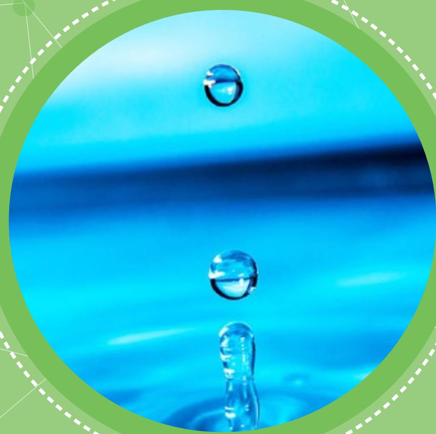
BOTSWANA ENVIRONMENT STATISTICS 2016

Revised Version (RV)



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PREFACE

This report is a revised version of the report that was released in November 2017. The revision is on Tables 7.4a, 7.4b, and 7.5b, and Figures 7.4 and 7.5a. The subsequent narratives under sub-sections 7.3.1 and 7.3.2 of the report were amended accordingly. The revised figures are for the National Problem Animal Incidents by species for the years 2010 to 2014, as well as the National Problem Animal Reports and amount of compensation attracted. The revision was necessitated by the need to correct erroneous calculation of the total National Problem Animal Incidents and the summary of the amount of compensation attracted.

The Report is the fourth edition in a series of five yearly Environmental Statistics Reports of Botswana. It presents latest available statistics and trends on environmental resource availability; resource use; emissions that take place as a result of the resource use; as well as the disasters that may happen as a result of the use or take place naturally. The United Nations Framework for Development of Environment Statistics guided the production of this Report.

It covers Climate; Water; Greenhouse Gases Emissions; Natural Disasters; Technological Disasters; Forestry and Wildlife. Information presented in this Report is vital for evidence based environmental planning and management. It also provides a basis for monitoring progress towards the attainment of Vision 2036 and the Sustainable Development Goals.

Secondary data was used in the production of the Report. Most notably from the Department of Meteorological Services; Department of Water Affairs; Water Utilities Corporation; National Disaster Management Office; Department of Mines; Department of Forestry and Range Resources; and Department of Wildlife and National Parks. I wish to recognise these stakeholders for the collaboration and the immense input they made.

I remain grateful for the invaluable contributions towards the preparation of this Report.

For more information and further enquiries, contact the Directorate of Stakeholder Relations at 367 1300. All Statistics Botswana outputs are available on the website at www.statsbots.org.bw, and at Statistics Botswana Information Resource Centre (Head Office, Gaborone).

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Dr. Burton S. Mguni
Statistician General
April 2019

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LIST OF ACRONYMS

AFOLU	Agriculture Forestry and Other Land Use
CH_4	Methane
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO_2 eq.	Carbon Dioxide equivalent
COP	Conference of the Parties
CSO	Central Statistics Office
DMS	Department of Meteorological Services
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organisation
GEF	Global Environment Facility
GHG	Greenhouse Gas
GPG	Good Practice Guidance
GWP	Global Warming Potential
HFCs	Hydrofluorocarbon
INC	Initial National Communication
IPCC	Intergovernmental Panel on Climate Change
JICA	Japan International Cooperation Agency
LULUCF	Land Use, Land Use Change and Forestry
NA1	Non Annex 1 (Developing country parties to the UNFCCC)
N_2O	Nitrous Oxide
NO_x	Nitrogen Oxides
PFCs	Perflourinated Compound
RCMRD	Regional Centre for Mapping of Resources for Development
SF_6	Sulphur Hexafluoride
SNC	Second National Communication
SO_2	Sulphur Dioxide
TNC	Third National Communication
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change

EXECUTIVE SUMMARY

The main purpose of the Report is to present and discuss current status and trends in the following environmental issues: Climate; Water; Emissions of Greenhouse Gases; Natural Disasters; Technological Disasters; Forestry and Wildlife.

According to the Report, the wettest months during 2015/16 were January, February and March; with the highest monthly total rainfall of 214mm recorded in Kasane in March. These months fall within the rainy season of Botswana which starts in October and ends in March.

Temperature in Botswana vary by region, with extremes in the north eastern and the south western regions. In 2015/16 the lowest mean monthly minimum temperature was recorded at Tsabong in July 2016, whilst the highest mean monthly maximum temperature was at Shakawe in October 2015.

In the period July 2015 to December 2016 Good Hope recorded the highest monthly average wind speed in September 2015 and September 2016. The winds in the country are predominantly easterly to north easterly.

The country draws water from nine dams, Dikgatlhong being the largest with a capacity of 400m3. Over the period 2014 to 2016 Ntimbale, Shashe and Dikgatlhong recorded the highest levels.

Water production is carried out through 16 management centres; seven in the southern region and nine in the northern region. In the period 2013/14 to 2015/16 all the southern management (except for Gaborone and Lobatse) had increasing water production. Water consumption in both centres showed a decline between 2013/14 and 2015/16.

As pertains to Greenhouse Gas emissions results show that even though the emissions fluctuated over the period 1990, 1994, 2000 and 2011 on the whole the country remained a net sink of greenhouse gases.

Natural disasters prevalent in Botswana include floods, storms and heavy rains. In 2013 Tutume experienced the highest number of households affected by floods. On the other hand North West and Central Districts were the hardest hit by heavy rains in 2013. On the technological disasters data on mining were the only readily available information on technological disasters and presented in this report. Accident reduction targets in mines were set from 2000 to date, the targets were only realised in 2001 when 40 accidents were recorded against the 41 set target. Between 1993 and 2016 the highest number of fatal accidents were recorded in 1998 with 73 accidents.

According to Botswana's forest distribution map of 2016, forests and woodlands cover about 27 percent of land area of the country. One of the major threats to forest cover is wild fire. In 2016 Ngamiland District accounted for 66 percent of total area burnt. Likewise the number of fires experienced in 2016 were highest in Ngamiland. The other threat to forests is from the Invasive Alien Species mainly found in Kgalagadi and Ghanzi Districts in the form of Prosopis or Sexanana in Setswana.

Despite government effort wildlife continues to experience some levels of poaching. In 2015 however poaching incidents were particularly low compared to the other years. In other cases animals damage people's property and in the process cause human wildlife conflict. During the period 2010 to 2014 Ngamiland and Central Districts constituted the majority of the incidents of problem animals which attract compensation. The species most involved were lion, leopard, wild dog and elephant. Total compensation paid in this period was more than P21 million.

The main fish species captured/produced in the country are Bream and Barbel, other species include Carp and Labeo. In the period 1996 to 2016 the Bream contributed the highest value of gross catch followed by the Barbel. Both fish production and the value of gross catch decreased significantly in 2016 most probably due to the ban on fishing at Lake Ngami in 2015/16.

1. CLIMATE

Botswana is semi-arid, and drought prone. Projections indicate that droughts will increase in frequency and severity and rainfall has been highly variable spatially and temporally. (Government of Botswana 2017). Botswana's climate is affected largely by the climate phenomena known as the El Niño and La Niña phases.

1.1. El Niño and La Nina

El Niño is a term used to refer to the warming of the El Niño Southern Oscillation (ENSO), while La Nina is its cooling phase, that is, the warming and cooling phases of the central to eastern tropical Pacific Ocean. The El Niño phenomenon occurs on average every three to seven years and can last between a few months to two years. The phenomenon is associated with effects on weather patterns that vary for different regions. The El Niño effect is associated with periods of drought or below normal rainfall in Southern Africa, while the La Niña effect is associated with periods of above normal rainfall. **Table 1.1** shows the El Niño and La Niña years from 1900 to 2016. The latest El Niño phase which ran from 2015 to 2016 is one of the strongest three on record.

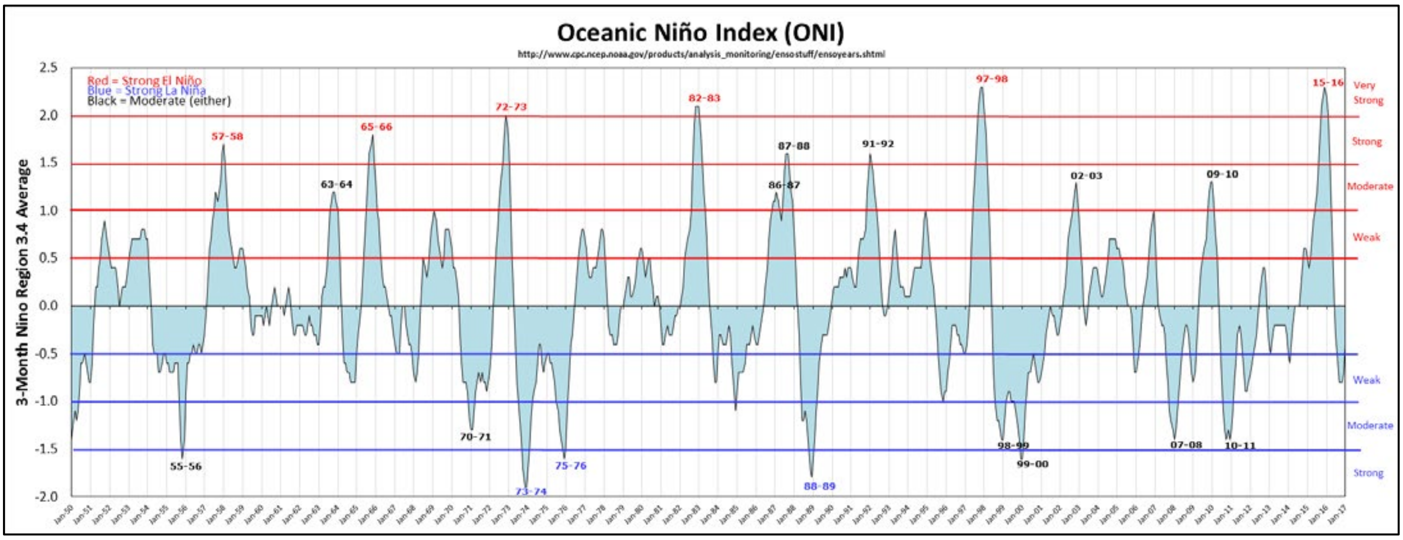
Table 1.1 El Nino and La Nina years 1900-2016

El Niño	La Niña
1900-1901	
1902-1903	1903-1904
1905-1906	1906-1907
	1908-1909
1911-1912	
1914-1915	1916-1917
1918-1919	1920-1921
1923-1924	1924-1925
1925-1926	1928-1929
1930-1931	1931-1932
1932-1933	1938-1939
1939-1940	
1940-1941	
1941-1942	1942-1943
1946-1947	1949-1950
1951-1952	
1953-1954	1954-1955
1957-1958	
1963-1964	1964-1965
1965-1966	
1969-1970	1970-1971
1972-1973	1973-1974
	1975-1976
1976-1977	
1977-1978	
1982-1983	
1986-1987	1988-1989
1991-1992	
1992-1993	
1994-1995	1995-1996
1997-1998	1998-1999
	2000-2001
2002-2003	
2004-2005	
	early 2006
2006-2007	
	2007-2008
2009	
	late 2010 - early 2011
2015-2016	

Source: Stormfax.com

Figure 1.1 shows the Oceanic Nino Index (ONI) trend over the years 1950 to 2017. The ONI is a 3 month running mean anomaly of the Sea Surface Temperatures (SST) of the Niño region. El Niño conditions are considered to be present when the ONI is +0.5 or higher, indicating significantly warmer east-central tropical Pacific temperatures. La Niña conditions are present when the ONI values are -0.5 or lower, indicating cooler than usual temperatures of the east-central tropical Pacific. (Dahlman: 2009) (See appendix III). The most recent El Niño, which is that of 2015 to 2016, is one of the strongest since 1950, equalled in ONI value by only that of the1997 to 1998 season. The strongest La Niña is that of the 1973 to 1974 season.

Figure 1.1 Oceanic Nino Index 1950 to 2017



Source: Golden Gate Weather Services (2017)

1.2. Rainfall

The Department of Meteorological Services (DMS) measures and monitors rainfall around the country. The rainy season in Botswana is from the beginning of October to the end of March every year, and forms part of the meteorological year, which starts in July and ends in June.

Botswana's rainfall is highly erratic with mean annual rainfall ranging from over 650mm in the northeast to less than 250 mm in the southwest and about 450 mm average rainfall per year, which is half of the global average annual rainfall. (Government of Botswana: 2001). The rainfall is usually higher than normal during the La Niña years and lower than normal during the El Niño years.

Table 1.3 shows the monthly rainfall by location for the meteorological year 2015/16.

Table 1.3 Monthly rainfall by location (2015/16)

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Francistown Airport	0.0	0.0	40.5	0.0	48.7	8.4	0.0	0.0	0.0	0.0	0.0	0.0
Gaborone Met H/Q	0.0	0.0	31.5	5.8	70.4	11.2	42.1	18.1	165.1	13.0	11.0	25.6
Sir Seretse Khama Airport	0.0	0.0	21.6	1.3	39.6	6.4	30.4	43.7	164.8	32.3	6.9	19.6
Gantsi Airport	0.0	0.0	0.0	0.0	0.0	37.7	51.6	16.8	30.2	18.0	0.0	0.0
Goodhope	0.0	0.0	25.9	1.5	27.0	15.4	34.3	0.0	104.5	7.8	0.0	4.1
Kanye Seepapitso SSS	3.4	0.0	0.0	0.0	49.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Lobatse Police Station	0.0	0.0	23.7	0.0	58.9	8.4	53.5	35.0	108.4	20.0	14.0	19.3
Mahalapye Met. Station	0.0	0.0	22.6	0.0	30.0	41.0	76.5	201.0	23.5	8.9	2.2	10.5
Maun Airport	0.0	0.0	0.0	4.1	8.8	10.1	77.2	60.6	131.7	26.1	0.0	0.0
Mochudi Police Station	0.0	0.0	0.0	5.5	32.5	0.0	29.8	18.0	58.8	16.0	0.0	15.0
Molepolole Police Station	0.0	0.0	0.0	0.0	0.0	0.0	86.5	8.5	0.0	0.0	0.0	35.5
Palapye Police Station	0.0	0.0	0.0	0.0	0.0	0.0	36.0	210.1	42.4	3.0	0.0	0.0
Serowe Police Station	0.0	0.0	0.0	0.0	0.0	6.0	41.0	33.0	7.0	0.0	0.0	11.0
Shakawe Met. Station	0.0	0.0	0.0	0.0	8.0	1.7	30.1	0.0	0.0	0.0	0.0	0.0
Tsabong Airport	0.0	0.0	26.3	4.2	0.0	0.0	15.7	21.0	27.5	112.1	8.6	0.0
Tshane Met. Station	0.0	0.0	1.3	32.0	0.0	5.4	53.4	2.8	107.9	9.8	9.0	0.0
Kasane Airport	0.0	0.0	0.0	0.0	0.0	0.0	79.1	164.0	214.1	20.4	0.0	0.0
Moshupa Police Station	0.0	0.0	0.0	0.0	15.0	0.0	22.3	22.0	43.7	75.7	0.0	0.0
Sowa Town	0.0	0.0	12.0	0.0	28.4	4.0	0.0	52.8	204.8	12.2	0.0	0.0
Lephephe	0.0	0.0	17.3	3.7	9.3	16.2	23.6	144.6	74.6	11.3	0.0	16.0
Lerala	0.0	0.0	0.0	25.6	49.1	0.0	34.0	79.3	60.6	4.2	0.0	0.0
Pandamatenga	0.0	0.0	0.0	8.0	28.5	36.6	61.7	182.8	82.9	2.3	0.0	0.0
Rakops	0.0	0.0	12.0	2.5	2.7	4.5	74	5.0	36.1	26.8	0.0	0.0
Oliphant's drift	0.0	0.0	0.0	0.0	23.0	0.0	-	59.0	54.0	0.0	0.0	0.0
Tutume	0.0	0.0	0.0	0.0	53.4	24.3	0.0	0.0	0.0	0.0	0.0	0.0

Source: Department of Meteorological Services

Dashes (-) show no data available

The wettest months during 2015/16 were January, February and March, with the highest monthly total rainfall (214mm) recorded at Kasane in March. The second highest monthly total rainfall was recorded at Palapye Police Station (210.1mm) in February, followed by that recorded at Sowa Town (204.8mm) in March. Figure 1.2 shows the country's total monthly rainfall, based only on those stations that had data, and indicative of monthly seasonal variation in rainfall. Rainfall peaked in March, during the 2015/16 meteorological year.

Figure 1.2 Total monthly rainfall 2015/16

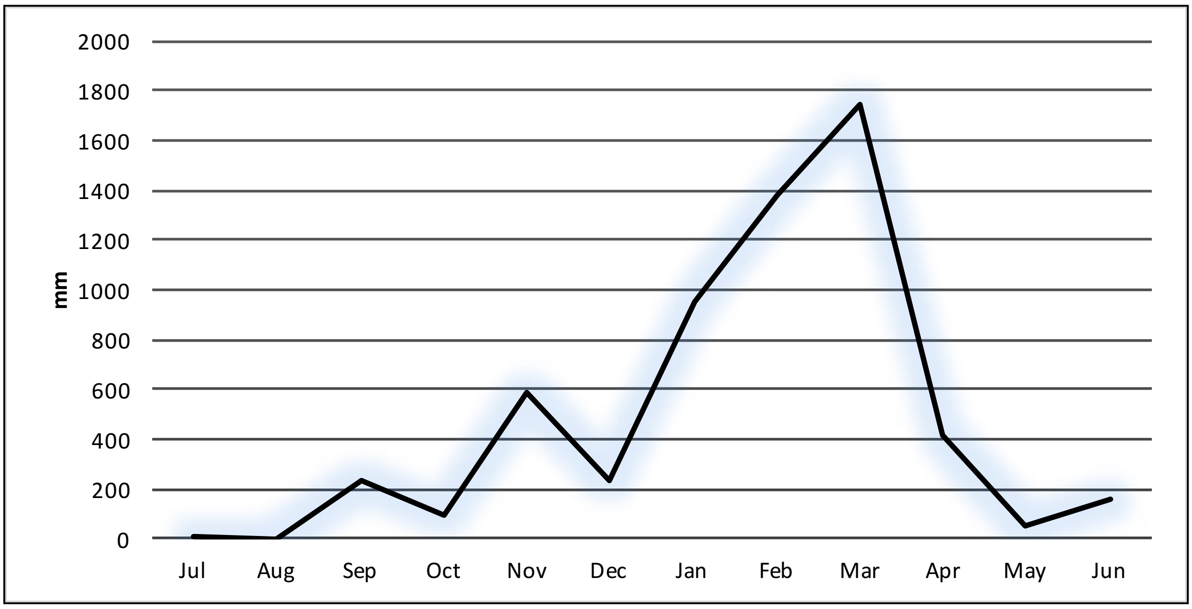


Table 1.4 shows total annual rainfall by locations over some years. The wettest locations for 2015/16 were Kasane, Mahalapye, and Pandamatenga in that order.

Table 1.4 Total annual rainfall by location 2010/11-2015/16

	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16
Kasane Airport	416.3	569.9	406.4	361.3	-	477.6
Mahalapye Met. Station	366.2	214.7	347.9	512.4	299.1	416.2
Pandamatenga	-	-	-	-	326.9	402.8
Gaborone Met H/Q	531.6	280.7	363.6	464.8	311.5	393.8
Sir Seretse Khama Airport	-	-	-	50.8	180.3	366.6
Lobatse Police Station	779.6	307.9	241.1	118.1	2.9	341.2
Maun Airport	627.9	406.3	355.0	341.3	114.2	318.6
Lephephe	-	-	-	141.4	307.7	316.6
Sowa Town	-	-	-	201.1	323.4	314.2
Palapye Police Station	473.3	233.5	351.1	152.0	-	291.5
Lerala	-	-	-	319.0	287.2	252.8
Tshane Met. Station	415.9	211.9	149.4	498.5	279.9	221.6
Goodhope	-	-	-	223.2	307.7	220.5
Tsabong Airport	413.0	213.4	160.3	435.8	167.3	215.4
Moshupa Police Station	-	-	-	-	87.9	178.7
Mochudi Police Station	514.7	317.3	192.9	478.9	300.5	175.6
Rakops	-	-	-	-	353.0	163.6
Gantsi Airport	596.0	235.1	172.5	146.3	-	154.3
Oliphant's drift	-	-	-	-	167.3	136.0
Molepolole Police Station	448.5	66.0	309.0	384.2	315.4	130.5
Serowe Police Station	369.0	100.5	396.3	161.8	-	98.0
Francistown Airport	543.7	293.3	387.5	716.9	2.7	97.6
Tutume	-	-	-	-	-	77.7
Kanye Seepapitso SSS	558.6	226.2	289.8	132.9	-	53.1
Shakawe Met. Station	493.0	485.8	405.5	745.3	386.4	39.8
Francistown Met. Station	-	-	-	304.9	398.3	-
Bobonong Police Station	338.7	541.7	242.8	438.5	-	-
Bokspits Agromet Station	300.3	249.5	187.4	652.6	-	-
Gumare	563.8	371.8	458.5	588.0	-	-
Kang	479.8	249.5	187.4	652.6	-	-

Source: Department of Meteorological Services
Dashes (-) show no data available

1.3. Temperature

Botswana has a high diurnal temperature range often associated with semi-arid climates. The temperatures also vary spatially, with extremes common in the north-eastern and the south-western regions of the country.

Tables 1.5 and 1.6 show the mean monthly minimum and maximum temperatures for some of the stations covering the country, during the latest complete meteorological year 2015/16, and some of the months into the 2016/17 meteorological year. The lowest mean monthly minimum temperature of the 2015/16 year was recorded at Tsabong during the winter month of July 2016.

