations an environment less effected by broad-scale climate change (Hockey, *et al.*, 2011; McClellan, *et al.*, 2005;).

The increased rate of climate change may cause a sudden drastic change of species composition with a significant negative effect on ecosystem stability and the services that these ecosystems provide (McClellan, *et al.*, 2005). The effects of climate change are compounded in desert margin areas as there are feedback cycles, which add to the effect of climate change and desertification. Combining the factors mentioned before in this chapter, these mechanisms include:

- The reduction of vegetation will in turn reduce the evapotranspiration, which is the only local input to the hydrological cycle, reducing the rainfall even further (Gonzalez, 2002; Middleton, 1991).

- The surface reflectance (albedo) is increased by vegetation clearance. This causes greater reflection of heat, thus reducing atmospheric temperatures at the land surface. Air sinks into these cooler areas reducing the potential for rain, which requires warm moist air to rise (Middleton, 1991).
- Gonzalez (2002) confirms that desertification is aggravated by the destruction and clearing of vegetation which further reduces the intake of carbon dioxide by plants, compounding the Greenhouse Effect.
- The primary source of soil erosion, particularly in marginal areas, is the impact of rain (Elagib, 2011). What rain there is will fall on denuded land, striking the soil with enough force to compact it. Water run-off will be increased as a consequence of denuded soil, with the net result being that less water will infiltrate the soil, further reducing the possibility of vegetation growth.

The feedback mechanisms in the marginal areas of Africa have strengthened as a result of increased unsustainable farming activities and vegetation removal, with desertification being the end result (Gonzalez, 2002; Middleton, 1991). The ecosystems will therefore have reduced resilience to recover (Gonzalez, 2002; Middleton, 1999; Reich *et al.*, 2000).

### **1.1.6 Livestock farming and the effects on the environment**

The study area is situated in the North-East District of Botswana (Figure 5.2). The area falls within the Tropical Woodland and Savannah Zone, but close to the Interzone as described by Penry (1994). The main activity of the study area is livestock farming, primarily cattle, but including goats and sheep.

Livestock farming is regarded by some authors as a primary contributor to desertification, particularly in arid regions (Acocks, 1975; Bock, 1984; MacDonald, 1992; Nsinamwa, 2005). The very interesting publication by Berry, *et al.* (1983) reported on environmental change in the West African Sahel dating back to first recorded history. A number of contributing factors created environmental degradation in this region, with cattle the primary cause. Ancient history confirms that cattle in the Sahel were introduced to the detriment of the environment, and subsequently not farmed as a consequence of political

unrest. During this period of unrest, from the thirteenth through to the nineteenth century, very few cattle were found in what is now known as the Sahel. Records confirm that the region recovered environmentally, with mature forests and extensive wildlife being evident. Once peace returned to the region, livestock farming again moved northwards into the areas that had recovered from livestock - principally cattle farming - with serious environmental impact. Berry, *et al.* (1983) reported that vegetation structure was detrimentally affected, as a consequence of excessive grazing by livestock (Abel & Blaikie, 1989; Acocks, 1975; Nsinmwa, 2005). Prior to the devastating drought of 1968 in the Sahel, there was an exponential increase in the number of cattle in the region, the implication being that the effects of the drought were compounded by a degraded environment as a consequence of extensive cattle farming.

Livestock farming in Botswana, prior to the discovery of diamonds and the commercialization of wildlife resources, was the major foreign exchange earner for the country. The promotion of beef production was part of agricultural policy in Botswana, which encourages beef production from small-scale cattle posts and traditional farming, to large scale commercial ranching (Ministry of Agriculture, 1990) with the result that the national herd has increased by 4% per year since 1900 (Barnes, *et al.*, 2008). Rural land distribution in Botswana is shared between wildlife activities (30%), commercial livestock farming (10%) and traditional livestock farming (60%)(Barnes, *et al.*, 2008).

Beef production in Botswana was geared to cater for the European beef market, which can be lost very quickly, as has been noted as recently as 2011. The foot-and-mouth virus, which emanated from KwaZulu-Natal in South Africa, was transmitted through Mozambique and Zimbabwe, eventually finding its way into the North-East District of Botswana. Vast numbers of livestock were destroyed, with cattle movements halted and abattoirs closed for slaughter. The effects on the economy were felt by the region, with many farmers having to find other sources of income (personal observation).