Table 1.5 Mean monthly minimum temperatures by location 2015/16

Year	Month	Gantsi	Shakawe	Maun	Francistown	SSKA	Mahalapye	Tsabong	Tshane
2015	Jul	6.2	6.0	12.5	7.6	5.7	7.3	3.3	6.2
	Aug	9.1	7.3	10.9	4.9	8.2	9.6	6.5	9.3
	Sep	14.1	14.1	17.3	-	-	15.0	12.6	13.0
	Oct	16.6	16.9	21.3	16.0	18.6	18.6	16.5	18.0
	Nov	17.7	18.7	21.6	17.2	18.1	19.1	16.1	17.0
	Dec	19.7	21.5	22.8	20.3	21.7	21.2	21.5	20.0
2016	Jan	21.0	20.7	22.6	18.4	21.6	20.9	22.6	22.4
	Feb	20.2	20.4	21.4	20.9	22.0	21.1	22.0	20.6
	Mar	18.2	19.6	20.5	17.7	18.1	17.9	18.2	18.2
	Apr	15.0	15.5	16.9	13.2	15.6	15.0	15.4	15.5
	May	8.5	8.4	11.9	8.1	9.7	9.4	8.9	9.2
	Jun	6.9	6.0	9.3	4.0	6.2	7.3	4.2	6.3
	Jul	4.5	4.5	8.2	4.3	4.1	5.5	2.1	3.2
	Aug	8.0	7.8	11.1	-	4.9	8.3	5.8	7.7
	Sep	13.5	12.8	16.9	13.1	14.0	15.5	11.0	12.8
	Oct	18.2	17.9	22.0	17.1	18.2	19.0	13.9	16.4
	Nov	20.2	19.8	22.3	19.3	19.8	19.0	19.2	19.7
	Dec	20.2	20.2	21.2	19.7	20.9	20.4	21.0	20.4

The highest mean monthly maximum temperature recorded during the 2015/16 meteorological year was that of Shakawe in October 2015. (see appendix III)

Table 1.6 Mean monthly maximum temperatures by location 2015/16

Year	Month	Gantsi	Shakawe	Maun	Francistown	SSKA	Mahalapye	Tsabong	Tshane
2015	Jul	25.0	27.8	27.0	26.2	22.8	24.1	22.8	23.4
	Aug	29.3	31.2	30.8	28.8	27.8	27.9	28.0	28.4
	Sep	32.5	34.9	33.4	29.4	-	29.2	29.4	31.2
	Oct	36.1	37.3	37.1	34.9	34.4	33.8	35.2	35.2
	Nov	35.7	36.5	36.3	34.5	33.4	32.9	33.2	33.8
	Dec	34.5	35.3	35.0	35.2	35.3	34.8	36.5	35.5
2016	Jan	33.9	33.3	34.3	33.4	33.8	32.7	36.3	34.5
	Feb	35.2	33.0	33.8	33.3	34.7	33.1	36.9	35.9
	Mar	31.1	31.1	33.1	29.3	30.3	29.2	32.7	31.3
	Apr	29.9	30.9	31.0	28.9	28.9	28.4	29.0	29.0
	May	26.5	28.2	27.6	25.7	24.2	24.5	24.3	24.8
	Jun	25.6	27.1	26.4	24.5	22.2	22.9	23.6	24.3
	Jul	24.3	26.6	25.6	24.2	22.2	22.6	21.3	22.2
	Aug	28.1	30.2	-	27.1	26.2	26.3	26.6	26.8
	Sep	32.9	35.1	33.6	32.4	30.9	30.7	30.2	31.0
	Oct	36.5	38.5	37.6	35.0	33.5	33.3	35.1	34.9
	Nov	35.0	34.6	35.3	33.7	32.7	31.8	36.1	34.8
	Dec	33.6	31.7	31.7	31.2	32.1	31.3	36.3	34.3

Table 1.7 and 1.8 show the mean annual minimum and maximum temperatures for the meteorological years over the period 2000/01 to 2015/16. Tsabong recorded the coolest annual mean minimum temperatures of the country, while Maun recorded the highest mean annual maximum temperatures.

Table 1.7 Mean annual minimum temperatures

	Gantsi	Mahalapye	Tsabong	Francistown	Maun	Tshane	Shakawe	Sir Seretse Khama Airport
2000/01	13.2	13.4	12.0	12.8	16.0	13.3	14.3	13.1
2001/02	12.9	14.1	11.3	13.5	16.6	13.5	14.7	12.5
2002/03	13.0	14.8	11.7	14.2	17.0	14.2	15.3	13.2
2003/04	13.4	14.3	12.0	13.7	16.4	13.9	14.4	13.1
2004/05	14.2	14.6	11.3	14.2	16.4	13.9	14.8	13.5
2005/06	13.5	14.3	11.7	13.9	15.9	13.2	14.3	13.3
2006/07	12.9	14.3	12.0	13.5	15.8	13.1	13.5	13.4
2007/08	13.0	13.3	12.2	13.0	15.3	13.0	12.9	12.8
2008/09	14.2	14.1	13.1	13.5	16.3	13.9	14.0	12.7
2009/10	14.3	14.3	12.8	14.1	16.5	13.9	14.8	12.8
2010/11	13.7	13.9	12.9	13.8	16.5	13.6	14.1	13.5
2011/12	13.1	12.5	11.5	12.9	16.0	12.7	13.2	12.2
2012/13	14.1	12.9	12.6	13.5	15.9	13.7	13.3	13.4
2013/14	14.0	13.0	12.4	13.7	16.7	13.3	15.2	13.6
2014/15	15.3	13.3	13.5	12.4	15.9	14.1	13.8	13.7
2015/16	14.4	14.6	17.4	13.5	15.0	15.2	14.0	14.7

Table 1.8 Mean annual maximum temperatures

	Gantsi	Shakawe	Maun	Francistown	Sir Seretse Khama Airport	Mahalapye	Tsabong	Tshane
2000/01	30.1	30.5	30.9	28.2	27.8	28.3	29.6	29.1
2001/02	30.6	31.3	31.7	29.7	27.8	29.0	29.3	29.5
2002/03	31.0	31.5	32.1	29.5	29.3	29.5	30.0	30.1
2003/04	29.8	30.2	31.0	28.4	28.1	27.8	29.7	29.5
2004/05	30.8	31.7	32.2	30.1	29.1	29.3	29.6	29.6
2005/06	29.2	30.1	30.5	28.8	28.2	28.3	28.8	28.5
2006/07	30.0	30.8	31.6	29.3	29.1	29.6	29.9	29.3
2007/08	29.6	30.4	30.7	28.3	27.4	27.7	29.7	29.1
2008/09	29.9	30.8	30.9	29.1	28.1	28.6	29.1	29.7
2009/10	29.3	30.3	30.5	28.9	27.1	28.2	28.7	28.9
2010/11	29.1	30.6	30.8	29.1	27.8	28.0	29.3	28.6
2011/12	30.0	30.6	31.3	29.8	28.7	28.8	29.4	29.2
2012/13	31.0	31.4	31.6	29.6	28.6	29.0	30.6	30.1
2013/14	28.7	30.3	30.0	28.8	27.7	28.1	28.7	28.4
2014/15	31.0	31.0	31.1	29.7	29.0	29.1	29.7	29.6
2015/16	31.3	32.2	32.1	30.3	27.3	29.5	30.7	30.6

Figures 1.5 and 1.6 show the deviations from the annual mean minimum and maximum temperatures for the country, between 2000/01 and 2015/16. The final year 2015/16 recorded high deviations from the mean, indicating above average maximum and minimum temperatures.

Figure 1.5 Mean minimum temperature deviation 2000/01 to 2015/16

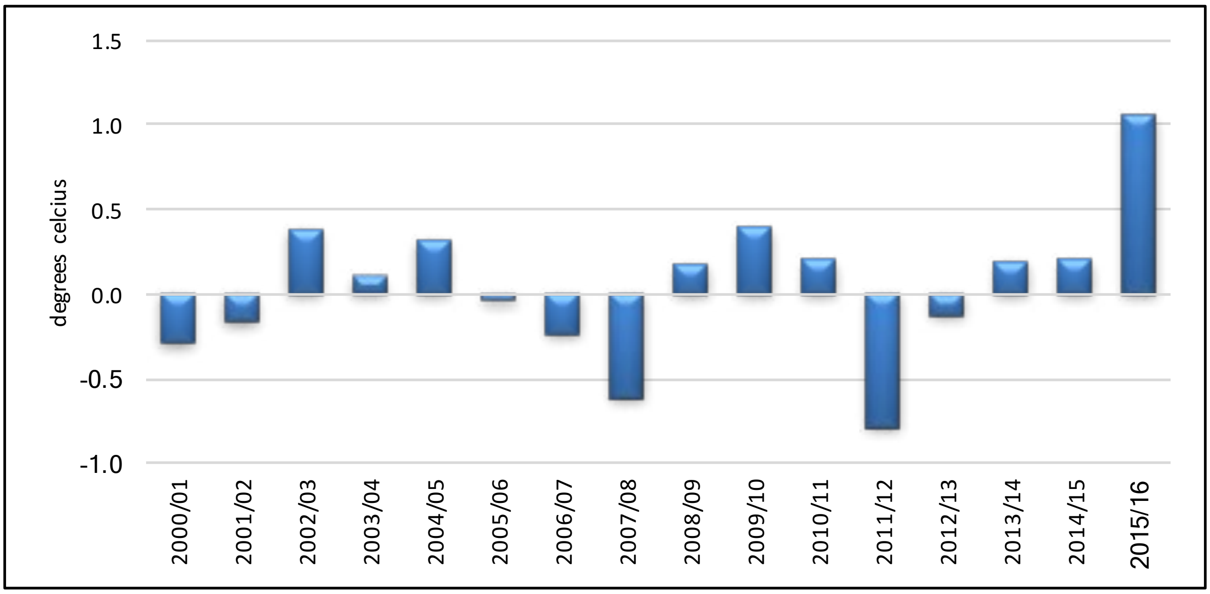
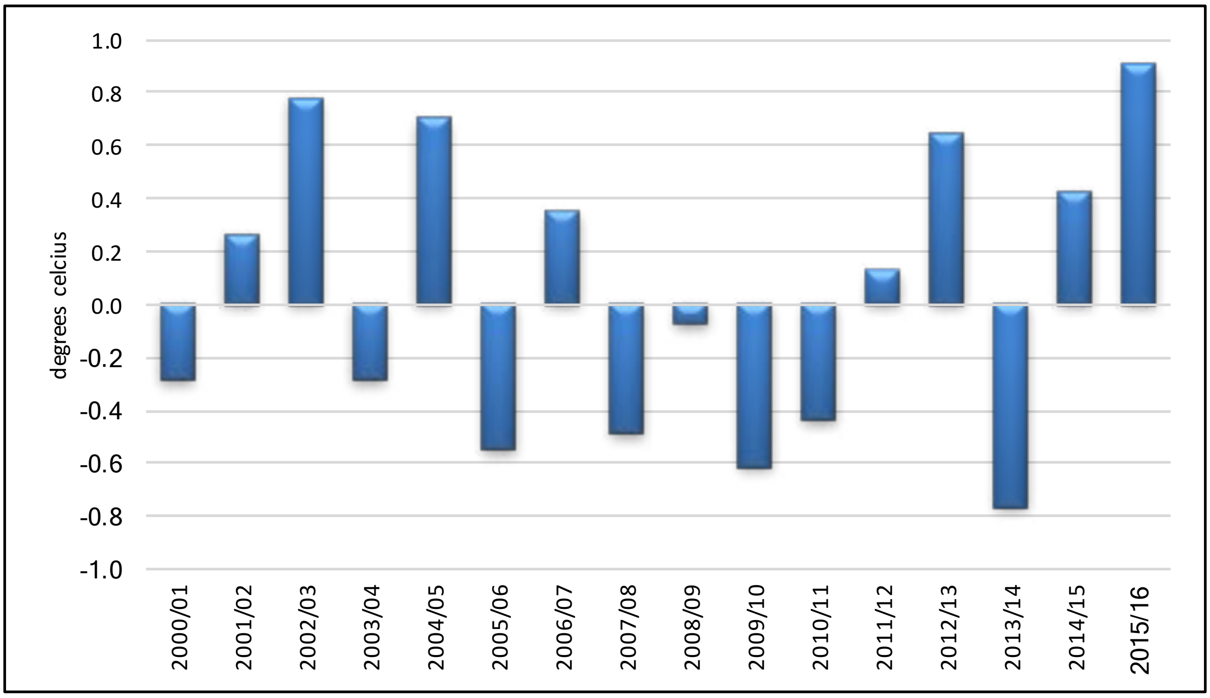


Figure 1.6 Mean maximum temperature deviation 2000/01 to 2015/16



1.4. Wind speed and direction

The Department of Meteorological Services (DMS) monitors wind speeds and direction in Botswana. Wind speed is recorded in metres per second (m/s) and graded using the Beaufort scale (see appendix III). Wind direction is recorded in degrees and is named according to the direction that it is blowing from.

1.4.1. Wind speed

Botswana lies under the horse latitudes in the major winds of the globe. The horse latitudes are a narrow zone of warm, dry climates between the westerlies and the trade winds, and are about 30 and 35 degrees north and south. (National Geographic: 2017). Table 1.9 shows the monthly average wind speed for each of the stations, from July 2015 to December 2016.

Table 1.9 Monthly average wind speed 2015/16 (m/s)

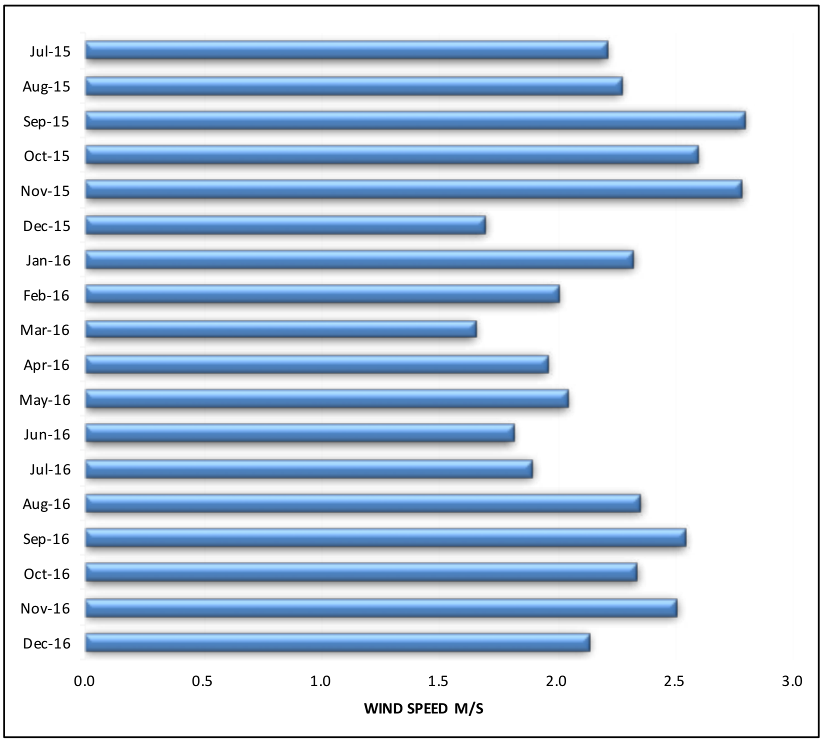
Year	Month	Ghanzi	Shakawe	Mahalapye	Tshane	Jwaneng	Sua Pan	Tsabong	Werda	Pandamatenga	Lephephe	Goodhope
2015	July	2.5	1.4	2.3	2.1	-	2.0	1.9	2.3	2.0	2.2	3.4
	August	2.4	1.3	2.3	2.3	-	2.1	2.2	2.3	2.3	2.2	3.3
	September	2.6	1.6	3.2	2.5	3.2	2.7	2.7	2.6	2.8	3.3	3.9
	October	2.5	1.5	3.1	2.0		2.9	2.2	2.1	2.7	3.2	3.7
	November	2.6	1.8	3.0	2.6	-	2.7	3.0	2.6	2.4	3.3	3.8
2016	January	2.0	1.3	3.1	2.0	-	2.4	2.4	2.2	1.7	3.1	3.0
	February	1.8	1.3	2.4	1.7	-	-	2.2	2.0	1.3	2.6	2.8
	March	2.0	1.3	1.7	-	-	-	-	-	1.6	-	-
	April	2.1	1.4	2.1	1.8	-	2.0	2.1	1.8	1.9	-	2.4
	May	2.2	1.5	2.0	2.0	-	2.0	1.9	1.9	1.9	2.1	2.9
	June	1.9	1.3	1.7	1.8	-	1.6	1.8	1.8	1.9	1.6	2.7
	July	2.0	1.5	1.9	1.9	-	1.9	1.8	1.8	2.1	1.8	2.3
	August	2.5	1.7	2.2	2.4	-	2.2	2.4	2.5	2.2	2.4	3.0
	September	2.6	1.5	2.9	2.5	-	2.2	2.3	2.3	2.4	2.8	3.9
	October	2.2	1.4	-	2.1	-	-	2.1	2.0	2.7	2.8	3.3
	November	2.3	-	2.7	2.1	-	2.2	-	2.3	2.1	2.8	3.6
	December	2.2	1.1	2.6	1.9	-	-	2.5	1.9	1.5	2.5	3.0
	Maximum	**2.6**	**1.8**	**3.2**	**2.6**	**3.2**	**2.9**	**3.0**	**2.6**	**2.8**	**3.3**	**3.9**
	Minimum	**1.8**	**1.1**	**1.7**	**1.7**	**3.2**	**1.6**	**1.8**	**1.8**	**1.1**	**1.6**	**1.8**

No data for Francistown, Gaborone and Selibe Phikwe
Dashes (-) show no data available

The station that recorded the highest monthly average wind speed is Goodhope, recording 3.9 m/s in September 2015 and again in September 2016. The second highest wind speeds by station are for Lephephe where a maximum average monthly wind speed of 3.3 m/s was recorded in September and October 2015.

Figure 1.7 shows the average wind speeds for all the stations. The highest average wind speeds are experienced during the months of September, November and October in that order. The period of highest average wind speeds annually preceded the rainy season for the period assessed.

Figure 1.7 Average wind speeds 2015/16 (m/s)



1.4.2. Wind direction

Wind direction is expressed in degrees and in terms of the direction that the wind is blowing from. For example, easterly winds blow from the east to the west. Box 1 shows an insertion characterising the determinants of the climatic conditions of Botswana.

Box 1 Botswana's climate

The main features of the climate are determined by Botswana's inland location, astride the subtropical high-pressure belt. During the summer months, the Inter-Tropical Convergence Zone (ITCZ) moves southward to about 20° S to bring moisture to the northern parts of the country. The rest of the subcontinent is influenced by a thermal low pressure cell. Moist air associated with the ITCZ, and the moist air which is fed in to the eastern parts of the country from the Indian Ocean, is warmed by the intense sunshine, leading to convective storms. The air becomes progressively drier westwards as most of the moisture is shed over the eastern and northern parts of the country. Between May and September the stable high pressure cell displaces the ITCZ and its associated thermal lows to the north, resulting in drier conditions in winter. Once every few weeks during the dry season, westerly waves displace the cell northward, drawing in cold air from the south and causing light frontal clouds.

Source: Department of Meteorological Services (2001)

Botswana's winds are predominantly easterly to north easterly except for the south west of the country where northerly winds are dominant. (Department of Meteorological Services: 2003). Table 1.10 shows the average wind directions recorded at meteorological stations between July 2015 and December 2016

Table 1.10 Average wind directions 2015/16 (degrees)

Year	Month	Ghanzi	Shakawe	Francistown	Mahalapye	Tshane	Jwaneng	SSKA	Sua Pan	Tsabong	Werda	Pandamatenga	Selibe Phikwe	Lephephe	Goodhope
2015	105.7	126.0	-	131.9	119.2	-	-	103.1	129.3	106.0	88.5	-	153.9	99.8	99.8
	102.8	134.1	-	88.3	115.4	-	-	105.3	107.5	111.4	80.9	-	119.8	72.1	72.1
	142.9	129.1	-	88.6	153.3	88.6	-	101.2	167.4	156.2	75.8	-	121.3	106.8	106.8
	121.4	136.6	18.8	76.4	128.2	21.3	15.9	99.6	150.0	122.5	92.6	35.5	103.0	70.9	70.9
	161.6	131.6	24.2	101.1	163.2	-	17.2	118.5	166.2	143.4	146.4	39.9	125.6	150.0	150
2016	January	123.0	164.2	-	72.8	152.4	-	-	97.7	101.9	81.4	119.5	-	92.2	109.2
	February	118.0	104.0	-	90.8	184.0	-	-	-	167.0	167.0	94.7	-	85.3	114.0
	March	115.5	113.8	-	100.2	-	-	-	-	-	-	69.7	-	-	-
	April	116.8	114.1	-	101.0	115.6	-	-	105.4	150.5	108.2	94.3	-	-	96.5
	May	134.1	136.9	-	70.7	100.6	-	-	108.5	96.6	98.4	94.6	-	103.3	64.8
	June	121.4	139.2	-	144.4	93.1	-	-	113.8	107.8	98.2	94.5	-	151.2	83.9
	July	146.9	153.1	-	165.1	130.7	-	-	139.5	132.6	143.9	109.6	-	148.0	140.2
	August	135.2	137.9	-	101.2	105.3	-	-	115.3	105.8	103.5	95.5	-	110.2	103.0
	September	130.6	122.5	-	93.3	152.3	-	-	97.6	190.5	166.9	82.2	-	126.3	103.7
	October	129.3	103.2	-	-	167.2	-	-	86.3	206.5	167.8	71.2	-	134.8	135.8
	November	103.8	1.4	-	70.4	108.5	-	-	93.0	-	179.0	82.1	-	82.3	115.3
	December	96.9	86.9	-	109.7	139.2	-	-	-	149.9	151.3	95.7	-	106.8	116.3

Dashes (-) show no data available

Table 1.11 Wind Direction by number of days 2016

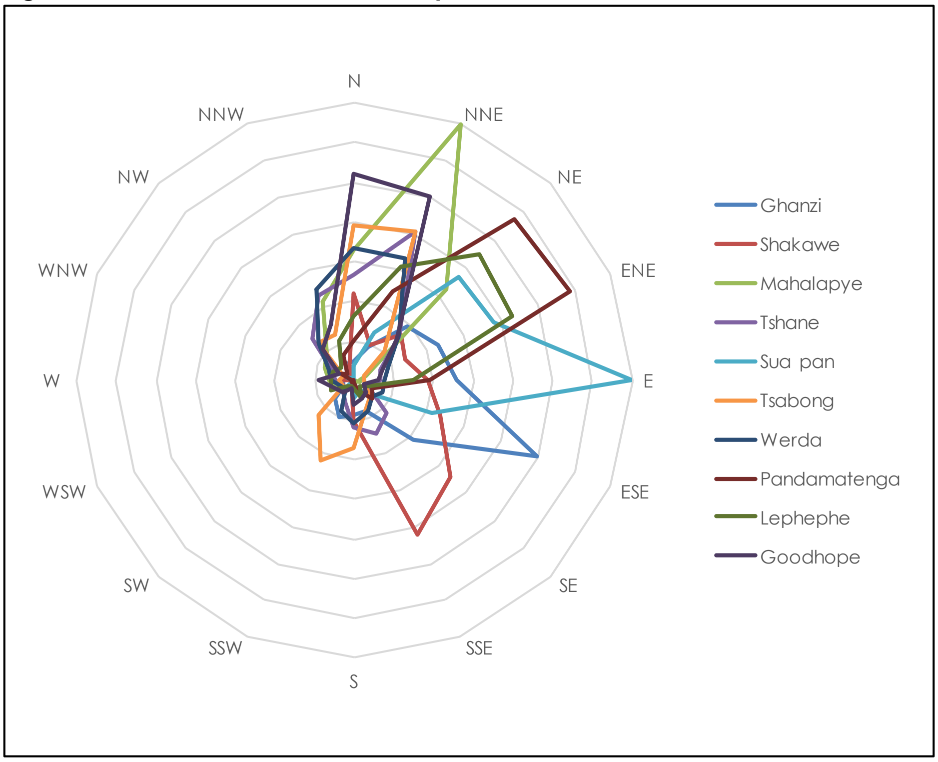
	Ghanzi	Shakawe	Mahalapye	Tshane	Sua pan	Tsabong	Werda	Pandamatenga	Lephephe	Goodhope
NNE	17	18	55	45	5	60	56	18	27	87
NE	35	30	117	68	18	62	56	45	52	84
ENE	42	25	55	26	51	16	27	105	75	25
E	47	34	5	12	52	4	16	108	72	13
ESE	91	42	2	11	96	4	13	35	25	10
SE	38	62	2	6	29	5	13	9	6	4
SSE	15	76	0	19	6	9	10	12	3	7
S	16	19	1	24	4	12	14	5	8	8
SSW	18	3	6	20	6	26	18	1	3	10
SW	12	0	4	10	1	33	14	1	3	4
WSW	6	0	3	7	3	19	6	0	4	7
W	5	5	8	5	0	5	6	1	11	9
WNW	5	0	11	8	0	6	10	1	10	15
NW	2	2	14	10	3	5	12	7	10	7
NNW	8	7	16	25	1	20	22	5	8	19
N	9	40	36	39	0	19	42	13	18	26
Total days recorded	**366**	**363**	**335**	**335**	**275**	**305**	**335**	**366**	**335**	**335**

Table 1.11 shows the predominant wind direction by number of days for the year 2016, for stations with data available. The winds were predominantly easterly.

Mahalapye and Sua Pan recorded winds blowing from the north northeast and east, respectively, on 35 percent of the days recorded in the year 2016. Ghanzi and Goodhope recorded east southeast and northeast winds on 25 percent of the year's days. Pandamatenga's winds were predominantly east northeast (30 percent) and north easterly (29 percent). Tsabong winds were predominantly north and north northeast (20 percent each) and Werda winds were also predominantly north and north northeast at 17 percent each of the recorded days.

Figure 1.8 graphically illustrates the dominant wind directions recorded in the year 2016.

Figure 1.8 Dominant wind direction by location 2016



2. WATER

2.1. Dam levels

Botswana's surface water is drawn from nine dams, which are listed in Table 2.1 together with the dams' capacities. The largest dam in Botswana is Dikgatlhong dam, followed by Gaborone and Letsibogo dams. The smallest dam is Nnywane followed by Bokaa dam. Molatedi dam is in South Africa and provides imported water to Botswana.

Table 2.1 Dam capacities

Dam	Capacity (Mm3)
Dikgathong	400
Molatedi (Republic of South Africa)	201
Gaborone Dam	141.4
Letsibogo	100
Thune	90
Shashe	85
Lotsane	40
Ntimbale	26.6
Bokaa Dam	18.5
Nnywane	2.3

Source: Statistics Botswana
Note: Molatedi dam is in South Africa and provides imported water to Botswana

Water Utilities Corporation records and monitors dam levels. Table 2.2 shows the dam levels recorded on one day of each month during the period January 2014 to December 2016.

Table 2.2 Percentage dam levels 2014-16

Year:	Date	Gaborone	Nnywane	Bokaa	Letsibogo	Shashe	Ntimbale	Thune	Lotsane	Dikgathong	Molatedi
2014	Jan 15th	11.6	16.0	4.8	84.5	96.0	105.5	n/a	77.5	43.8	14.0
	Feb 17th	13.2	74.7	38.5	100.9	98.3	100.0	41.6	99.1	101.0	20.2
	Mar 14th	16.0	75.6	57.0	103.7	103.4	102.0	55.5	108.3	106.5	26.0
	Apr 14th	15.1	73.0	56.2	97.7	97.3	98.4	55.7	96.4	98.9	35.3
	May 16th	13.7	67.6	50.2	93.6	94.3	97.5	58.7	94.2	98.3	34.6
	Jun 27th	12.5	61.1	46.0	90.1	91.1	95.8	58.7	89.4	97.0	32.8
	Jul 15th	11.3	54.6	41.8	86.6	87.9	94.1	54.0	84.5	95.6	31.0
	Aug 29th	9.8	54.1	36.3	77.5	83.4	90.5	52.0	82.9	95.4	28.4
	Sep 23rd	8.5	51.1	30.5	78.7	80.6	88.7	51.2	80.7	92.3	26.8
	Oct 8th	7.5	47.0	27.3	75.9	78.9	87.3	49.9	77.5	91.2	24.7
	Nov 14th	6.1	40.2	22.0	72.3	75.1	84.1	48.1	75.2	88.2	21.7
	Dec 15th	5.2	92.1	19.7	70.7	71.5	84.1	48.1	71.7	87.1	20.8
2015	Jan 15th	4.7	93.2	20.5	69.9	83.7	89.6	47.7	73.4	88.0	18.0
	Feb 17th	4.2	94.2	21.2	69.0	95.8	95.0	47.2	75.0	88.8	15.2
	Mar 9th	3.4	88.4	18.4	65.2	93.9	92.0	46.8	72.2	87.4	15.2
	Apr 15th	2.7	85.6	15.5	58.3	92.6	97.9	45.5	70.0	85.6	13.4
	May 15th	2.2	79.5	11.9	55.7	93.9	95.9	44.3	67.4	84.1	12.5
	Jun 15th	1.7	73.3	8.2	53.1	95.1	93.9	43.1	64.8	82.5	11.5
	Jul 17th	1.6	66.7	2.4	49.2	91.5	89.8	41.5	61.3	80.9	10.2
	Aug 26th	1.5	60.5	2.0	46.3	87.9	89.3	43.0	59.9	79.4	8.9
	Sep 22nd	1.4	56.2	2.0	43.8	85.1	86.3	39.1	58.3	78.3	8.4
	Oct 6th	1.4	53.4	2.0	43.3	83.2	85.3	39.1	57.4	77.6	7.6
	Nov 13th	1.1	46.2	2.0	38.3	79.6	83.6	37.6	51.7	74.5	5.2
	Dec 14th	1.3	65.3	45.8	36.4	76.5	81.0	-	-	72.5	5.0
2016	Jan 18th	1.7	100.0	51.7	35.6	83.8	82.7	36.5	46.5	70.4	7.3
	Feb 15th	1.7	93.3	49.4	36.5	80.7	91.0	37.0	44.4	70.0	7.0
	Mar 17th	9.0	102.6	73.5	68.7	100.8	101.6	37.3	98.0	88.0	8.9
	Apr 20th	18.8	94.6	99.0	75.9	98.1	97.8	39.9	96.9	97.9	39.3
	May 19th	18.6	88.2	91.5	72.9	95.4	95.4	37.0	93.2	95.9	36.0
	Jun 6th	17.2	80.1	88.5	71.1	93.7	93.8	37.0	91.0	94.5	35.0
	Jul 21st	16.1	77.3	82.5	67.9	89.4	90.6	36.2	87.8	92.1	33.7
	Aug 8th	15.5	74.1	80.0	66.0	87.2	88.0	-	-	91.0	n/a
	Sep 12th	14.4	68.0	75.7	63.3	83.6	88.5	-	-	-	29.7
	Oct 10th	13.2	61.5	71.4	60.6	80.5	87.0	-	-	-	-
	Nov 18th	13.7	54.0	71.8	57.3	77.8	79.8	29.9	91.5	84.2	24.7
	Dec 8th	14.6	74.5	99.8	56.3	76.3	78.7	29.9	92.6	83.2	24.9
	Dec 8th	14.6	74.5	99.8	56.3	76.3	78.7	29.9	92.6	83.2	24.9

Source: Water Utilities Corporation
Dashes (-) mean no data

In 2014 the dam levels peaked during the month of March, in 2015 during the month of February and in 2016 they peaked during the month of April. These months are at or around the end of the rainy season that starts in October and ends in March of the subsequent year, every meteorological year. The meteorological year in Botswana begins in July and ends in June of the subsequent year.

The dam levels were generally at their lowest during the month of December in 2014, and during the months of November and December in 2015, while in 2016 they were at their lowest during the months of February and December.

Figure 2.1 Average levels per dam 2014 to 2016

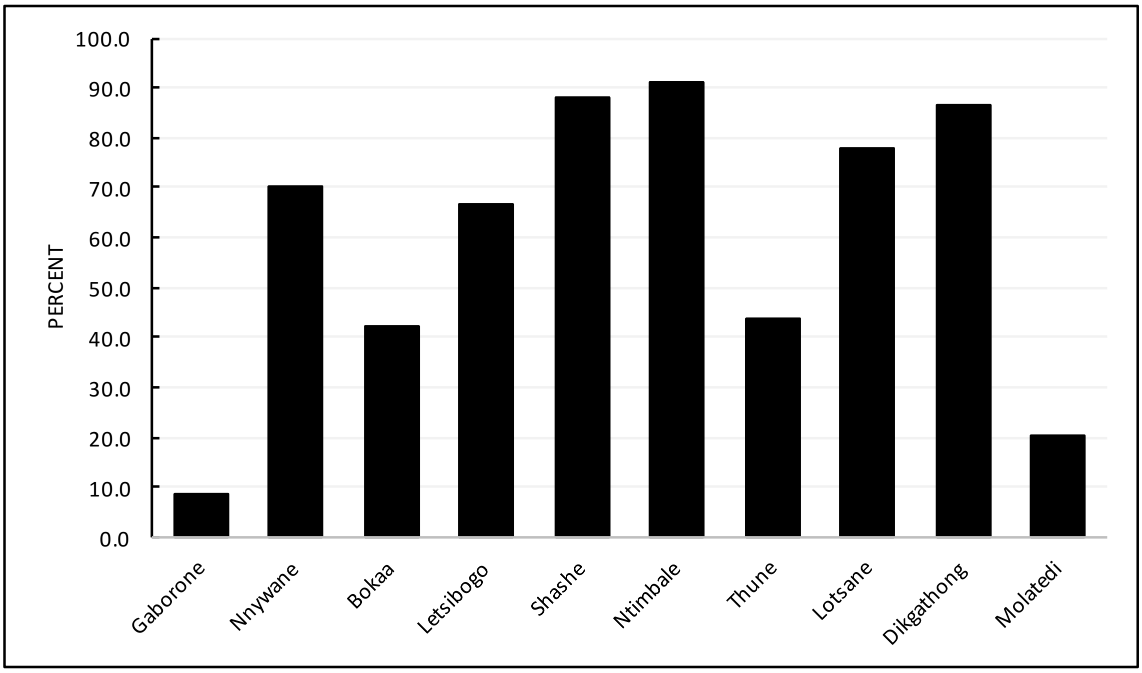
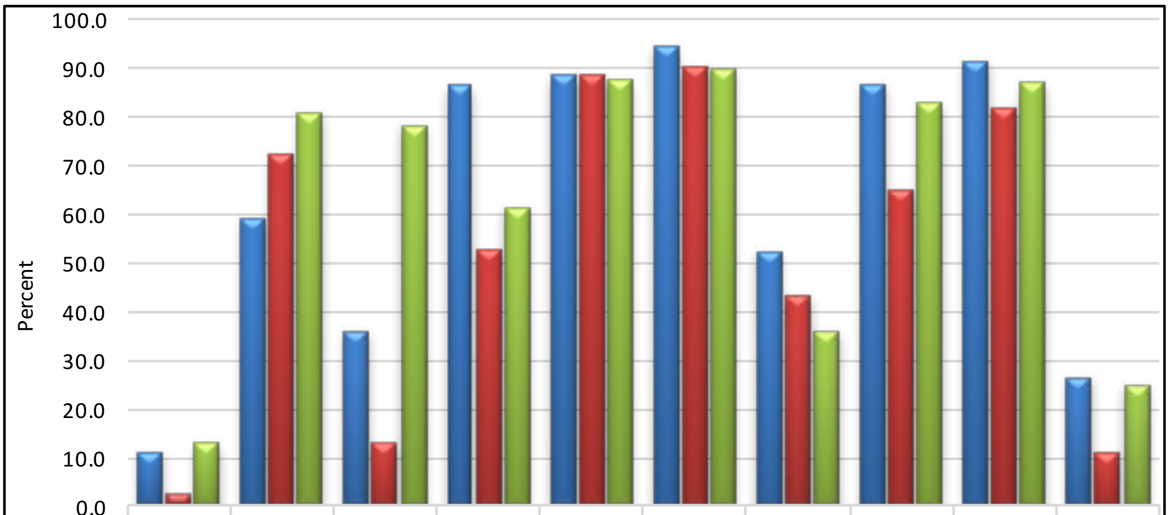


Figure 2.1 shows the average annual dam levels for each dam for the period 2014 to 2016. This figure compares the percentage level performances of the dams. Ntimbale, Shashe and Dikgatlhong dams recorded the highest levels for most of the time. Gaborone, Bokaa and Thune dams recorded the lowest levels during the three years. Molatedi dam in South Africa also recorded lower levels than most of the dams.

Figure 2.2 Average annual dam levels (percent) 2014/16



	Gaborone	Nnywane	Bokaa	Letsibogo	Shashe	Ntimbale	Thune	Lotsane	Dikgathong	Molatedi
2014	10.9	58.9	35.9	86.0	88.2	94.0	52.1	86.4	91.3	26.4
2015	2.3	71.9	12.7	52.4	88.2	90.0	43.2	64.7	81.6	10.9
2016	12.9	80.7	77.9	61.0	87.3	89.6	35.6	82.4	86.7	24.7

Figure 2.2 shows the annual average dam levels per dam. This figure compares each dam's annual performance in terms of its percentage levels. On average, the year 2015 recorded the lowest levels. The years 2014 and 2016 were closely matched, with the year 2016 marginally higher than 2014.

2.2 Abstraction

Figure 2.3 shows the water abstraction for the dams between 2009/10 and 2014/15. The highest abstraction volumes are mostly those for Gaborone, Letsibogo and Shashe dams. Gaborone dam's abstraction is particularly lower than that from Letsibogo and Shashe dam during the 2014/15 year. This was a drought year when the dams experienced low levels. Thune dam is currently not in extractive use due to current lack of infrastructure.

Figure 2.3 Total annual water abstraction from WUC dams (kilolitres) 2009/10 – 2014/15

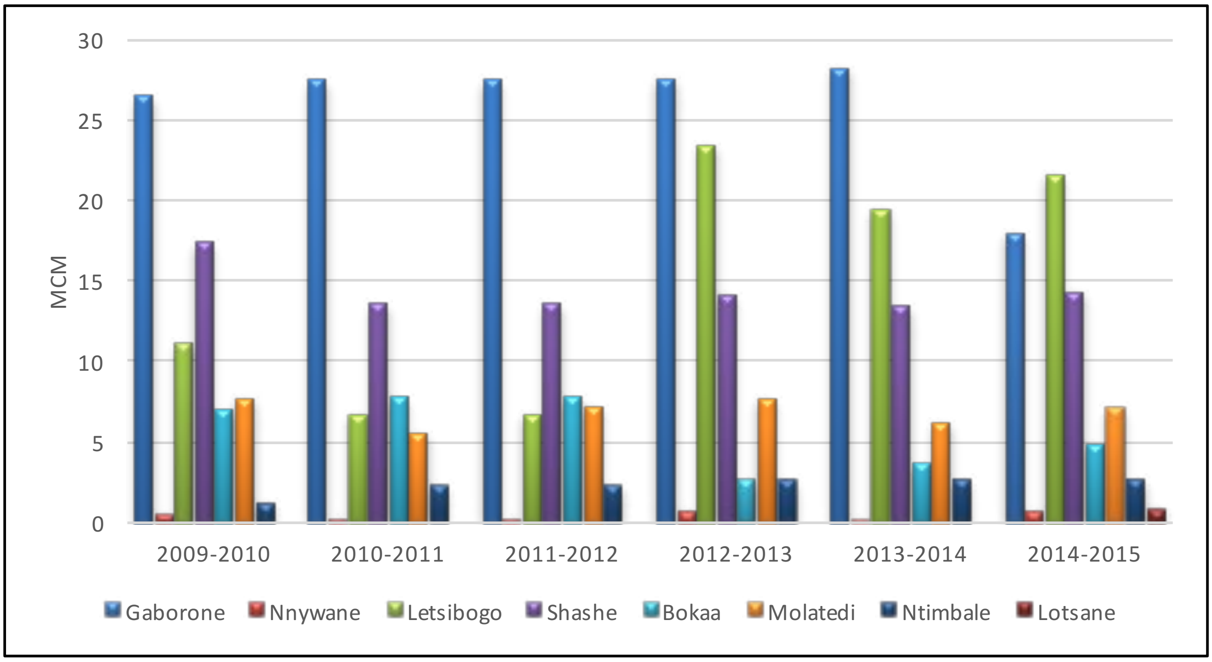


Table 2.3 shows the dam levels as at 24th of February 2017, the areas supplied by the dams and the number of months the dam could continue to supply the area given the percentage level indicated. Although Dikgatlhong is the largest dam, it supplies Greater Gaborone, Mahalapye and Palapye and could supply for 24 months without inflow. Molatedi has the lowest percentage level but could supply for 52 months without inflow, however, the dam is in South Africa and supplies imported water to Gaborone.

Table 2.3 Dam levels as at 24th February 2017

Dam	Capacity MCM	Level (%) As at 24th February 2017	Months of supply without inflow	Area supplied
Dikgatlhong	400	105.7	24	Greater Gaborone Mahalapye Palapye
Molatedi	201	50.2	52	Greater Gaborone
Gaborone	141.4	96.3	30	Greater Gaborone
Letsibogo	100	>100.0	23	S/Phikwe , BCL & Mmadinare
Thune	90	76.6	-	-
Shashe	85	107	23	Greater Francistown
Ntimbale	26.5	103.5	15	North East &Tutume Sub-District
Lotsane	42.35	101.5	29	22 villages of Tswapong North
Bokaa	18.5	105	13	Greater Gaborone
Nnywane	2.3	>100.0	13	Lobatse

Source: Water Utilities Corporation
Dash (-) indicates no data available

2.3 Production

Water production is carried out by the Water Utilities Corporation (WUC) through sixteen (16) management centres. There are 7 management centres in the southern region and nine (9) management centres in the northern region. Table 2.4 shows the list of management centres.

Table 2.4 List of water management centres

Region		Management Centre
Southern region	1	Gaborone
	2	Molepolole
	3	Lobatse
	4	Mochudi
	5	Kanye
	6	Tsabong
	7	Ghanzi
Northern region	8	Selibe Phikwe
	9	Palapye
	10	Serowe
	11	Letlhakane
	12	Mahalapye
	13	Kasane
	14	Masunga
	15	Francistown
	16	Maun

2.3.1 Water production by Management Centres

Gaborone management centre serves the Greater Gaborone area, which has the highest population and carries most of the economic activity of the southern region and the country at large. In the northern region, Francistown management centre serves the country's second city, which is also the second most populated settlement.