The loss of the lucrative European beef markets will take the advantage away from livestock farming to wildlife activities (Barnes, *et al.*, 2008). Policy regarding the encouragement of land allocation to livestock farming should be aware of these sensitive forces. Barnes, *et al.*, (2008) make the observation that livestock farming, particularly on a commercial basis, is not economically viable in the more remote areas of Botswana. Currently, government subsidies have to support this industry in these areas.

Fairbanks (2004) examined the trends of bird species richness when compared to land use in South Africa. In his study, he drew comparisons between two different land use types, which adjoined one another. This unusual set of circumstances was created by the apartheid administration of South Africa, particularly during the 1960's, 1970's and 1980's. During this time, the country was governed according to ethnicity. The homelands were created and governed by the Black population group and were predominantly areas of subsistence living. The areas governed by the White population group were areas of intensive farming and industrial practices (Fairbanks, 2004). The study showed a positive relationship between avian richness and intensity of human development.

The positive effect on avian richness in the White-governed areas of KwaZulu-Natal could be attributed to artificial land uses, such as the creation of dams, planting of trees and construction of buildings. The richness was not necessarily an increase in the indigenous bird species, but rather an increase in more generalist species (Fairbanks, 2004). The position could be reached where resident birds associated with the patches of remaining indigenous vegetation, combined with birds, which exploited the human-modified environment, would result in increased species richness.

By contrast, the subsistence-managed areas showed a decline in bird species richness. Subsistence farming was primarily livestock farming, which affects grasslands significantly as a result of overgrazing and possibly a lack of law enforcement. Many grassland bird species, particularly the grass and ground nesting guilds, found maintaining their presence difficult as a result of the intense pressure on grasslands. In these same areas, woody vegetation had been removed for construction material and fuel, which may have affected the distribution of birds that use trees for nesting, feeding and as an area of refuge (Du Plessis, 1995; Fairbanks, 2004).

Todd and Hoffman (1999) tested the effects of grazing on herbaceous species richness and seed production in the succulent Karoo of South Africa, using fence line contrast between communal and commercial farmland. Fence line contrasts provide an ideal experiment testing the effects of different grazing intensities. Todd and Hoffman (1999) believed that livestock can and will have a detrimental effect on the biodiversity of a region, while overgrazing can be regarded as the dominant factor that reduces biodiversity. Increased grazing pressure will lead to assemblages of toxic and spinescent woody vegetation, moving away from palatable perennial grasses to unpalatable annual

grasses (Joubert & Ryan, 1999; Nsinamwa, 2005; Todd & Hoffman, 1999). The research conducted by Perkins and Thomas (1993) compared the soil chemical data around a borehole to the chemical data of a control area where there was no grazing. The soil surface and soil at a depth of up to 30cm were compared. There was a marked increase in pH and chemicals such as potassium, nitrogen, phosphates, sodium, calcium and magnesium in the soil around the well-used borehole. Some of these increases were judged excessive. As the tests increased in distance from the borehole, the chemical differences of the surface soil and soil at 30cm were significantly reduced. At 1,500m from the borehole, the differences were almost negligible (Perkins & Thomas, 1993).

The effect of overgrazing or excessive grazing can reduce the vigour of the grasses' ability to recover as a result of reduced carbohydrate reserves, thereby making the grazed plants less competitive, particularly during the critical growth period. The palatability of the grasses plays an important role in grazing pressure. The more palatable the grass, the more significant the grazing pressure, which could result in a decline of valuable forage species along a grazing gradient, depending on the grazing pressure (Nsinamwa, 2005).

Extensive grazing pressure is a threat to unprotected areas of Botswana. Much of the country has irregular rainfall, which, when combined with intensive grazing, has resulted in herbaceous vegetation being grazed beyond its ability to recover effectively. The net result has been large areas of denuded soil. The cascading effects of reduced vegetation include less shelter and food for many other plants and animals, which combine to reduce the diversity of the grasslands (Herremans, 1998b).