Table 2.5 Southern Management Centres Annual Water Production 2012/13 to 2015/16 (Kilolitres)

	Gaborone	Lobatse	Kanye	Molepolole	Tsabong	Mochudi	Ghanzi
2012/13	30,130,446.0	9,310,921.6	6,700,956.4	4,233,828.5	323,022.0	3,517,238.0	1,512,674.7
2013/14	30,452,527.0	4,488,496.0	3,471,882.0	2,299,452.0	610,023.0	2,674,458.0	851,080.0
2014/15	23,746,583.0	8,916,946.0	6,933,019.0	6,271,383.3	1,445,927.4	3,527,084.0	1,356,663.1
2015/16	24,435,785.0	6,891,735.0	6,492,403.6	6,037,715.4	1,496,076.8	3,570,378.5	1,411,126.0

Source: Water Utilities Corporation
Dash (-) shows no data available

Table 2.5 above shows the water production for the southern management centres from 2012/13 to 2015/16. The southern management centres show that starting 2013/14, there was increasing water production for Kanye, Molepolole, Tsabong, Mochudi and Ghanzi management centres, while only Gaborone and Lobatse management centres had a declining trend in water production. Tsabong's water production increased more than two fold during the 2012/13 to 2015/16 period. Gaborone water production has been affected by the extremely low levels reached by Gaborone and Bokaa dams. Water production was also interrupted often due to maintenance and repair work on the North-South Carrier pipeline.

Table 2.6 Northern Management Centres Annual Water Production 2012/13 to 2015/16 (Kilolitres)

	Francistown	Serowe	Palapye	Selibe Phikwe	Letlhakane	Kasane	Masunga	Mahalapye	Maun
2012/13	14,164,976.5	3,230,928.0	2,415,097.3	8,295,707.8	1,394,510.8	1,527,715.4	6,040,348.0	4,661,359.6	-
2013/14	13,432,600.0	3,208,992.0	2,419,766.0	8,161,580.0	1,143,993.0	958,096.0	2,359,870.0	2,252,070.0	-
2014/15	14,468,595.0	3,175,946.0	2,867,553.4	7,974,811.0	1,479,061.0	1,866,431.0	4,573,256.5	4,559,195.3	3,712,910.3
2015/16	15,889,994.0	4,262,267.0	3,527,980.0	11,119,405.0	1,884,045.3	1,554,640.0	4,600,709.3	5,100,037.7	4,280,335.0

Source: Water Utilities Corporation
Dash (-) shows no data available

In Table 2.6 above, all the northern management centres except Masunga, are characterised by generally rising water production between 2012/13 and 2015/16.

2.3.2 Water production by settlements

Table 2.7 shows the water production for selected settlements.

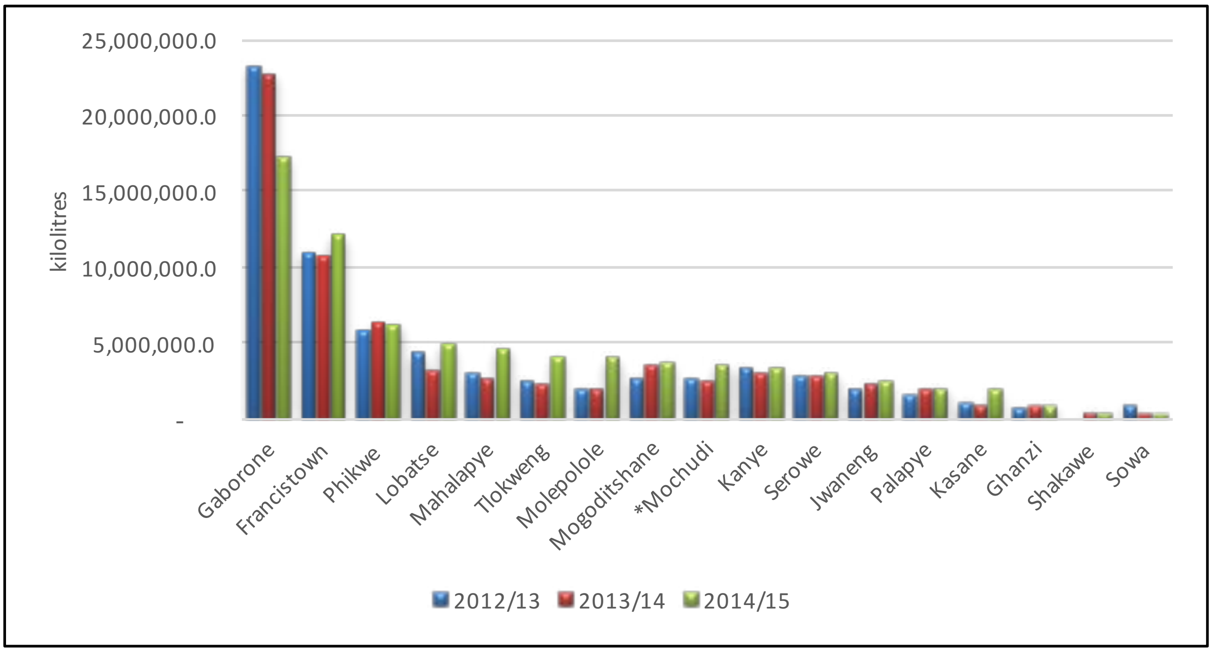
Table 2.7 Annual Water Production for selected settlements 2012/13 to 2014/15 (Kilolitres)

	2012/13	2013/14	2014/15
Gaborone	23,217,704.0	22,633,546.0	17,211,304.3
Francistown	10,923,534.0	10,751,528.0	12,042,156.8
Phikwe	5,765,405.0	6,276,996.0	6,201,722.0
Lobatse	4,296,432.0	3,203,284.0	4,835,417.2
Mahalapye	2,962,299.0	2,590,991.0	4,559,195.3
Tlokweng	2,462,150.0	2,269,810.0	4,036,820.0
Molepolole	1,924,879.0	1,871,983.0	4,015,603.7
Mogoditshane	2,635,198.0	3,491,664.0	3,716,243.0
*Mochudi	2,597,478.0	2,386,233.0	3,527,084.0
Kanye	3,332,039.0	2,910,841.5	3,410,424.0
Serowe	2,843,131.0	2,749,003.0	2,953,383.8
Jwaneng	1,914,626.0	2,289,752.0	2,377,761.2
Palapye	1,491,922.0	1,871,834.0	1,962,974.5
Kasane	1,057,322.7	835,720.0	1,866,431.0
Ghanzi	773,369.7	810,870.3	799,294.1
Shakawe	-	393,925.0	384,597.0
Sowa	839,340.0	310,360.0	293,759.0

Incudes Morwa, Pilane, Rasesa, Bokaa
Dash (-) shows no data available
2015/16 data not available at time of publication

The general trend in water production for the settlements is that of increase between 2012/13 and 2014/15. A gradual increase is noticeable in Ghanzi, Palapye, Jwaneng, Kanye, Mochudi, Mogoditshane, Lobatse and Phikwe, while Francistown, Mahalapye, Serowe, Molepolole, Tlokweng, and Kasane showed a sharp increase in the water supplied to them. Shakawe and the mining town of Sowa on the other hand had a fall in the water supplied to them .

Figure 2.4 Annual Water Production for selected settlements 2012/13 to 2014/15 (Kilolitres)



2.4 Consumption

Water consumption is measured here using billed water. Water Utilities Corporation (WUC) bills customers based on meter readings and derives the billed water consumption. Table 2.8 shows the billed water consumption for the 2013/14, 2014/15 and 2015/16 financial years, for each of the management centres.

Table 2.8 Annual Water Consumption by Management Centres 2013/14 to 2015/16 (kilolitres)

	2013/14	2014/15	2015/16
Gaborone	22,916,268.0	21,273,171.0	20,792,005.0
Mochudi	2,674,458.0	2,827,371.0	2,320,610.0
Molepolole	2,299,452.0	2,903,148.0	3,654,304.0
Lobatse	4,488,496.0	4,644,376.0	3,747,109.0
Kanye	3,471,882.0	3,793,108.0	3,834,742.0
Tsabong	610,023.0	904,489.0	958,380.0
Ghanzi	851,080.0	997,761.0	1,074,239.0
Southern MCs Total	**37,311,659.0**	**37,343,424.0**	**36,381,389.0**
Francistown	13,432,600.0	11,917,562.0	10,800,676.0
Selibe Phikwe	8,161,580.0	7,649,071.0	8,560,012.0
Palapye	2,419,766.0	2,697,102.0	2,967,836.0
Serowe	3,208,992.0	2,441,788.0	2,306,358.0
Mahalapye	2,252,070.0	2,567,216.0	2,411,964.0
Kasane	958,096.0	1,072,352.0	1,163,494.0
Masunga	2,359,870.0	2,735,497.0	2,788,723.0
Letlhakane	1,143,993.0	1,113,182.0	1,216,807.0
Northern MCs Total	**33,936,967.0**	**32,193,770.0**	**32,215,870.0**

Source: Water Utilities Corporation

For the southern management centres' 2013/14 to 2015/16 Consumption, figures show a declining trend for Gaborone, Lobatse and Mochudi management centres. Kanye, Molepolole, Ghanzi and Tsabong had increasing consumption from 2013/14 to 2015/16. The weight of the declining consumption of Gaborone management centre resulted in a decline in the total consumption for the southern management centres.

For the northern management centres' 201314 to 2015/16 consumption, Francistown has the highest consumption and shows a declining trend in its consumption. Serowe and Letlhakane also show a declining trend in their water consumption. Mahalapye, Selibe Phikwe, Palapye, Kasane and Masunga have increasing water consumption trends. The total consumption for northern management centres shows a decline over the 2013/14 to 2015/16 period.

2.5 Environmental Water Quality

Water quality is the chemical, physical and biological characteristics of water. Water quality monitoring is important because the quality of water in the environment affects aquatic life as well the surrounding environment. Such monitoring also allows environmental monitoring because the water quality parameters are also affected by the surrounding environment. The Department of Water Affairs tests the quality of water at various points in rivers around the country. There are no quality standards for water in the environment in Botswana. Botswana Bureau of Standards (BOBS) provides drinking water standards. Table 2.9 Shows the BOS 32:2009 drinking water standard, the BOS 463:2011 irrigation water standard, and the South African Aquatic ecosystem which applies to water in the environment. The South African Aquatic Ecosystem water quality standards are for environmental water and are hereby used as a proxy against the drinking and irrigation water standards available for Botswana.

Table 2.9 Drinking water standards

Parameters	Units	BOS 32:2009 Drinking Water Standard (Maximum Allowable limits)	BOS 463:2011 Water quality for irrigation	RSA Aquatic ecosystem
Dissolved Oxygen (DO)	mg/L	n/a	n/a	03-08
Potential of Hydrogen (pH)	pH Units	5.5-9.5	6.5-8.4	6.5-8.5
Electronic Conductivity (EC)	µs/cm	3100	3000	400
Turbidity	NTU	5	n/a	n/a
Total Dissolved Solids (TDS)	mg/L	2000	2000	n/a
Calcium (Ca)	mg/L	200	n/a	n/a
Magnesium (Mg)	mg/L	100	n/a	n/a
Sodium (Na)	mg/L	400	230	n/a
Nitrates (NO3)	mg/L	50	30	n/a
Phosphates (PO4)	mg/L	n/a	n/a	0.025
Potassium (K)	mg/L	100		
Chlorides (Cl)	mg/L	600	350	200
Sulphates (SO4)	mg/L	400	200	n/a
Iron (Fe)	mg/L	2	5	n/a
Manganese (Mn)	mg/L	0.5	0.2	0.18
Copper (Cu)	mg/L	2	0.2	0.0003
Lead (Pb)	mg/L	0.01	n/a	0.0002
Intestinal Enterococci	cfu/100ml	Not to detect in 100ml sample	n/a	n/a
Faecal coliform	Cfu/100ml	Not to detect in 100ml sample	<1000	n/a

Source: Adapted from Limpopo Joint Water Quality Baseline Report

This report examines environmental water quality data from three river channels, for which tests were done at different locations for various parameters at different points in time. The parameters tested are Potential for Hydrogen (pH), Electronic Conductivity (EH), Sulphates (SO4), Nitrates (NO3), Chlorides (Cl), Magnesium (Mg), Sodium (Na) Calcium (Ca), Total Dissolved Solids (TDS), Potassium (K), Iron (Fe) and Manganese (Mn).

The water quality standards referred to herein should be considered as a proxy for the unavailable water quality standards for water in the environment in Botswana. Water in the environment does not have to meet drinking water quality standards.

2.5.1 Chobe River Basin

The Chobe River flows along the Botswana-Namibia border eastwards and into the Zambezi River. Data from water quality tests carried out by the Department of Water Affairs is used. The data is for tests carried out in June and October 2013, at various points along the river's channel. Tables 2.10 and 2.11 show the test results.

The results of the tests indicate that the water quality was within standards for most of tests. Total Dissolved Solids (TDS), Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (k), Chlorides (Cl), Sulphates (SO4), Nitrates (No3) and Manganese (Mn) all were within the limits of the two BOS standards for drinking water and irrigation water. A few of the parameters tested exceeded one of the standards occasionally. The Potential for Hydrogen (pH) has remained within the BOS 32:2009 drinking water standards, but exceeded the irrigation water standards (BOS 463:2011) for the June 2013 tests at Kazungula village. Electronic Conductivity (EC) was within the BOS 32:2009 and BOS 463:2011 for both the June and October 2013 tests, exceeding 400 µs/cm (South Africa Aquatic Ecosystem standards) in October 2013 at Kasane, Ngoma and Mabele. Iron (Fe) was mostly within the drinking and irrigation water standards, but high at Kasane, Ngoma, and Lenyanti's two test sites in June 2013.

Table 2.10 Water quality test results for Chobe River Basin June 2013

Village	Kazungula	Kasane	Ngoma	Lenyanti	Lenyanti	Lenyanti	Lenyanti	Lenyanti	Lenyanti	Kwando	Kwando	Kwando
Location	chobe Zambezi confluence @ Ferry Station	Upstream Sedudu Island	Ngoma Bots/ Namibia borderpost bridge	King's Pool at BDF camp	Sajawa Hydro G-Station	Zibadianja Lagoon	Down-stream Savuti channel at bridge	Dumatau	Selinda Spillway	Lebala camp	Up-stream Bots/ Namibia border line	Down-stream Kwando lagoon lodge
pH	9.3	7.41	7.71	7.54	7.01	7.16	7.65	7.26	7.44	8.05	7.38	7.27
EC µs/cm	59	64	65	154	141	178	176	148	163	152	118	121
TDS mg/l	46	20	66	160	154	150	176	162	104	146	82	104
Ca mg/l	15.8	8.29	11.1	23.5	20.8	25.5	25.6	21.9	24	22.4	82.7	19.1
Mg mg/l	2.45		2.42	3.86	3.28	4.94	4.93	3.8	4.3	4.11	16.5	3.34
Na mg/l	1.44	4.44	3.36	6.52	6.07	7.85	8.38	6.19	6.9	8.57	9.12	4.76
K mg/l	0.44	0.55	0.54	4.3	3.95	4.7	5.13	4.82	4.51	5.3	4.51	3.42
Cl mg/l	0.81	1.55	1.21	0.48	0.29	0.7	1.22	0.4	0.72	2.62	16.26	3.55
SO4 mg/l	0.97	1.83	3.36	2.4	0.64	1.67	1.76	1.5	1.77	2.24	143.9	1.25
NO3 mgl/	0.42	0.37	0.22	0.69	0.25	10.4	0.55	0.19	0.77	0.62	10.47	Nd
F mg/l	0.24	0.13	0.22	0..25	0.12	0.25	0.16	0.19	0.24	0.23	3.4	0.21
Fe mg/l	1.25	44.9	85.5	29	13.7	0.02	0.02	0.02	0.02	0.02	0.08	0.01
Mn mg/l	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.11 Chobe River Basin Water quality test results for October 2013

Village	Kazungula	Kasane	Ngoma	Lenyanti	Lenyanti	Lenyanti	Lenyanti	Lenyanti	Lenyanti	Kwando	Kwando	Kwando	Shaile	Mabele
Location	chobe Zambezi confluence @ Ferry Station	U/stream Sedudu Island	Ngoma Bots/ Namibia borderpost bridge	King's Pool at BDF camp	Sajawa Hydro G-Station	Zibadianja Lagoon	D/stream Savuti channel at bridge	Dumatau	Selinda Spillway	Lebala camp	U/stream Bots/ Namibia border line	D/stream Kwando lagoon lodge	D/stream BDF Camp	Muchenje Point
pH	6.23	6.4	6.66	6.39	6.3	6.54	6.44	6.3	6.64	6.18	6.2	6.34	6.49	6.82
EC µs/cm	107.1	491.2	484.6	182.5	160.3	183.2	185.5	153.6	184.4	142.3	115.5	124.2	242.1	497.4
TDS mg/l	68.56	314.3	310.2	116.8	102.6	117.2	140	89.8	118	91.1	73.89	74.9	154.9	318.3
Ca mg/l	16.25	29.84	68.6	24.4	22.02	22.3	22.79	20.83	22.85	18.35	15.33	15.91	30.75	56.14
Mg mg/l	4.03	8.08	14.05	3.89	3.37	4.02	4.13	3.17	4.03	2.81	2.38	2.45	5.27	13.86
Na mg/l	14.3	48.64	28.04	5.74	5.25	7.46	6.95	4.87	6.23	4.45	4.06	4.04	9.26	26.72
K mg/l	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
Cl mg/l	1.12	127.77	17.38	0.69	6.3	2.35	2.37	1.2	2.06	0.87	1.35	1.03	19.97	1.09
SO4 mg/l	7.02	11.24	60.42	2.58	1.01	5.64	5.34	3.29	5.05	0.82	3.43	3.18	10.05	5.62
NO3 mg/l	3.42	1.29	2.01	1.24	4.77	1.73	0.22	0.34	3.99	17	3.03	0.88	1.01	1.54
F mg/l	0.55	0	0.65	0.33	1.49	0.47	0.33	0.33	0.41	0.24	0.2	0.22	0.53	0.41
Fe mg/l	0.41	0.2	0.41	0.15	0.44	0.09	0.08	0.16	0.08	0.15	0.21	0.14	0.7	0.19
Mn mg/l	0.22	0	0	0	0	0	0	0.08	0	0	0	0	0	0

2.5.2 Thamalakane River Microbial water quality

Microbiological water quality tests are used to test water for the presence of bacteria. The presence of certain pathogens in water can suggest the possibility of contamination by sources of pollution such as sewerage. While pathogens should not be present in drinking water, the standards are less stringent for recreational water and irrigation water, where ingestion of the water is less likely.

There are currently no guidelines for environmental water in Botswana. Table 2.12 shows recommendations for quantitative levels of the bacterial organisms in recreational waters used by different organisations and provinces of North America. These are used as a proxy for assessing Thamalakane River's microbial water quality.

Table 2.12 Selection of recommendations for quantitative levels of organisms in recreational water in North America (cfu)

Organization or province	Fresh water/100ml	Marine and fresh water/100ml
Health Canada	200 Escherichia coli or faecal coliforms	-
Alberta	1000 total coliforms	-
	200 faecal coliforms	-
British Columbia	-	77 E Coli
	-	200 faecal coliforms
	-	20 enterococci
Quebec	200 faecal coliforms	-
Ontario	100 E coli	-
US-EPA	126 E coli	-
	35 enterococci	-

Source: adapted from Canadian Journal of Infectious Diseases and Medical Microbiology

The Thamalakane River flows through Maun village, and is not particularly used for recreational bathing, but young people may partake in recreational swimming at some points in the river. The Big Tree spot is also known as a picnic spot and boating by the public is evident.

The Department of Water Affairs ran some microbial tests at seven (7) locations along the Thamalakane River in Maun village. The tests were run through surveys at various points in time between February 2008 and July 2010. The locations were Boro buffalo fence, Audi camp, Botswana Defence Force (BDF) point, Big tree, Maun Lodge, Maun hospital and Sitatunga C Camp. Tables 2.13 to 2.16 show the results of the tests.

Table 2.13 Thamkalakane River Test Results for Faecal Streptococci (cfu)

	Boro Buffalo Fence	Audi Camp	BDF Point	Big Tree	Maun Lodge	Maun Hospital	Sitatunga C Camp
Feb-08	314	258	222	230	80	326	80
Mar-08	94	76	64	112	86	104	146
Apr-08	112	64	200	134	84	32	40
May-08	142	16	0	128	152	132	64
Jun-08	264	166	84	318	290	22	12
Jul-08	250	166	182	142	150	130	40
Aug-08	230	194	84	58	92	54	62
Oct-08	-	30	40	30	60	18	46
Nov-08	66	114	46	30	26	94	16
Dec-08	118	130	194	12	8	68	106
Mar-09	174	36	82	80	352	492	664
Apr-09	80	90	22	18	42	44	30
May-09	144	170	30	76	68	114	144
Jun-09	-	112	287	165	96	65	80
Jul-09	-	280	64	114	238	146	178
Sep-09	-	42	48	48	122	52	62
Jan-10	-	338	254	174	231	145	332
Mar-10	136	52	26	296	68	46	502
Jun-10	2	172	56	36	80	54	-
Jul-10	-	146	64	42	56	84	130

Source: Department of Water Affairs
Dashes (-) show no data

Table 2.14 Thamkalakane River Test Results for Faecal Coliform (cfu)

	Boro Buffalo Fence	Audi Camp	BDF Point	Big Tree	Maun Lodge	Maun Hospital	Sitatunga C Camp
Feb-08	492	164	158	96	26	2 160	30
Mar-08	46	226	56	274	700	130	16
Apr-08	2	170	20	50	0	42	0
May-08	0	0	2	2	0	4	10
Jun-08	78	54	16	194	124	10	20
Jul-08	204	26	42	44	138	10	12
Aug-08	178	98	74	26	116	16	74
Oct-08	-	22	32	774	126	100	94
Nov-08	0	147	34	62	52	66	22
Dec-08	50	184	126	50	82	52	74
Mar-09	42	138	8	136	452	1 334	934
Apr-09	56	40	42	30	86	26	46
May-09	235	32	0	0	34	30	38
Jun-09	-	84	158	106	46	100	114
Jul-09	-	10	12	10	20	12	30
Sep-09	-	192	2	0	6	6	14
Jan-10	-	196	216	152	201	102	302
Mar-10	242	196	0	208	210	24	182

Source: Department of Water Affairs
Dashes (-) show no data

Table 2.15 Thamkalakane River Test Results for E-Coli (cfu)

	Boro Buffalo Fence	Audi Camp	BDF Point	Big Tree	Maun Lodge	Maun Hospital	Sitatunga C Camp
Mar-09	48	18	264	16	22	1 402	792
Apr-09	26	40	22	8	16	12	10
May-09	201	24	36	0	14	32	36
Jun-09	-	158	208	112	86	102	112
Jul-09	-	40	18	34	58	22	58
Sep-09	-	148	2	14	30	10	60
Jan-10	-	130	62	106	158	74	90

Source: Department of Water Affairs
Dashes (-) show no data

Table 2.16 Thamalakane River Test Results for Total Coli (cfu)

	Boro Buffalo Fence	Audi Camp	BDF Point	Big Tree	Maun Lodge	Maun Hospital	Sitatunga C Camp
Apr-08	42	12	0	48	2	16	32
May-08	214	26	22	14	24	28	24
Jun-08	242	68	202	116	36	16	0
Jul-08	380	538	82	102	240	374	40
Aug-08	190	176	88	54	266	26	100
Oct-08	-	40	16	0	112	38	100
Nov-08	34	201	56	16	42	20	12
Dec-08	24	14	22	6	72	2	28

Source: Department of Water Affairs
Dashes (-) show no data

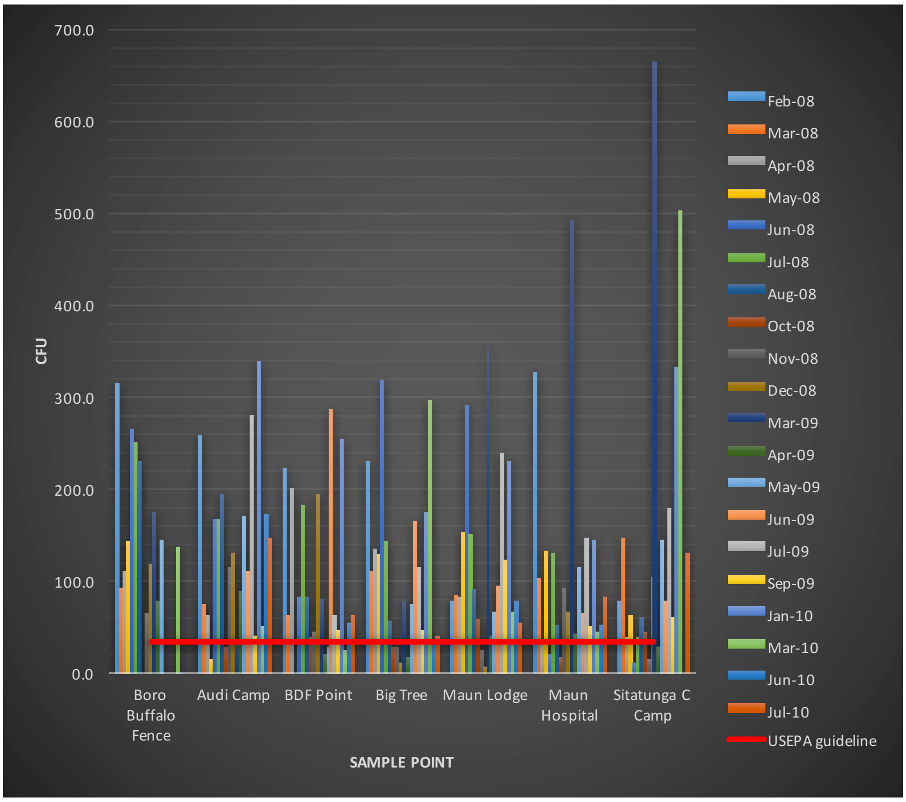
When compared against the Alberta freshwater guidelines for total coliforms, the 2008 microbial test results indicate that the water is of reasonable quality, that is, below 1000 total coliforms. None of the test results exceed 1000 cfu (colony forming units) of total coliforms. The highest total coliform cfu recorded was 538 cfu at Audi Camp point, followed by Boro Buffalo fence point at 380 cfu, and Maun hospital point at 374 cfu, all recorded in July 2008.

The most stringent guidelines for Escherichia coli (E-coli), is that of British Columbia at a maximum of 77 E-coli for marine and fresh water, while the least stringent is that of Health Canada at 200 E-coli for freshwater. The amounts of E-coli found in the samples were high in March 2009, when Maun hospital point recorded 1402 cfu, and downstream Sitatunga C Camp point recorded 792 cfu, while BDF point recorded 264 cfu.

All the guidelines referred to for faecal coliforms indicate a maximum quantity faecal coliform of 200 cfu. The highest cfu recorded was at Maun hospital point in February 2008, at 2,160 cfu, followed by 1334 cfu at the same point in March 2009, and 934 cfu at Sitatunga C Camp point, also in March 2009. Of the 122 recordings between February 2008 and March 2010, sixteen (16) or thirteen (13) percent exceeded the 200 cfu guideline maximum used.

Enterococci is a sub group of the Faecal Streptococci, and is thus used here as a proxy guide for the faecal streptococci test results. Faecal enterococci and their larger streptococci group are found in the faeces of warm-blooded animals and are thus an indicator of faecal pollution of environmental waters. The bacteria can be found in soils and are not always an indication of the occurrence of faecal pollution. Enterococci guidelines often recommend low cfu counts of enterococci compared to E-coli and total coliform counts. British Colombia recommends a threshold of 20 cfu while the United States of America's Environment Protection Agency (USEPA) recommend no higher than 35 cfu of enterococci in fresh water. Only nineteen (19) or fourteen (14) percent of the 134 tests recorded below 35 cfu of enterococci. Figure 2.5 shows the test results for faecal streptococci against the USEPA maximum cfu for enterococci for fresh water.

Figure 2.5 Thamalakane river faecal streptococci test results (cfu)



2.5.3 Thamalakane-Boteti River physical and chemical water quality

Boteti River flows from the Okavango Delta and through the Thamalakane River to discharge into the Makgakgadi Pans. Water quality tests for physical and chemical quality were done by the Department of Water Affairs in surveys covering the period March 2009 to November 2013. The tests were done at 32 points along the river channel, and were carried out partly monthly but not regularly, with the longest period between subsequent tests being 4 months.

Table 2.17 shows the summarised test results for Potential for Hydrogen (ph) carried out between March 2009 and November 2013, along the Thamalakane-Boteti River channel. On a pH scale, a pH is acidic when below 5.6 and alkaline when above 7.0. At 7.0 the pH is neutral. The BOS 32:2009 standard for irrigation water is pH 6.5 to 8.4. This is used as a proxy for the environmental waters of the Thamalakane-Boteti River channel.

Table 2.17 Summary pH results for the Thamalakane-Boteti River channel 2009-2013

Date	No. of stations tested	No. below 6.5	No. above 8.4	% below 6.5	% above 8.4
Mar-09	7.0	0.0	0.0	0.0	0.0
Apr-09	7.0	0.0	0.0	0.0	0.0
May-09	7.0	0.0	0.0	0.0	0.0
Jun-09	6.0	0.0	0.0	0.0	0.0
Jul-09	6.0	0.0	0.0	0.0	0.0
Sep-09	6.0	0.0	0.0	0.0	0.0
Jan-10	6.0	0.0	0.0	0.0	0.0
Feb-10	6.0	0.0	0.0	0.0	0.0
Mar-10	7.0	0.0	0.0	0.0	0.0
May-10	7.0	6.0	0.0	85.7	0.0
Jun-10	6.0	6.0	0.0	100.0	0.0
Jul-10	6.0	3.0	0.0	50.0	0.0
Aug-10	6.0	5.0	0.0	83.3	0.0
Sep-10	6.0	6.0	0.0	100.0	0.0
Jan-11	9.0	9.0	0.0	100.0	0.0
Mar-11	8.0	0.0	0.0	0.0	0.0
May-11	16.0	0.0	1.0	0.0	6.3
Aug-11	14.0	3.0	0.0	21.4	0.0
Oct-11	14.0	0.0	0.0	0.0	0.0
Jan-12	13.0	13.0	0.0	100.0	0.0
Mar-12	11.0	11.0	0.0	100.0	0.0
Apr-12	8.0	0.0	1.0	0.0	12.5
May-12	11.0	1.0	0.0	9.1	0.0
Aug-12	5.0	5.0	0.0	100.0	0.0
Sep-12	7.0	7.0	0.0	100.0	0.0
Dec-12	11.0	0.0	0.0	0.0	0.0
Mar-12	6.0	0.0	0.0	0.0	0.0
May-13	10.0	10.0	0.0	100.0	0.0
Aug-13	4.0	4.0	0.0	100.0	0.0
Nov-13	4.0	4.0	0.0	100.0	0.0

Source: Department of Water Affairs
Dashes (-) show no data

The recommended limit of alkalinity (8.4) was surpassed in two (2) of the 240 tests results, which were of May 2011 and April 2012. The recommended limit of acidity for irrigation water (6.5) was surpassed in 93 out of the 240 tests carried out.

Table 2.18 shows the summary of results from the tests for parameters other than pH. All except one (1) of the parameter tests recorded within the standards used. Only manganese (Mn) showed a level beyond the guideline in one (1) of the 29 tests carried out for it.

Table 2.18 Summary of water quality test results Thamalakane-Boteti River

Parameter	Number of tests done	Limit or guide range	Number over the limit or outside range	Standard/guide referred to
Total Dissolved Salts	229	2000	0	BOS 463:2011
Calcium	184	200 mg/l	0	BOS 32:2009
Cl	142	350 mg/l	0	BOS:463:2011
NO3	137	30 mg/l	0	BOS:463:2011
Mn	29	0.2 mg/l	1	BOS:463:2011
Mg	184	100 mg/l	0	BOS 32:2009
k	21	100 mg/l	0	BOS 32:2009
EC	240	3000 µs/cm	0	BOS:463:2011
SO4	137	200 mg/l	0	BOS:463:2011

Source: Summarised from Department of Water Affairs data

2.5.4 Molopo River physical and chemical water quality

The Molopo River is an ephemeral river that runs in a generally westerly direction and form part of the borderline between Botswana and South Africa. The sands of the Kalahari Desert absorb most of its flow and thus the majority of points of water quality sampling are boreholes and watering points. Table 2.19 shows the summary of test results for physical and chemical quality from 23 points along the Molopo River channel. A maximum of 111 tests were carried out between April 2010 and June 2014.

Table 2.19 Molopo River summary water quality test results 2010-2014

Parameter	Symbol		Limits	No of tests	criteria	Test results	% below/ above guide
Potential for Hydrogen	pH	BOS 463:2011	Range 6.5 - 8.4	111	< 6.5	1	0.9
					> 8.4	0	0
Electronic Conductivity	EC	BOS 463:2011	3000	111	> 300	1	0.9
Total Dissolved Solids	TDS	BOS 463:2011	2000	111	> 2000	82	73.9
Potassium	k	BOS 32:2009	100	111	> 100	20	18
Cholrides	Cl	RSA Aquatic ecosystem	200	111	> 200	27	24.3
		BOS 463:2011	350		> 350	85	76.6
		BOS 32:2009	600		> 600	77	69.4
Sulphates	SO4	BOS 463:2011	200	110	> 200	78	70.9
		BOS 32:2009	400		> 400	52	47.3
Iron	Fe	BOS 32:2009	5	111	> 5	17	15.3
		BOS 463:2011	2		> 2	25	22.5
Manganese	Mn	RSA Aquatic ecosystem	0.18	111	> 0.18	9	8.1
		BOS 463:2011	0.2		> 0.2	6	5.4
Calcium	Ca	BOS 32:2009	200	111	> 200	1	0.9
Magnesium	Mg	BOS 32:2009	100	111	> 100	8	7.2
Nitrates	NO3	BOS 32:2009	50	109	> 50	108	99.1
		BOS 463:2011	30		> 30	47	43.1
Sodium	Na	BOS 463:2011	230	111	> 230	86	77.5
		BOS 32:2009	400		> 400	85	76.6

Source: Summarised from Department of Water Affairs data

The results indicate that potential for hydrogen (pH), electronic conductivity (EC), Potassium (k), Chlorides (Cl), Iron (Fe), Manganese (Mn), Calcium (Ca) and Magnesium (Mg) are mostly within the standards referred to. Total dissolved Solids (TDS), Chlorides (Cl), Sulphates (SO4), Nitrates (NO3) and Sodium (Na) recorded test results mostly higher than the recommended guide referred to.

3.0 EMISSIONS OF GREENHOUSE GAS (GHG)

3.1 Introduction

In recognizing the challenges posed by climate change and the importance of taking the necessary action to mitigate climate change impacts, the Government of Botswana ratified the United Nations Framework Convention on Climate Change (UNFCCC) on 27 January, 1994 which came into force on 27 April, 1994 (Republic of Botswana, 2011). In spite of the fact that the country is a minor emitter of greenhouse gases (GHGs), different sectors of the economy of Botswana are negatively affected by climate change. Water situation in particular, affects the agricultural sector through long dry spells which influences food insecurity, lack of pasture for grazing livestock, among others. Republic of Botswana (2011) asserts that both crops and livestock, rangelands and forestry are resources upon which livelihoods depend, hence the need to assess and monitor the causes and impacts climate change. Other economic sectors that are impacted by climate change include tourism, health, and energy.

Botswana is expected by the climate change secretariat to conduct the country situation assessment regarding its position, national circumstances and responses to climate change. This country has thus far managed to prepare and submit two reports to the UNFCCC, Initial National Communication of 2001 and Second National Communication of 2011. Preparations are on-going to start work on the Third National Communication. These National Communications are funded through the Global Environment Facility (GEF), with UNDP as its implementing agency. The ultimate objective of the Climate Change Convention (UNFCCC) is to achieve "... stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (http://unfccc.int/ghg_data/items/3800.php). Estimating the levels of greenhouse gas (GHG) emissions and removals is an important element in an effort to achieve the aforesaid objective, hence the need to analyse trends in GHGs emissions in the Botswana for the period 1990 to 2011. Parties are expected to submit their assessment (National Communications) possibly after four years from their previous communication, and in the interim prepare and submit Biennial Update Reports (BURs) biennially.

3.1.1 Greenhouse Gases

Greenhouse gases (GHGs) are gases that trap heat in the atmosphere and make the planet warmer. The main gases are either emitted or removed to and from the atmosphere. They include, Carbon Dioxide (CO_2), Methane (CH4), Nitrous Oxide (N_2O), and Fluorinated gases.

Carbon dioxide (CO_2): CO_2 enters the atmosphere through burning fossil fuels (coal, natural gas, and oil), solid waste, trees and wood products, and also as a result of certain chemical reactions (e.g., manufacture of cement), and CO_2 is removed from the atmosphere (or "sequestered") when it is absorbed by plants as part of the biological carbon cycle. (EPA, 2017)

Methane (CH_4): CH_4 is emitted during the production and transport of coal, natural gas, and oil and the emissions also result from livestock and other agricultural practices and by the decay of organic waste in municipal solid waste landfills (EPA, 2017).

Nitrous oxide (N_2O): Nitrous oxide is emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste.

Fluorinated gases: Hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and nitrogen trifluoride are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes. Fluorinated gases are sometimes used as substitutes for stratospheric ozone-depleting substances (e.g., chlorofluorocarbons, hydro chlorofluorocarbons, and halons). These gases are typically emitted in smaller quantities, but because they are potent greenhouse gases, they are sometimes referred to as High Global Warming Potential gases ("High GWP gases").
(**https://www.epa.gov/ghgemissions/overview-greenhouse-gases**)

According to the United States Environmental Protection Agency (2017), each gas's effect on climate depends on the following factors: i) how much of these gases are in the atmosphere, ii) how long do they stay in the atmosphere, and iii) how strongly do they impact the global temperatures.

The primary sources of greenhouse gas emissions are; i) electricity production (burning of fossil fuels, particularly coal and natural gas); ii) transportation (burning of fossil fuels for cars, trucks, trains and planes using fuel (petrol, gasoline and diesel); iii) industry (burning of fossil fuels for energy, some other chemical reactions); iv) commercial and residential (burning of fossil fuels for heat and cooking, as well as management of waste); v) agriculture (emissions come from livestock such as cows, agricultural soils, and management of crop residues); and vi) land use and forestry (land can either absorb CO_2 acting as a sink, or act as source of CO_2 through cutting down of trees).

3.1.2 Methodology

Though this chapter presents trends on GHG emissions from different reports, the methodological approaches were similar with slight improvements to the earlier versions. The presentation of the GHG emissions is a requirement under Article 4.1(a) of the Convention. Article 4 of the UNFCCC, requires Parties to develop, periodically update, publish and make available to the Conference of the Parties national inventories of anthropogenic emissions (Republic of Botswana, 2011).

The Botswana GHGs inventory prepared before the INC was for the base year 1994. The emissions were estimated for some sources and removals in the energy sector, land use and forestry, agriculture, waste and industrial sectors. The methodology was based on the Revised IPCC 1996 Guidelines, with emission factors (default) based on the same Guidelines.

The INC considered five main modules: energy, industrial processes, agriculture, waste and land use change and forestry (LUCF), as guided by revised Intergovernmental Panel on Climate Change (IPCC) of 1996. The SNC GHG inventory covers the major sources and sinks as well as most gases mandated by Decision 17/CP8 of UNFCCC Conference of the Parties (COP) 8 (Republic of Botswana, 2011). This National GHG Inventory was also prepared based on the Revised 1996 IPCC Guidelines for National GHG Inventories, Good Practice Guidance (GPG) and Uncertainty Management in National GHG Inventories (IPCC 2000), and Good Practice Guidance (GPG) for Land Use, Land-Use Change and Forestry (IPCC 2003). The default emissions factors and IPCC Tier 1 methodology were used in line with Decision 17/CP.8 of UNFCCC Conference of Parties (COP) 8, due to lack of country-specific emission factors. The year 2000 was the base year, and three direct GHG were considered, CO2, CH4, and N2O. The calculation emissions estimates was done using the software for Non-Annex 1 Countries to the UNFCCC (UNFCCC-NAI Software). For the 2016 Inventory, the base year was 2011. The following four main modules were covered: energy, industrial processes, Agriculture, Forestry and Other Land Use (AFOLU), and waste, as guided by the Intergovernmental Panel on Climate Change (IPCC) 2006 GHG Inventory Reference Manual. The emission factors in all categories of the study are derived from 2006 IPCC Inventory Software.

The Decision 17/CP.8 as stipulated in the FCCC/CP/2002/7/Add.2 of 2003 states:

"(a) That Parties not included in Annex I to the Convention (non-Annex I Parties) should use the guidelines contained in the annex to this decision for the preparation of second and, where appropriate, third national communications and, where appropriate, initial national communications, except where Parties have initiated the process of preparing second national communications and received funding under the expedited procedures or on an agreed full cost basis prior to the approval of the guidelines annexed to this decision;

(b) That, in using these guidelines, non-Annex I Parties should take into account their development priorities, objectives and national circumstances; and

(c) That these guidelines should be used to provide guidance to an operating entity of the financial mechanism for funding the preparation of national communications from non-Annex I Parties…" (pg. 2).

3.1.3 Activity Data Sources

Data sources for the inventories prepared during the review period were taken from different sources:
The Department of Energy Affairs provided energy statistics (balance). Other sources were the then Central Statistics Office, now Statistics Botswana who provided the agricultural census covering the year 2000, and other agricultural annual surveys data, Department of Forestry and Range Resources, Food and Agricultural Organisation (FAO) and different data bases. Surveys and studies prepared by international organizations such as UNEP/RISØ, JICA, and Regional Centre for Mapping of Resources for Development (RCMRD) (land cover change), among others.

Emission estimates for petroleum combustion were made using the emission factors contained in Emission Factor Data Base. Local classification of forests was used in the estimation of emissions of GHG from the Land Use Change and Forestry Sector. The data used for the waste sector (population) was estimated using the average between the 1991 and 2001 census since there was no census in 2000. While the 2011 Population and Housing Census data was used for the 2011 population estimates.

During the preparation of the GHG Inventories, inventory of gases with direct greenhouse effect - CO_2, CH_4 and N_2O, from key sources were prioritized. The inventory of gases with indirect greenhouse effect - CO, NOx, SO_2, and the emissions of HFCs, PFCs, and SF6 compounds were not identified. According to the Republic of Botswana (2011), the estimation of gases such as CO, NO_x, SO_2 from direct fuel combustion require detailed process information such as combustion conditions of the different types of fuels, size and age of the different engine types and the engine maintenance and operational practices which are not available locally. During the review period, the estimation of other gases such as HFCs, PFCs, and SF6 was not possible due to unavailability of activity data.

3.2 Summary of GHG Emissions & Removals

Table 3.1 shows the summary of the national greenhouse gas emissions and removals for the inventory years, 1990, 1994, 2000, and 2011. Botswana's GHG emissions fluctuated during the review period; increasing from emissions of 7,851.46 Gigagrams of Carbon Dioxide equivalent (Gg CO_2 eq) and removal of -43,322.15 Gg CO_2 eq in 1990 to emissions of 9,315.61 Gg CO_2 eq and removal of -38,733.60 Gg CO_2 in 1994. The trend saw a dip from the 1994 figures to 7,434.26 Gg CO_2 emissions and removals of -42,941.00 Gg CO_2 eq in 2000, then a significant increase to 24,189.26 Gg CO2 and removal of -128,400 Gg CO_2 eq in 2011. Though the emissions fluctuated during the period under review, the results indicate that Botswana has remained a net sink during the period (-35,470.69 Gg CO2 eq in 1990; -29,418.00 Gg CO_2 eq in 1994; -35,506.74 Gg CO_2 eq in 2000; and -103,411.55 Gg CO_2 eq in 2011).