Perkins and Thomas (1993) hypothesized that the extent of environmental change as a result of excessive grazing in the Kalahari would increase with the exposure to grazing. These changes would include reduced nutrients in the soil, increased compaction, reduced water filtration and increased water and wind erosion, resulting in a decrease in grass cover and an increase in woody vegetation (Perkins & Thomas, 1993). Bock *et al.* (1984) suggest that overgrazing will cause shrub invasion, which, once this pattern of invasion has been set in place, may be difficult to stop even if control measures were set in place.

Light grazing, as an alternative to heavy grazing, could have a positive effect on herbaceous species richness, but as grazing intensity increases, the species richness will be reduced (Joubert & Ryan, 1999; Nsinamwa, 2005).

### 1.1.7 Biological indicators

Chapter 1 is an introduction to the possible impacts of climate change and land-use, specifically livestock farming, on the environment. It is with these impacts in mind that this paper attempts to assess these impacts with the aid of using birds as a biological indicators of environmental change.

The use of organisms to indicate the condition of the landscape is an accepted biogeographical tool (Brandl, *et al.*, 1985), which permits observers to note the effects of man on the environment. Wallgren *et al.*, (2009) concluded that when assessing impacts as a result of different land uses, a multi-species approach should be adopted in order to attain a more realistic result.

Bock *et al.* (1984) studied the responses of birds, rodents and vegetation to extensive grazing compared to a large enclosure where grazing was not permitted for 15 years. The ungrazed area supported as much as 45% more grass cover, which was comparatively more heterogeneous, with as much as four times the shrub cover when compared to the grazed area. Interestingly, the grazed area supported significantly higher numbers of birds in summer, but with little difference recorded in the winter months. The number of rodents was considerably higher in the ungrazed area. The species of bird and rodent common in the grazed area were typical of those species adapted xeric conditions as a consequence of heavy grazing. Rodents had superior olfactory abilities, which enabled them to locate food in the more dense cover of the ungrazed area. Birds, on the other hand, were more mobile with greater visual ability, which assisted in avoiding predators in open areas as well as foraging for food. Birds, rodents, and vegetation are therefore valuable indicators of desertification in marginal areas (Bock, *et al.*, 1984).

The arid and semi-arid areas of southern Africa have been affected significantly by anthropogenic changes to the landscape, which, when combined with the effects of climate change, is reflected in the redistribution of some vertebrate populations (MacDonald, 1992). Livestock farming is the most practiced land use in these arid areas of

southern Africa with the impact being primarily the replacement of the grass sward with woody vegetation, commonly known as bush encroachment. Vertebrate indicators of extensive bush encroachment in this region include the Common Reedbuck (*Redunca arundinu*) (Smithers, 1983) and the Magpie Shrike (*Corvinella melanoleuca*) (Hockey, *et al.*, 2005). Both species were recorded in previously open grass areas and grass areas with scattered trees, which were common in the arid and semi-arid areas of southern Africa, but which are now heavily encroached by bush. Both the Common Reedbuck and Magpie Shrike are locally extinct from these bush-encroached areas.

The observed southward and westward movement of some bird species in southern Africa could be attributed to climate change as suggested by Hockey *et al.* (2011) and supported by MacDonald (1992), who analyzed some vertebrate species in the same region and found similar trends. The eastward movement by some vertebrate species was likely due to extensive grazing. This grazing resulted in reduced moisture infiltration in the upper levels of soil (MacDonald, 1992), which, in turn, stimulated the movement of termites in an easterly direction as these insects respond positively to dry conditions. Two vertebrate species, the Bat-eared Fox (*Otocyon megalotis*), and the Aardwolf (*Proteles cristatus*), consume termites as a major part of their diet (Smithers, 1983) and have benefited from this eastward movement of Harvester Termites (*Hodotermes mossambicus*). Both the Bat-eared Fox and the Aardwolf have increased their range in an easterly direction, reflecting the easterly distribution of termites (MacDonald, 1992).