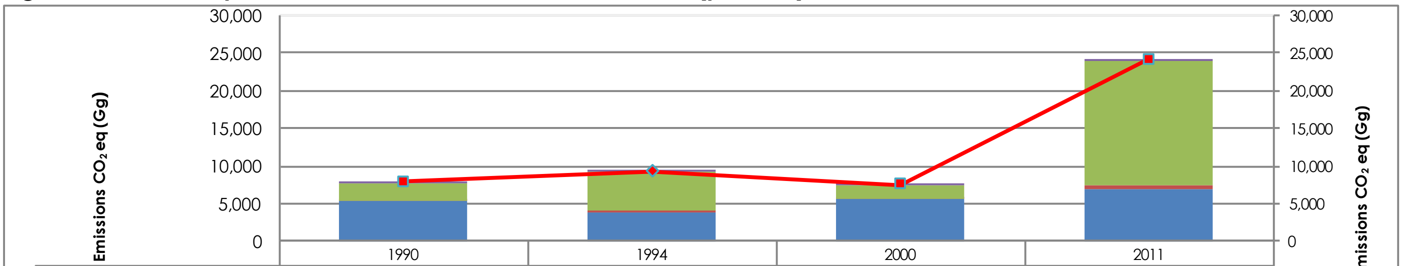
The key category analysis reveal that the energy sector (67.12% in 1990, and 74.49% in 2000) and AFOLU sector (54.39% in 1994, and 68.72% in 2011) were the main GHG emitters during the review period. (Table 3.1 & Figure 3.1)

Table 3.1: Summary of National Greenhouse Gas emissions (positive) & removals (negative), 1990, 1994, 2000, & 2011

GHG Source & Sink Category	1990		1994		2000		2011	
	Emissions CO_2 eq (Gg)	Sink CO_2 eq (Gg)	Emissions CO2 eq (Gg)	Sink CO_2 eq (Gg)	Emissions CO_2 eq (Gg)	Sink CO_2 eq (Gg)	Emissions CO_2 eq (Gg)	Sink CO_2 eq (Gg)
Energy	5 270.07		3 866.00		5 537.92		6 894.50	
Industrial Processes (IPPU)	211.83		211		0.04		540.72	
AFOLU	2 197.84	-43 322.15	5 066.61	-38 733.60	1 785.00	-42 941.00	16 540.89	-127 520.56
Waste	171.72		172		111.3		132.34	
Total Emissions	**7 851.46**		**9 315.61**		**7 434.26**		**24 108.45**	
NET TOTAL (after subtracting sink)	**-35 470.69**		**-29 418.00**		**-35 506.74**		**-103 411.55**	

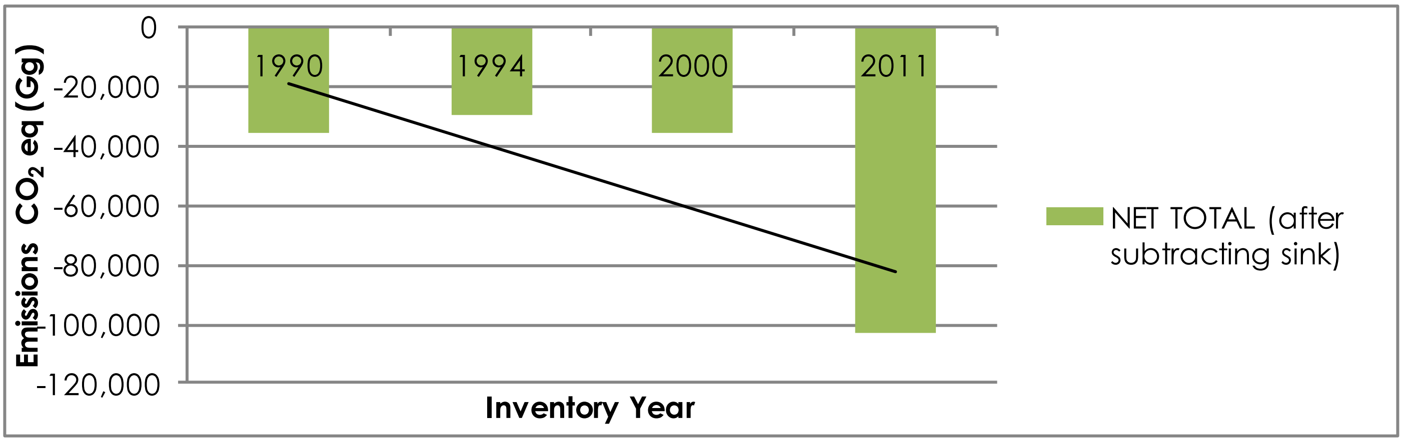
Note: AFOLU for the years 1990 & 2000 only included conversions to forest under Land Use change and forestry.
Year 1994: LULUCF= (-38 734) & Agirc = 5 067
Year 1990: LULUCF= (-43 322) & Agirc = 2 198

Figure 3.1: Summary of National Greenhouse Gas emissions (positive), 1990, 1994, 2000, & 2011



	1990	1994	2000	2011
Waste	171.72	172.00	111.30	132.34
AFOLU	2,197.84	5,066.61	1,785.00	16,540.89
Industrial Processes (IPPU)	211.83	211.00	0.04	540.72
Enery	5,270.07	3,866.00	5,537.92	6,894.50
Total Emissions	7,851.46	9,315.61	7,434.26	24,108.45

Figure 3.2: Summary of Total National Greenhouse Gas emissions after subtracting sink, 1990, 1994, 2000, & 2011



3.3 Inventory of GHG Emissions from Energy Sector

The major energy consumers in Botswana in 2011 were residential, transport and industry at 42%, 27% and 23% respectively (SNC, 2011: 20). In 1990 the main sources considered under the energy sector were almost the same as the aforementioned, they include fuel combustion encompassing stationary (e.g. boilers, power stations, household devices) and mobile (transportation) sources, and fugitive emissions from coal mining (UNDP & DMS, 1999). During the preparation of the 1990 – 2011 GHGs inventory, the percentage of wood-fuel and petroleum products was accounted for under the land-use change and forestry sector (AFOLU). According to (SNC, 2011) Botswana also has one of the lowest per capita energy consumption in the world with commercial energy utilisation accounting for about 10% of the total energy consumption. The country's over dependence on wood-fuel and low levels of commercial energy consumption does not mean that Botswana is a net emitter of GHG, since there is a reduction of CO2 sink due to an increasing deforestation. Figure 3.3a shows a schematic of source of GHG emissions from the energy sector.

Figure 3.3a: Sources of GHG emissions from the Energy Sector

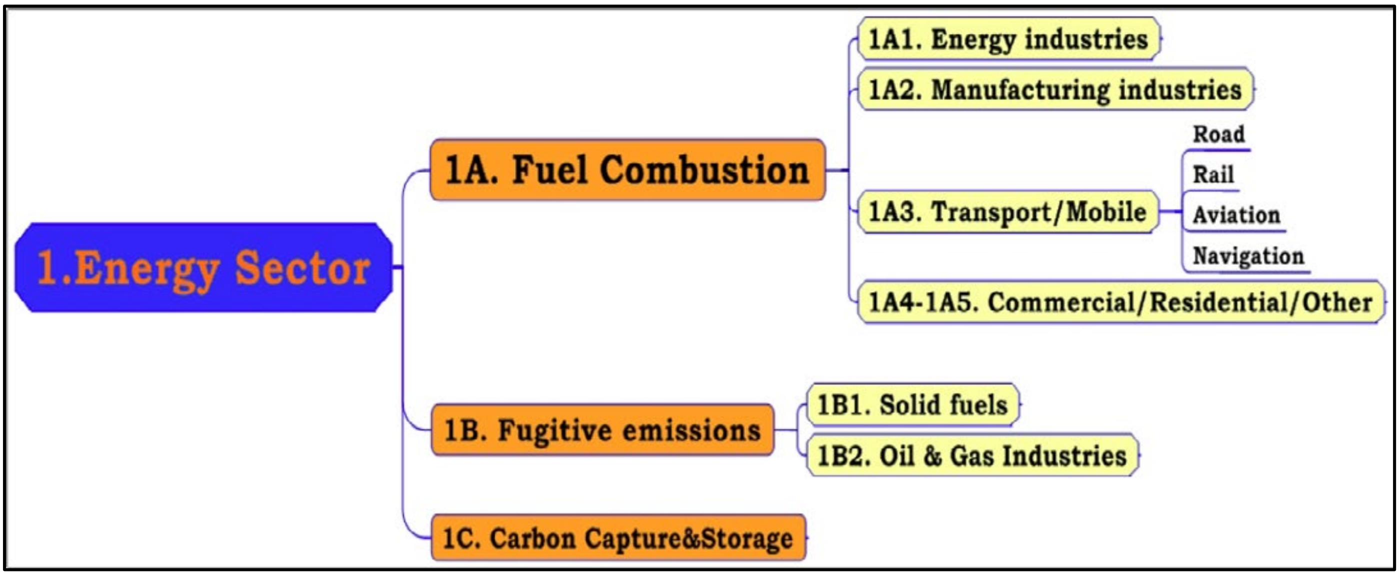


Table 3.2 and Figure 3.3b present a summary inventory of GHG emissions from the energy sector by category. The inventory categories constituting this sector include: i) fuel combustion (sectoral); ii) fugitive emissions from solid fuels; and iii) emissions from biomass based fuels. The total GHG emissions from the energy sector fluctuated during the review period, with the highest emissions recorded in 2011 (7,539.74 Gg CO_2 eq) and the lowest values recorded in 1994 (3,866.00 Gg CO_2 eq). The largest share of the emissions by category, were constituted by the fuel combustion with 93.35 % of total energy emissions in 1990, 92.83 % in 1994, 97.20 % in 2000 and 91.23 % in 2011 (Table 3.2 & Figure 3.3b).

It is evident from the results that energy industries (electricity and heat production/transformation) is the major sub-category that contributes to high emissions from the fuel combustion category, with contributions of 40.99%, 48.80%, 38.07%, and 53.18%, estimated in 1990, 1994, 2000, and 2011, respectively. The emissions from the fuel combustion saw an increase of 91.65% from the year 1994 (3,588.96 Gg CO_2 eq) to 2011 (6,878.21 Gg CO_2 eq). This might be attributable to the use of coal in Morupule Colliery for electricity generation.

It is evident from Table 3.2 that fugitive emissions from the solid fuels were on the decrease, with 253.48 Gg CO_2 eq in 1990, 253.47 Gg CO_2 eq in 1994, 155.06 Gg CO_2 eq in 2000, and 16.29 Gg CO_2 eq in 2011. Fugitive emissions from fuels are limited to the mining sector because Botswana has no oil or natural gas and no associated pipeline activities (Adedoyin et al. 2016: 22).

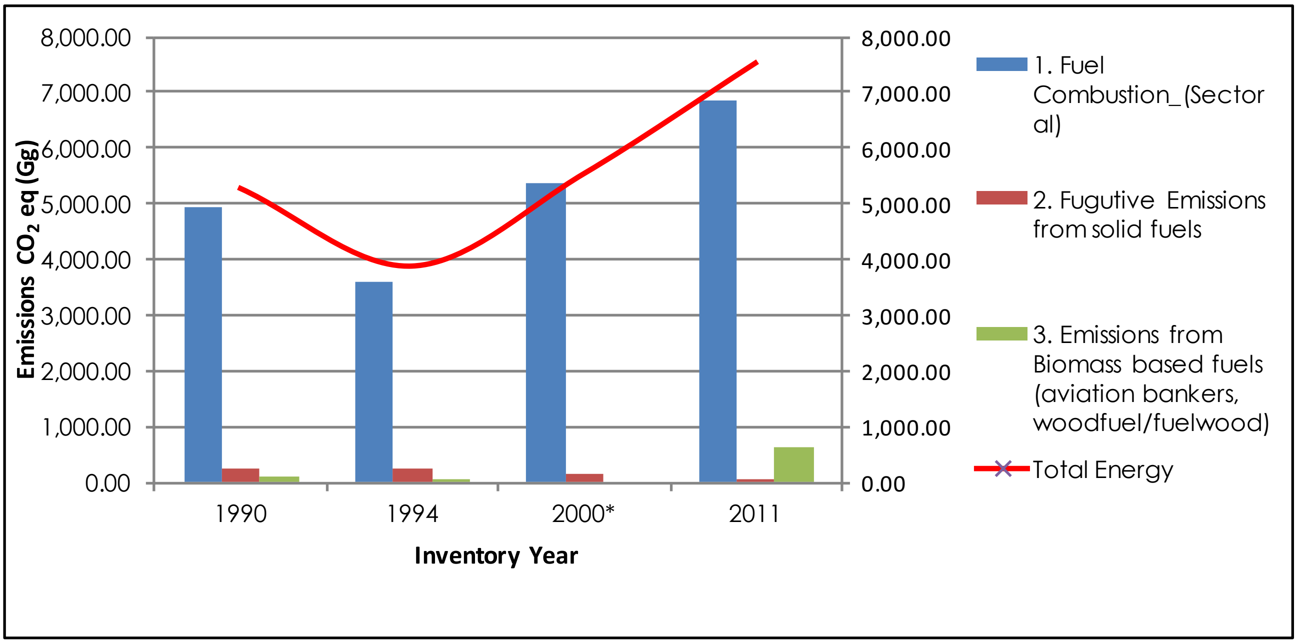
The emissions from biomass fuels were highest in 2011 with 645.24 Gg CO_2 eq in 2011. According to Adedoyin et al. (2016) total carbon released from coal/wood fuel combustion was 645.24 Gg, with 592.91 Gg of carbon released from wood, and 52.33 Gg from coal.

Table 3.2: Summary Inventory of GHG emissions from Energy Sector

Inventory Category	CO_2 Emissions (Gg)			
	1990	1994	2000*	2011
1. Fuel Combustion_(Sectoral)	**4 919.60**	**3 588.96**	**5 381.94**	**6 878.21**
a) Energy Industries (electricity & heat production/transformation)	2 016.78	1 748.52	2 049.02	3 657.59
b) Manufacturing Industries & Construction (e.g. mining)	606.11	518.29	-	1 235.52
c)Transport	1 326.49	801.26	498.33	1 985.10
d) Other (household, agric, government, trade & hotels)	970.22	797.46	2 834.59	
2. Fugitive Emissions from solid fuels	253.48	253.47	155.06	16.29
3. Emissions from Biomass based fuels (aviation bankers, woodfuel/ fuelwood)	96.99	23.57	-	645.24
Total Energy	**5 270.07**	**3 866.00**	**5 537.00**	**7 539.74**

Note: For the year 2000 emissions from biomass have been captured under residential & government. Manufacturing industries & construction have been captured under Energy Industries.

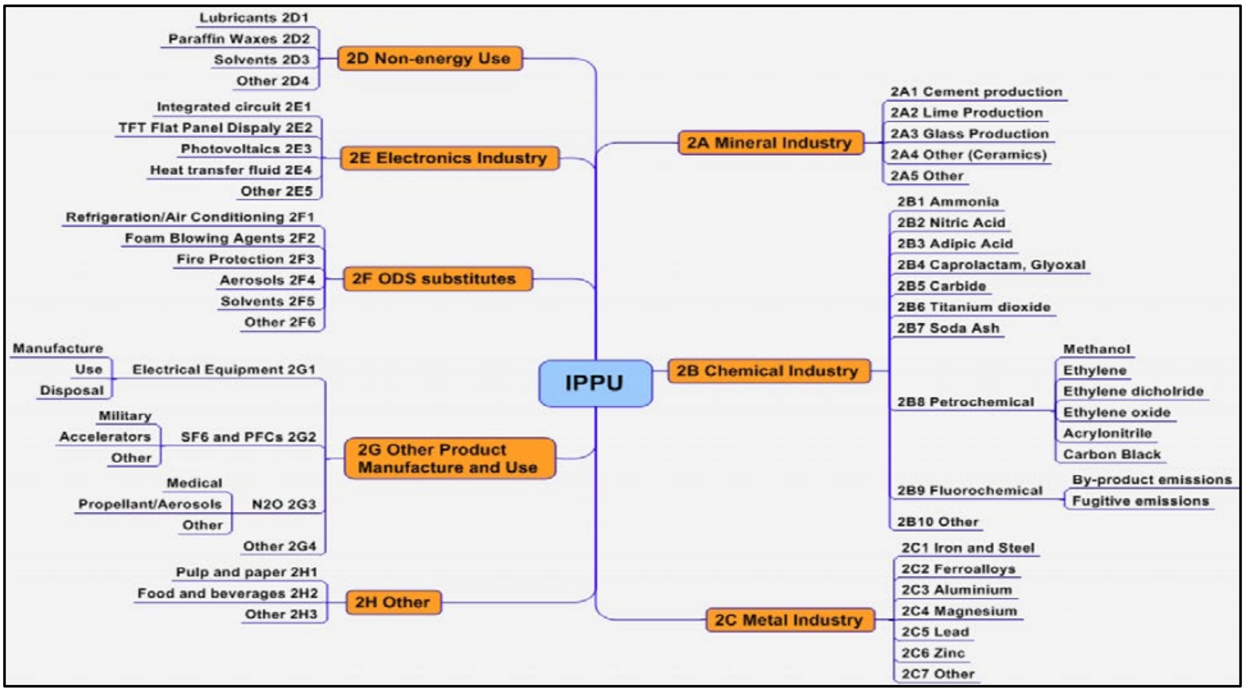
Figure 3.3b: Summary Inventory of GHG emissions from Energy Sector, 1990, 1994, 2000 & 2011



3.4 Inventory of GHG Emissions from Industrial Processes and Product Use (IPPU) Sector

Botswana is not a heavily industrialized country, it currently has two main industrial processes (Adedoyin et al. 2016) that have a meaningful contribution to the national GHG inventory. They include soda ash production and the limited production of cement (Adedoyin et al. 2016). Emissions of other industrial processes have been taken care of under sectors, e.g. the energy-related emissions from the copper-nickel smelter are already accounted for in the estimates for the energy sector (Republic of Botswana, 2001). During the production of the SNC of 2011 the emissions were minimal and only calculated from the alcoholic beverage production sector. Figure 3.4a depicts sources of GHG emissions from the IPPU sector.

Figure 3.4a: Sources of GHG emissions from the IPPU Sector



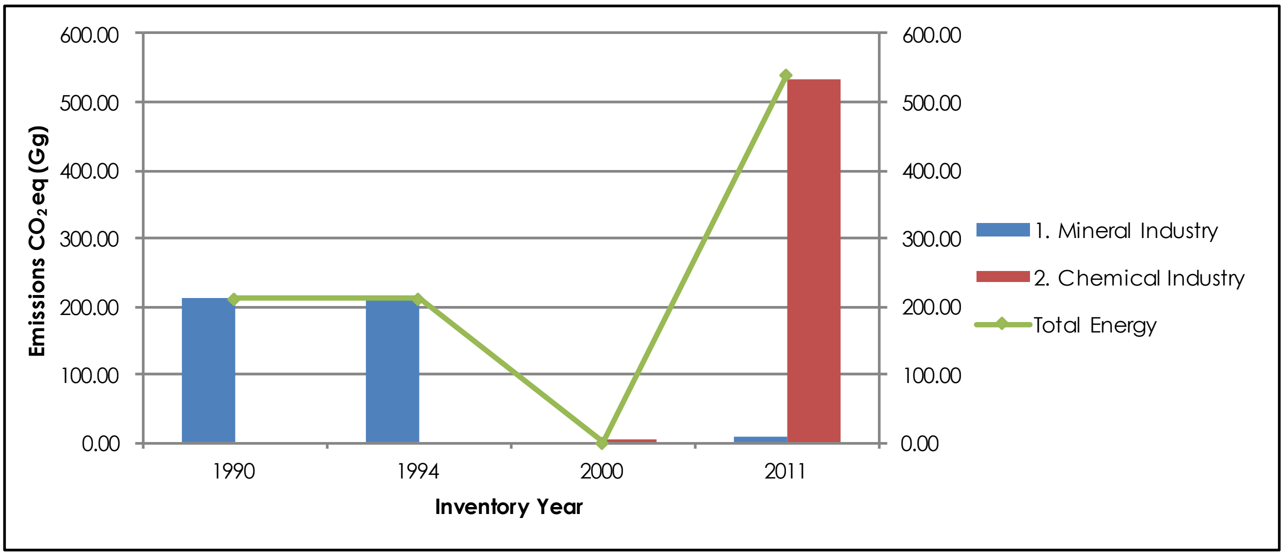
Source: Shermanau (2017b)

Table 3.3 shows that emissions from the industrial processes fluctuated during the 1990 – 2011 period, with the highest emissions recorded in 2011 (540.72 Gg CO_2 eq) and lowest in 2000 (0.04 Gg CO_2 eq). However, during the inventory years 1990 and 1994 mineral industry was the only inventory category emitting GHGs and in the year 2000 there was data on mineral industry (cement production, lime production and glass production). Adedoyin et al. (2016) reports that the emissions of GHG from soda production during the 2011 inventory year was estimated from the amount of trona (T-brine) utilized, while the main solvents used was from Perchloroethylene. These solvents are mainly used in dry cleaning companies and hotels, and data were sourced from International Merchandise Trade Statistics Unit of Statistics Botswana.

Table 3.3: Summary Inventory of GHG emissions from Industrial Processes Sector

Inventory Category	CO2 Emissions (Gg)			
	1990	1994	2000*	2011
1. Mineral Industry	211.83	210.8	0	7.67
2. Chemical Industry	**0**	**0**	**0.04**	**533.05**
Total Emissions	**211.83**	**210.8**	**0.04**	**540.72**

Figure 3.4b: Summary Inventory of GHG emissions from Industrial Processes Sector, 1990, 1994, 2000 & 2011



3.5 Inventory of GHGs Emissions from AFOLU Sector

This section presents the emissions and sinks of GHGs from the AFOLU sector which constituted by Agriculture, Forestry, and Other Land Use. It is through the management practices of livestock and crops, and land use conversions that contribute to the emissions of GHG into the atmosphere, as well as the sequestration of carbon (sinks). Given below are the national circumstances of the management practices under the AFOLU sector that influences the GHG emissions.

The agriculture sector in Botswana, is dominantly driven by animal and crop production. Livestock production dominates Botswana agriculture, particularly beef cattle. The country's farm management practice is three-fold: extensive small-scale farm practice, semi-intensive production system, and intensive production system. The extensive production system is characterized by natural grazing of animals with little supplementation. On the other hand, the semi-intensive systems involve letting dry animals to graze openly while the milking ones are normally fed with high protein feeds to boost their milk production. The intensive system is usually practiced by large-scale farmers in ranches. In most cases total zero grazing of the animals is practiced.

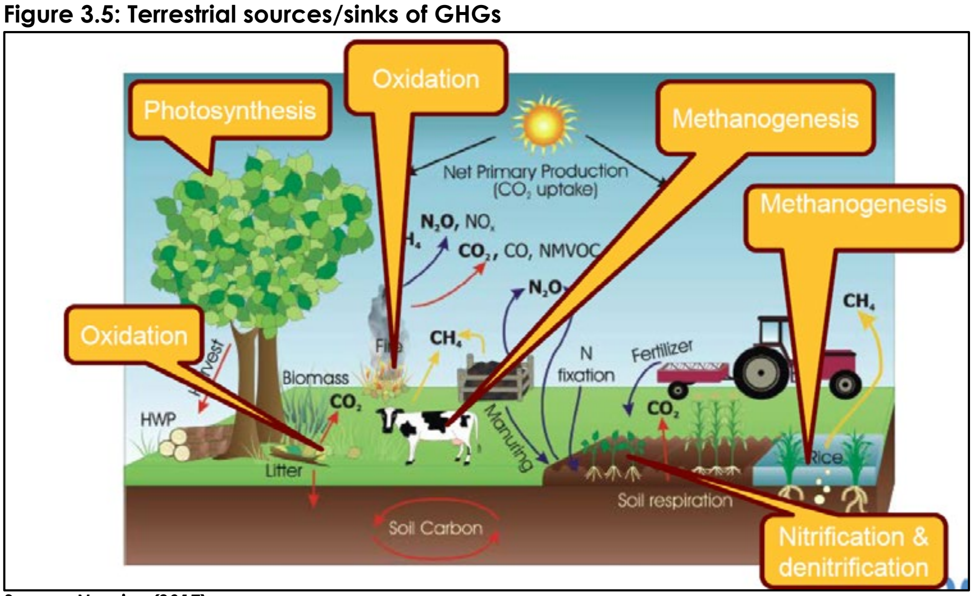
The afore-mentioned management systems contribute to the emissions of GHG. Of domesticated animals, ruminant animals (cattle, camels, donkeys, sheep and goats) are the major source of methane emissions with cattle being the most important source globally (Adedoyin et al. 2016). Methane is produced as part of the normal fermentative digestive process of animals. In addition, livestock manure is also source of methane and it is primarily composed of organic material and therefore the potential for methane emissions is great (refer to Figure 3.5). The portion of this emission potential which is actually produced from the decomposition of livestock manure under anaerobic conditions (IPCC, 1996).

Only about 0.7% of total land area is arable. Crop production systems in Botswana are constituted by small scale and commercial farming systems. The majority of the small scale farms are rain fed with little to no fertilization and liming, while a few (commercial farms) are irrigated, fertilized and limed. Minimum tillage is widely promoted among small holder farmers through Poverty Eradication Program and NGOs in Botswana. Like in the management of livestock, crop management also contributes to the emissions of GHG, particularly burning of crop residues, addition of fertilisers to the soil, rotation of crops among other management practices. The adoption of more intensified cropping systems (for example, reducing the frequency of summer fallow, including legumes in the rotation, use of higher inputs of inorganic fertilizers and chemicals) has been shown to increase crop yields compared with traditional fallow-wheat or wheat monoculture systems (Campbell et al. 2005;). However, the increased use of inorganic fertilizers and pesticides in high-yielding systems increases greenhouse gas emissions (Dusenbury et al. 2008; Guo et al. 2010; Gan et al. 2014).

Land-use changes affect the chemical composition of the atmosphere, and CO_2 is the major gas released as a result of land-use change (Adedoyin et al. 2016). Other gases such as Methane, Nitrous Oxide, Carbon Monoxide, etc. are also released due to changes in land-use. All these emissions lead to concentrations of greenhouse gases. The removal of CO_2 is done by photosynthetic activity of plants. If the vegetation is cleared this important process is curtailed.

The sources and sinks of carbon from Land Use and Land Cover Change (LULCC) are significant in the global carbon budget. The LULUCC contributed about 33% of anthropogenic carbon emissions to the total emissions over the last 150 years (Houghton, 1999), with about 20% of total emissions in the 1980s and 1990s (Denman et al. 2007), and about 12.5% of total emissions over 2000 to 2009 (Friedlingstein et al. 2010). The decline is attributable to the rise in fossil fuel emissions. The land is currently a net sink despite LULCC emissions (Canadell et al. 2007; Le Quer´e et al. 2009). This net sink might be because of a combination of LULCC (e.g., forests growing on abandoned croplands) and the effects of environmental changes on plant growth, such as the fertilizing effects of rising concentrations of CO_2 in the atmosphere and nitrogen (N) deposition, and changes in climate, such as longer growing seasons in northern mid-latitude regions (Houghton et al. 2012). Houghton et al. (2012) further note that in an ideal world, land use and land-cover change would be defined broadly to include not only human-induced changes in land cover, but all forms of land management (e.g., tillage, fertilizer use, shifting cultivation, selective logging, draining of peatlands, use or exclusion of fire). (Figure 3.5)

Figure 3.5: Terrestrial sources/sinks of GHGs



Source: Ngarize (2017)

For this report the emissions and removals from the LULCC were divided according to the following source/sink categories: Conversions to Forest, Conversions to Cropland, Conversions to Grassland, Conversions to Wetland, Conversions to Settlements, and Conversions to Other Lands.

Table 3.4 and Figure 3.6 depict the summary inventory of GHG emissions and sinks from the AFOLU Sector for the period 1990 to 2011. The total CO_2 emissions from the AFOLU sector followed a fluctuating trend during the review period, with the highest estimates recorded in 2011 at 16,540.89 Gg CO_2 and the lowest estimates recorded in 2000 at 1,785.00 Gg CO_2. These emissions were mainly from the agriculture sector. The emissions from the agriculture sector were constituted by methane emissions from domestic livestock enteric fermentation and manure management which experienced an increase from the inventory years 1994, 2000, and 2011 with 1,945.36 Gg of CO_2 eq, 2,025.00 Gg of CO_2 eq and 2,502.73 Gg of CO_2 eq, respectively.

Nitrous oxide emissions from animal waste management systems were on the increase during the same period with 1.91 Gg of CO_2 eq recorded in 1994, 75.00 Gg of CO_2 eq in 2000 and 8,938.81 Gg of CO_2 eq in 2011. The increase in emissions from animal waste management systems from 2000 to 2011 might have been attributable to the fact that a more robust and user-friendly tool for estimating emissions from livestock for the preparation of the 2011 inventory was used. It is called the Agriculture and Land Use National Greenhouse Gas Inventory Software Program (ALU) developed at Colorado State University to conduct national greenhouse gas inventories for the Agriculture and Land Use, Land Use Change and Forestry sectors.

Indirect nitrous oxide emissions from leaching was only estimated for the inventory years 1994 and 2011, with total estimates of about 66.34 Gg of CO_2 eq and 2,892.39 Gg of CO_2 eq, respectively. The estimates of CO2 from biomass burning of agricultural waste experienced a dip from about 3,053 Gg of CO_2 eq recorded in 1994 to 2,368.54 Gg of CO_2 eq in 2011.

The trend in estimated sources and sink from land use conversions fluctuated during the 1990 – 2011 inventory years, with the lowest emission estimates recorded in 1994 of 912.59 Gg CO_2 eq and the highest emissions of 23,505.76 Gg CO_2 eq in 2011. On the other hand, the highest sink estimates were recorded in 1994 with -38,733.91 Gg CO_2 and the lowest in 2011 of -127,520.56 Gg CO_2. The reduction in the sink from land use change depicted in 2011 was mainly driven by the following source categories (conversions to cropland, 745.688346 Gg CO_2 eq; conversions to grassland, 22,363.25 Gg CO_2 eq; and conversions to settlements, 396.81829 Gg CO_2 eq) and sink categories (conversions to forest, -146,186.20 Gg CO_2 eq; and conversions to other lands, -4,840.11 Gg CO_2 eq) (Figure 3.7). According to (Adedoyin et al. 2016) an estimated 100,000 Gg of CO_2 was included in the 2011 estimates as a carbon-sink-recovery of the 13,586,774.41 Ha of land which was affected by wildfire in 2010, yielding a total sink of -127,520.56 Gg of CO_2 eq. (Table 3.4)

Table 3.4: Summary Inventory of GHG emissions from AFOLU Sector

GHG Source & Sink Category	1990	1994	2000	2011
	Emissions CO2 eq (Gg)	Emissions CO2 eq (Gg)	Emissions CO2 eq (Gg)	Emissions CO2 eq (Gg)
1. Agriculture	**5 270.07**	**5 066.61**	**1 785.00**	**16 540.89**
a) Enteric Fermentation & Manure Management (CH4)	0.00	1 945.36	1 710.00	2 502.73
b) Animal Waste Management Systems (N2O)	0.00	1.91	75.00	8 938.81
c) Indirect Emissions from Leaching (N2O)	0.00	66.34	-	2 892.39
d) Biomass Burning (crop waste)	0.00	3 053.00	-	2 368.54
2. Land-Use Change & Forestry (sink)	**-43 322.19**	**-38 733.91**	**-42 941.00**	**-127 520.56**
a) Conversions to Forest	-43 322.19	-39 646.50	-42 941.00	-146 186.20
b) Conversions to Cropland	0.00	0.00	-	745.69
c) Conversions to Grassland	0.00	0.00	-	22 363.25
d) Conversions to Settlements	0.00	0.00	-	396.82
e) Conversions to Other Lands	0.00	912.59	-	-4 840.11
AFOLU Net Total (after subtracting sink)	**-38 052.12**	**-33 667.30**	**-41 156.00**	**-110 979.67**

Note: AFOLU for the years 1990 & 2000 only included conversions to forest under Land Use change and forestry.
Year 1994: LULUCF= (-38 734) & Agirc = 5 067
Year 1990: LULUCF= (-43 322) & Agirc = 2 198

Figure 3.6: Summary Inventory of GHG emissions from Agriculture, 1990, 1994, 2000 & 2011

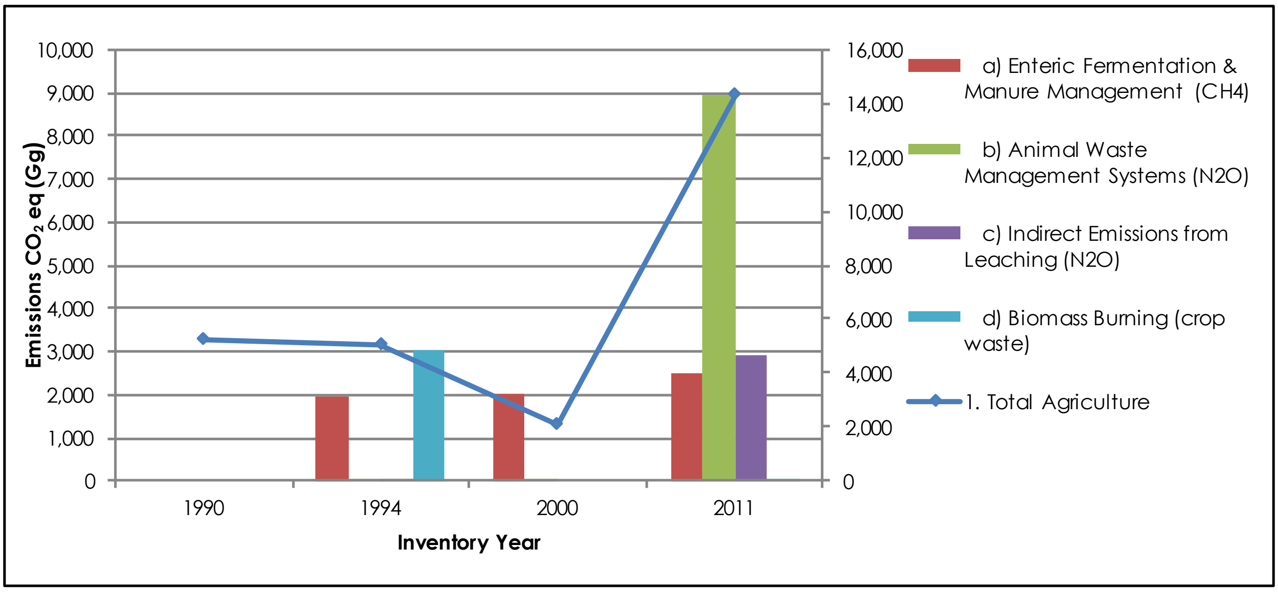
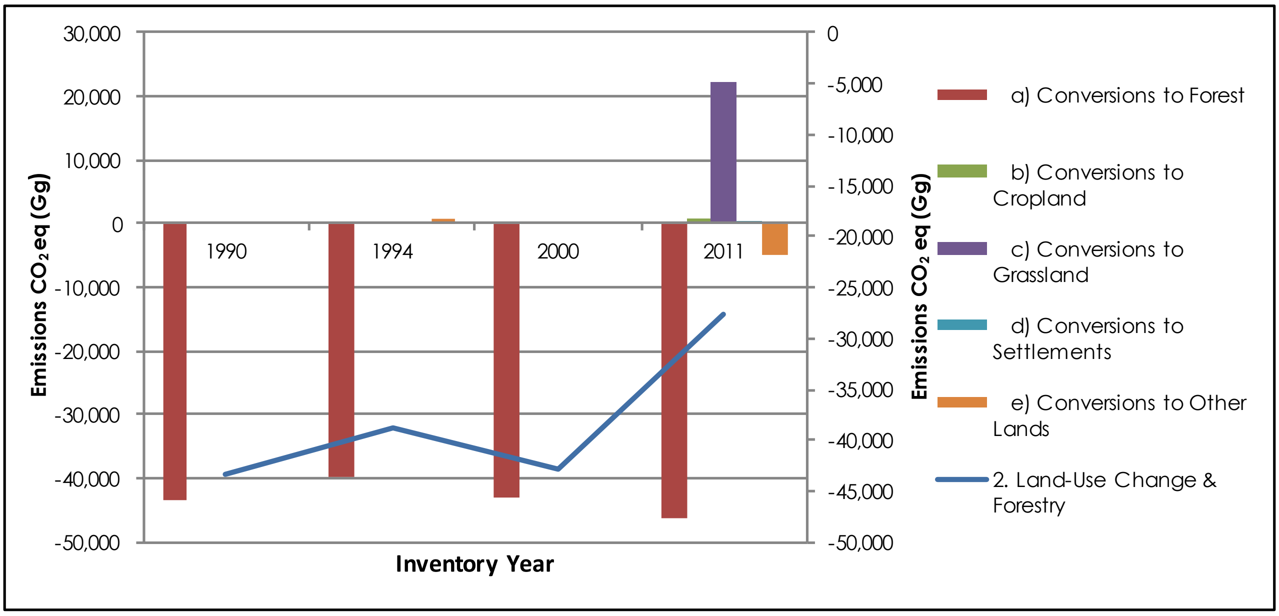


Figure 3.7: Summary Inventory of GHG emissions from Land-Use Change and Forestry, 1990, 1994, 2000 & 2011

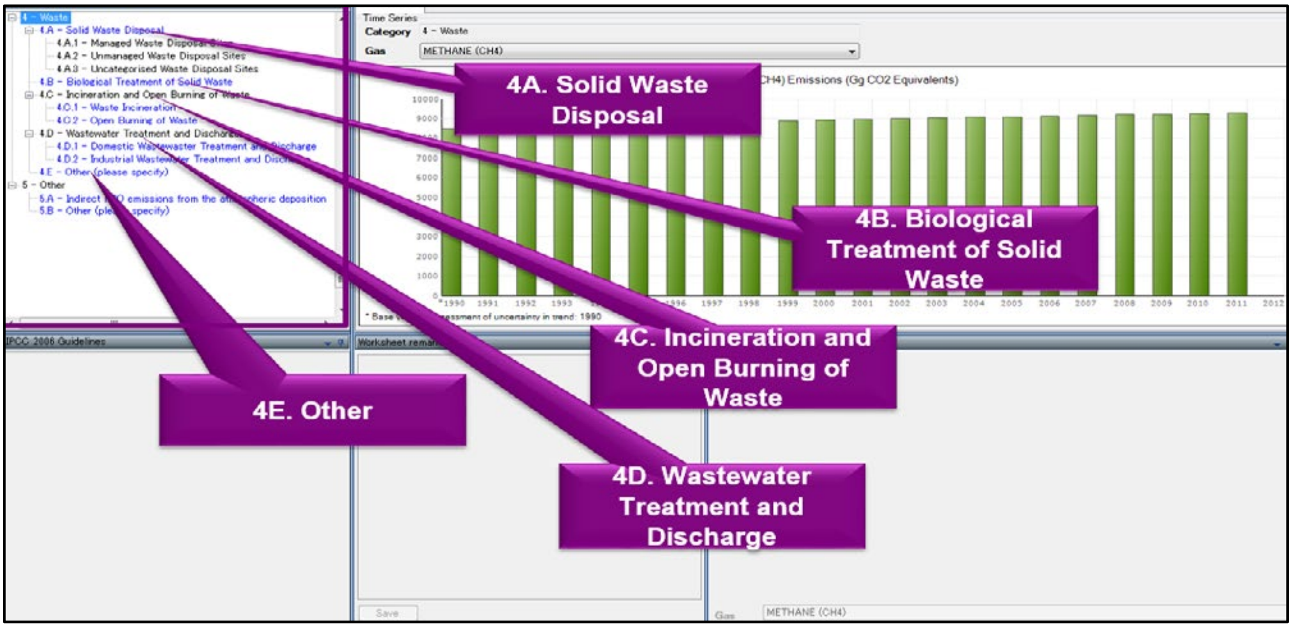


3.6 Inventory of GHGs Emissions from Waste Sector

The purpose of this section of the report is to present trends of GHG emissions for the inventory years 1990 to 2011. The source of emissions are from the following categories: i) solid waste disposal from sanitation facilities (Municipal waste, water borne- use of sewer lines/septic tanks; pit latrines), and ii) waste water treatment and discharge (e.g. domestic).

Waste in Botswana is divided into Municipal Solid Wastes and Liquid Wastes. Liquid waste disposal in the country has sewer lines and septic tanks. The use of pit latrines is common in both rural and urban areas. Most of the waste at dumping sites in Botswana is not managed; therefore the methane content from dumping sites is low (Republic of Botswana, 2012). The Municipal Solid Wastes in the main towns of Botswana are dumped in shallow pits originally used for extraction of materials for road construction, and the wastes end up in relatively shallow, open piles decomposing mainly under aerobic conditions to produce carbon dioxide and a small amount of methane (Adedoyin et al. 2016). Further, Adedoyin et al. (2016) note that there is no classification of municipal garbage into the international components of: vegetable matter, paper, plastic, metal, glass, aluminium (empty cans) and debris, as a result GHGs are difficult to estimate by category of waste. Figure 3.8a depicts sources of GHG emissions from the IPPU sector.