Similar trends in invertebrate population redistributions have been associated with the application of insecticides and herbicides, which, when combined with increasing specialization of farming, had a negative effect on some invertebrate populations. Intensively grazed grasslands will result in the reduction and loss of some species of grasshoppers, ants, spiders, and butterflies, all of which are food sources for the young chicks of a number of birds (Arroyo, *et al.*, 1999). The increased plant material which results from managed land could have a positive effect on some phytophagous taxa, but the general pattern of reduced invertebrate species diversity with increased intensification and specialization of arable farming will be evident. The impact of intensive arable farming can be reduced significantly by encouraging uncultivated field margins, ditches and road

verges, thus providing diverse food resources for many invertebrate and vertebrate species (Arroyo, *et al.*, 1999).

Churchill and Ludwig (2004) found in their study on the effect of a grazing gradient on spiders that some spiders were highly sensitive to disturbance, particularly when perennial grasses were reduced and replaced by annual grasses. Jumping spiders are active predators with highly developed eyesight used to stalk prey on complex vegetation surfaces. When these surfaces (particularly in perennial grass and tree canopy patches) are reduced, there is a significant reduction in jumping spider abundance (Churchill & Ludwig, 2004). Spiders can be adversely affected by grazing intensity. Although indirect, this impacts on birds too, as there will be less prey due to a reduced spider population and because many birds use spider web to reinforce their nests (Hockey, *et al.*, 2005).

In the study conducted by Cagnolo *et al.* (2002) on the lower structural complexity of a habitat as a result of heavy grazing, the results suggested there would be an impoverishment of the insect assemblage as a result of reduced food availability, refuges, oviposition sites and microclimates. Most insect groups may have been unable to cope with the conditions created by heavy grazing, yet there were some guilds that benefited from the conditions (Cagnolo, *et al.*, 2002). The guilds, which were disadvantaged by heavy grazing, included secondary consumers, such as parasites and predators, with chewing insects replacing sucking insects. Cagnolo *et al.* (2002) suggest in their findings that low grazing, as the alternative option to heavy grazing, would ensure the preservation of insect communities of high diversity in these grasslands.

## 1.2 Conclusion and problem statement

The world population, particularly the African population in sub-Saharan Africa, is growing at a considerable rate. As the population increases, there is increased demand for food and living space. Although there is a trend worldwide that sees more urbanization, much of the sub-Saharan population is found in rural areas. A substantial portion of this population is found in dry-land areas, which have sensitive ecosystems (Middleton, 1991).

The main consequence of the increased demand on the marginal areas of Africa for living space and agriculture is reduced biological diversity and desertification, where the potential of these areas to support life and livelihood is reduced. This potential is reduced

by both human activity and natural causes, principally climate change. Climate change is and has been a natural phenomenon, which has been recorded a number of times in ancient history. The primary cause of current climate change is anthropogenic alteration of the gaseous composition of the atmosphere, forcing temperature increases throughout the world, thus affecting climate and the distribution of plant and animal species (McClellan, *et al.*, 2005).

The focus of this dissertation is on the desert margins of Africa, particularly Botswana, where the demand for living and farming space in the marginal areas is becoming more evident. The sinking of boreholes in the most remote areas of Botswana is an indication of the spread of livestock activities deep into the desert margin areas (personal observation). Livestock activities have influenced the biodiversity of these marginal areas. The accepted understanding by many authors of the impacts on the vegetation as a result of overgrazing is that the succulent perennial grasses are over-utilized and replaced by less palatable annual grasses, which when combined with bush encroachment results in a significant impact on the vegetation structure. Grasses lose the competitive edge with bushes and are replaced by them (Acocks, 1964; Abel & Blaikie, 1989; Savory & Butterfield, 1999; Tainton, 1999;). What rain does fall in the desert margins often falls on bare ground, as the grass has been removed by overgrazing. Water run-off leaves the sub-surface soil dry, compacted and susceptible to wind and water erosion (Abel & Blaikie, 1989).

The biodiversity of the marginal areas of sub-Saharan Africa will be compromised by the demands for living space and agriculture, combined with climate change. Changes in biodiversity are complex, but biological tools can be used to monitor and assess these changes. A number of references have been made to using biological indicators, both vertebrate and invertebrate, to monitor changes in biodiversity. Birds were used in the current study to monitor the effects of land use in the marginal areas of North-East Botswana.

Problem statement: Does land use, and particularly the intensity of livestock farming, have an effect on bird diversity?

A literature review will be made in Chapter 2 to address the problem statement. A number of hypotheses will be made, which will be tested by this study.