Figure 3.8a: Sources of GHG emissions from the Waste Sector



Source: Jamsranjav (2017)

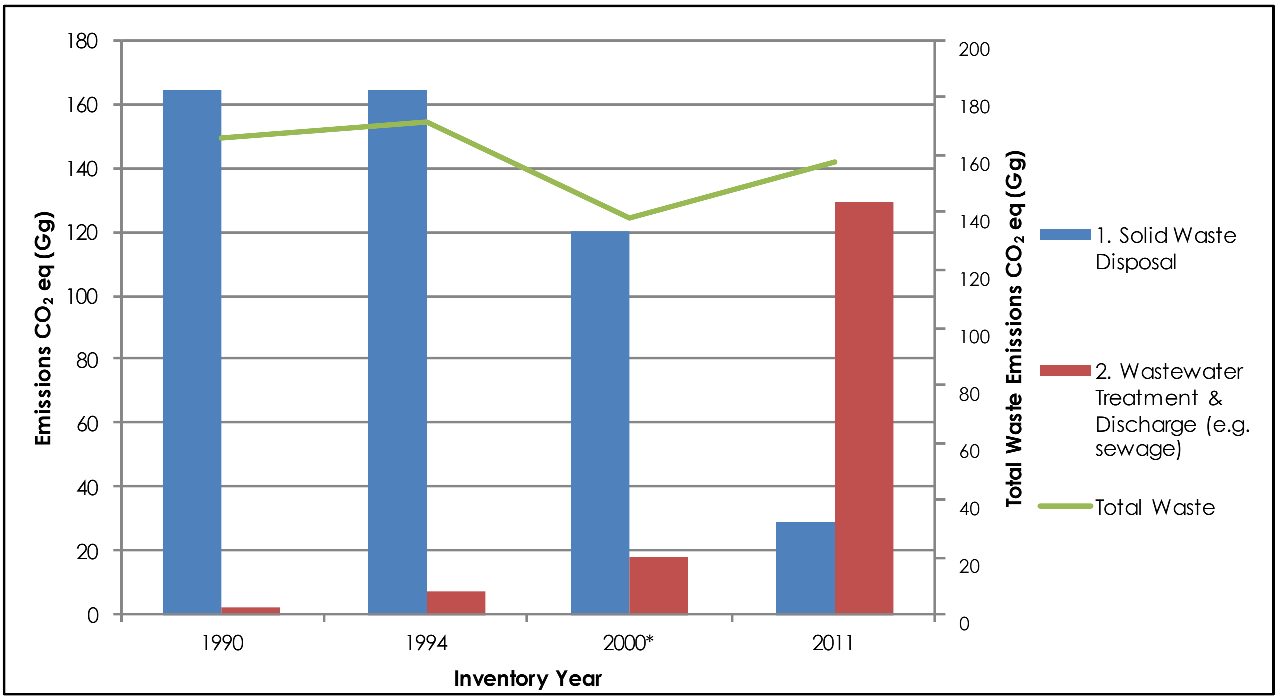
Table 3.5 and Figure 3.8b depict the summary of GHG emissions from the waste sector. It is evident from the table that total emissions from waste fluctuated during the review period with the highest of 171.80 Gg of CO_2 eq estimated in 1994, and lowest of 138.25.80 Gg of CO_2 eq recorded in 2000. The contribution of the solid waste disposal to the total waste GHG emissions was on the decline during the review period. There was about 82.6 percent drop of solid waste disposal emissions from 164.33 Gg of CO_2 eq in 1990 to 28.68 Gg of CO_2 eq in 2011. On the other hand, the contribution of the waste treatment and discharge to the total waste GHG emissions followed an upward, with the highest emissions estimated at 129.07 Gg of CO_2 eq in 2011 and lowest of 2.05 Gg of CO2 eq recorded in 1990.

Table 3.5: Summary Inventory of GHG emissions from Waste Sector

Inventory Category	CO2 Emissions (Gg)			
	1990	1994	2000*	2011
1. Solid Waste Disposal	164.33	164.43	119.75	28.68
2. Wastewater Treatment & Discharge (e.g. sewage)	2.05	7.37	18.5	129.07
Total Waste	**166.38**	**171.8**	**138.25**	**157.75**

Note: For the year 2000 emissions from biomass have been captured under residential & government. Manufacturing industries & construction have been captured under Energy Industries.

Figure 3.8b: Summary Inventory of GHG emissions from Waste Sector, 1990, 1994, 2000 & 2011



4.0 NATURAL DISASTERS

4.1 Introduction

This chapter provides current statistics together with a trend analysis on natural and technological disasters, focusing on floods, storms, heavy rains, and accidents occurring at the mines. For natural hazards the focus is on the incidences, impacts and responses.

Natural disasters are the aftershock of natural hazards affecting daily human activities (CSO, 2009). Disasters are a serious disruption of the functioning of a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources (NDMO, 2010). They are naturally occurring events. The hazard exists because of human activities, which are constantly exposed to natural forces (Dunno, 2011: 7). Though the NDMO (2008) identified a number of disasters and risks (flooding, drought, animal epidemics and wild land fires, motor vehicle accidents, and human epidemics) prevalent in Botswana, this report zeros into floods, storms, heavy rains, and disasters occurring at the mines.

4.2 Floods and Storms Incidences, Impacts/Damages and Responses

Trends on flood and storm occurrence by year, location, number of households and individuals affected, and assistance given is presented in this sub-section. Flooding usually takes place in a situation where water overflows in a dry place or within existing water bodies (Statistics Botswana, 2014). While a "storm" is defined as a violent disturbance of the atmosphere with strong winds, and usually rain, thunder, lightning, or snow (Statistics Botswana, 2013: 119). A combination of both storms and floods occurrence are common in Botswana, and they usually cause destructions to property and the environment.

4.2.1 Floods

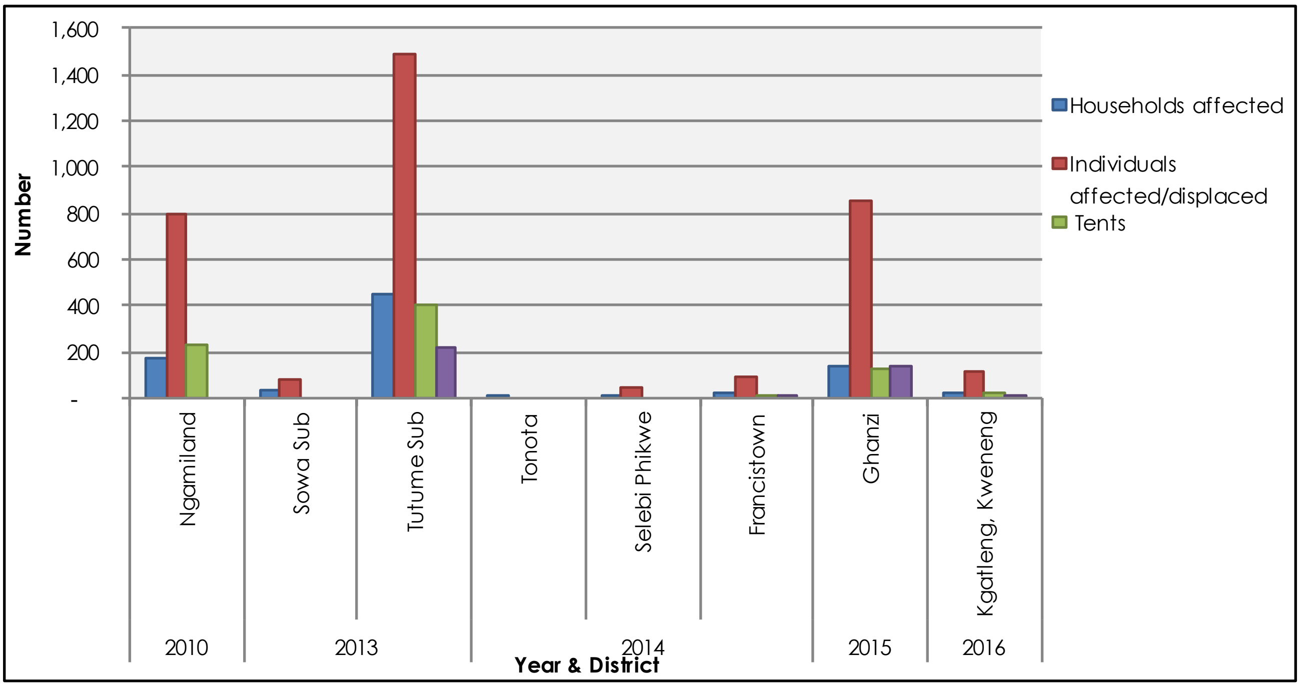
Table 4.1 depicts floods incidences and impacts by village and district for the 2010 – 2016 period. It is evident from the Table that the district with the highest number of households affected by floods during the review period was Tutume sub-district with 446 and recorded in 2013. During the same year a total of 1,489 individuals were affected/displaced by floods in nine villages of Tutume sub-district. Subsequently, a total of 400 tents were issued to the victims of the 2013 floods in Tutume sub-district to provide temporary shelter. Second after Tutume in terms of the floods impacts was Ngamiland district which recorded from nine villages, a total of 168 households affected, from which 800 individuals were affected/ displaced in the year 2010. Tonota was the least affected by floods during the period of review with only 5 households affected by floods.

Table 4.1: Floods Incidences & Impacts by Village and District, 2010 – 2016

District	Year	Villages	Impact/Damages		Assistance given	
			No. of households affected	Total no. of individuals affected / displaced	Tents	Food Baskets
Ngamiland	**2010**	Ikoga, Nxamasere, Etsha 13, Mohembo east, Kauxhwi, Jao Flats, Eretsha, Beetsha, Gudigwa, Tubu	168	800	235	-
Sowa Sub	**2013**	Sowa Town	31	84	-	
Tutume Sub		Matsitama, Dukwi, Mosetse, Marapong, Zoroga, Tutume, Goshwe, Maposa, Makoba	446	1 489	400	218
Tonota	**2014**	Serule	5			-
Selebi Phikwe		Selebi Phikwe	10	42		-
Francistown		Francistown	25	87	2	7
Ghanzi	**2015**	D'kar, Kuke, New Xade, Chobokwane, Ghanzi Township, Grootlaagte, Qabo	140	859	130	136
Kgatleng, Kweneng	**2016**	Leshibitse, Molepolole, Mmanoko	20	113	17	13

Source: National Disaster Management Office

Figure 4.1: Floods Impacts & assistance given by District, 2010 - 2016



4.2.2 Storm Incidences (Hailstorms, Storm Winds & Thunderstorms)

Out of a total of 1,630 households affected by storm-related natural disasters during the 2010 to 2016 period, about 48.5 percent were struck by hailstorm, while about 32.7 percent and 4.7 percent were hit by storm rains and thunderstorms, respectively. Kgatleng and Central districts were the hardest hit with 359 households, resulting in 14 tents and 57 food baskets provided for relief.

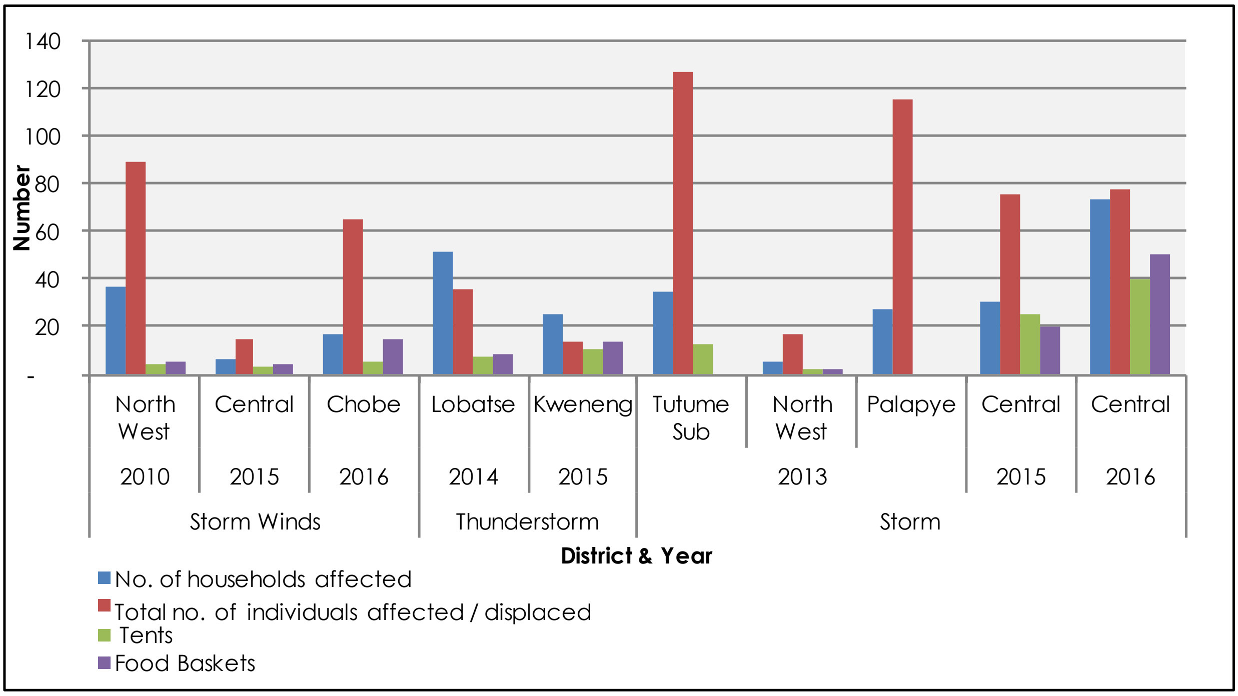
Among the storm rains incidences alone, Mahalapye sub-district (329) had the highest number of households affected in 2012 followed by North West district with 132 households affected in the year 2010. As for hailstorms, the hardest hit district was Central and Kgatleng districts during the year 2015 followed by Moshupa sub-district with 114 households affected, 506 individuals misplaced during the year 2013. With regards to the storms impacts, it is evident from the Table 4.2 that the Central district, specifically Serowe and Mabeleapudi villages, recorded the highest number of households affected by storm with a total of 73 recorded in 2016.

Table 4.2: Storm Incidences, Impacts & Responses by District, 2010 – 2016

Incident	Year	District	Villages	Impact/Damages		Assistance given	
				No. of households affected	Total no. of individuals affected / displaced	Tents	Food Baskets
Storm Rains	**2010**	**North West**	Maun	132	568	132	69
	2012	**Mahalapye Sub**	Mahalapye	329	1 756	119	322
	2013	**Palapye Sub**	Maunatlala, Seolwane, Mogapi, Matolwane, Mogapinyana, Malaka	27	115	-	-
	2015	**Central**	Pallaroad	45	211	22	18
Hailstorm	**2010**	**Kgatleng**	Ramotlabaki, Malolwane, Kgomodiatshaba	32	212	32	-
	2010	**Ngwaketsi**	Ntlhantlhe, Lekgolobotlo	49	-	18	-
	2013	**Kgatleng**	Morwa, Bokaa, Oodi, Rasesa, Malotwana, Mochudi	81	242	32	27
		North West	Maun	5	17	2	2
		Kweneng	Salajwe	32	96	3	19
		Moshupa Sub	Kgomokasitwa	114	506	46	56
		Mahalapye Sub	Poloka, Setsile	19	-	-	-
	2014	**Kgatleng**		39		7	12
	2015	**Central, Kgatleng**	Gobojango, Rasetimela, Borotsi,Mabumahibidu, Dandane, Mosweu, Boseja, Oodi Bokaa	359	54	14	57
	2016	**Gantsi**	Otjiseu, Boikarabelo,Mogobe, Motoroko, Sunset, Botshabelo	30	55	4	2
	2016	**North East, Goodhope, Kgatleng**	Pole, Mosojane, Lorwana,Modipane	9	42	2	2
	2016	**Kweneng**	Mmatseta, Molepolole	10	50	6	6
	2016	**Kgatleng**	Dikgonnye, Mathubudukwane, Ramonaka	12	45	4	3
Storm Winds	**2010**	**North West**	Maun	37	89	4	5
	2015	**Central**	Mabuo	6	15	3	4
	2016	**Chobe**	Kazungula	17	65	5	15
Thunderstorm	**2014**	**Lobatse**	Lobatse	51	36	7	8
	2015	**Kweneng**		25	14	10	14
Storm	**2013**	**Tutume Sub**	Tutume	35	127	13	
		North West	Maun	5	17	2	2
		Palapye	Maunatlala, Seolwane, Mogapi, Matolwane, Malaka, Mogapinyana	27	115	-	-
	2015	**Central**	Mathangwane, Makobo, Nshakashogwe, Mabuwe, Selolwane, Jamataka,Matsitama, Goshwe, Maenjane	30	75	25	20
	2016	**Central**	Serowe, Mabeleapudi	73		40	50

Source: National Disaster Management Office

Figure 4.2: Storms Impacts & Responses by District, 2010 – 2016



4.2.3 Heavy Rains

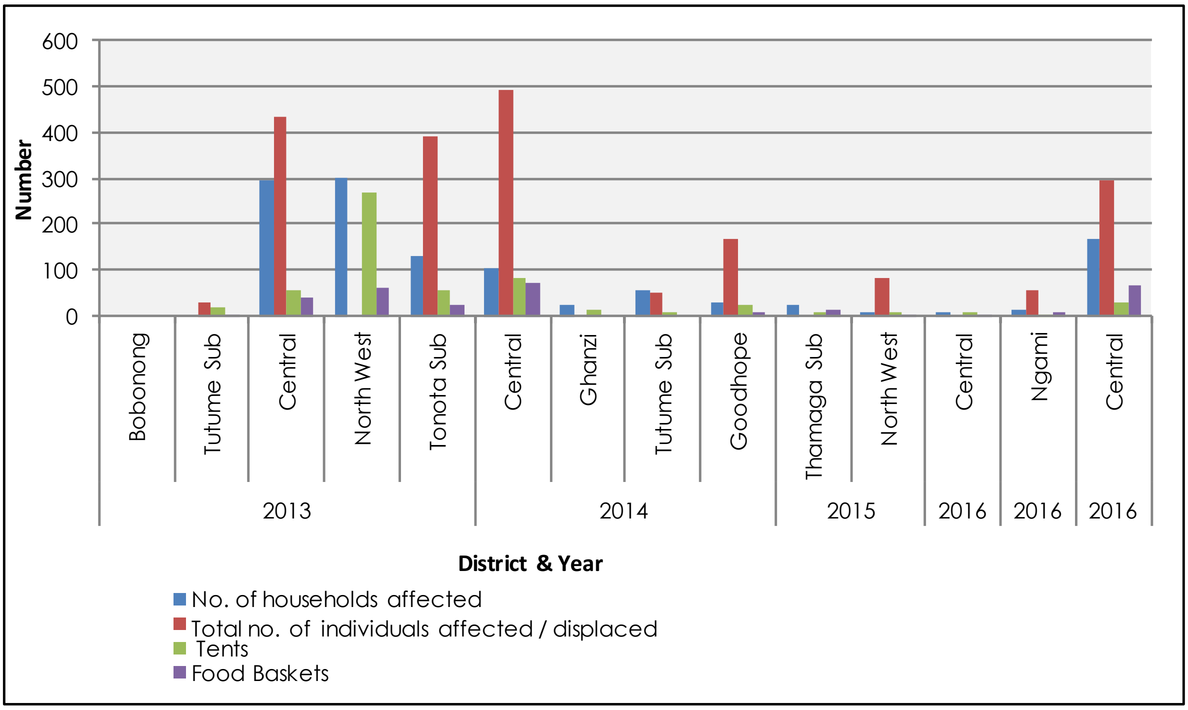
The analysis of the impacts/damages caused by heavy rains and the assistance given as response shows that the year 2013 constituted about 62.3 percent of the total number of households affected by heavy rains during the 2010 – 2016 period. In 2013 the North West and Central districts experienced the highest number of households affected by heavy rains with 303 and 294, respectively. In 2016 alone, a total of 190 households were affected by floods, with 168 in the Central district, 13 in Ngamiland district, and 9 in the Central district. (Table 4.3 and Figure 4.3).

Table 4.3: Heavy Rain Incidences & Impacts by District, 2010 - 2016

Incident	Year	District	Villages	Impact/Damages		Assistance given	
				No. of households affected	Total no. of individuals affected / displaced	Tents	Food Baskets
Heavy Rains	**2013**	**Bobonong**	Lepokole, Mathathane, Molalatau, Mmadinare, Tsetsebjwe				
		Tutume Sub	Tutume		32	18	5
		Central	Maunatlala, Topisi, Moreomabele, Tamasane, Mogapi, Lesenepole, Mosweu, Mokokwana, Seolwane, Lerala, Majwaneng, Ratholo, Goo Tau, Goo Sekgweng, Mathakola, Mokungwane, Lecheng	294	433	54	42
		North West	Tsau, Nxaraga, Semboyo, Shorobe, Toteng, Makalamabedi, Makankung, Sehithwa, Chanoga, Xhana, Phuduhudu, Maun,	303		271	61
		Tonota Sub	Tonota, Shashemooke, Mabesekwa, Mandunyane, Foley, Gojwane, Serule	133	393	57	26
	2014	**Central**	Serowe, Dimajwe, Mmashoro, Tshimoyapula, Mabeleapodi	106	491	81	75
		Ghanzi	Tshootsha, Charleshill	24		12	
		Tutume Sub	Tutume	57	49	11	
		Goodhope	Sekhutlane, Leporung, Mmakgori	28	169	23	8
	2015	**Thamaga Sub**	Thamaga	25		10	14
		North West	Bodibeng	11	85	11	5
	2016	**Central**	Pilikwe, Maape, Ramokgonami	9		6	3
		Ngami	Samedupe,Sanyedi, Boseja-kubung, Disaneng, Botshabelo, Chobe,Mabudutsa, Kgosing, Moeti	13	57	5	7
		Central	Serowe, Moiyabana, Mabuo, Motshegaletau, Mabeleapudi,,Majwanaadipitse, Tshimoyapula, Otse, Mokgenene	168	296	29	67

Source: National Disaster Management Office

Figure 4.3: Heavy Rains Incidences & Impacts by District, 2010 - 2016



4.3 Training and Capacity Building Programmes

Table 4.4 depicts training and capacity building programmes conducted in Botswana by the National Disaster Management Office during the period 2010 – 2016. The highest number of participants trained was in 2011 with a total of 480. These participants were trained on disaster management and development of fire management strategy. During the year 2011 the majority of participants were trained in Gaborone. The other years which recorded the highest number of participants after 2011 are 2015 and 2014 with 310 and 280 participants, respectively. In 2015 alone, several thematic areas were covered which include: i) Disaster planning for District Health Management Teams; ii) District Disaster management training; iii) Risk, vulnerability training for Community based disaster risk management; iv) Training on Risk and Vulnerability Assessment; and v) Workshop on Geo- Hazard disaster preparedness plans. In 2014 the trainings focused on the following themes: i) Camp Coordination and Management; ii) Risk and Vulnerability Assessment; and iii) Basic introduction to disaster risk reduction for media. The least number of participants were recorded in 2010, with a total of 60 participants.

Table 4.4: Training and Capacity Building Programmes, 2010 - 2016

Year	Dates	Districts Trained/ Stakeholders	Location of Training Program	No of participants	Activity
2010	**6-9 Dec 2010**	Lethakane	Francistown	10	District Disaster management training
		Serowe		10	
		Palapye		10	
		Selebi Phikwe		10	
		Bobonong		10	
		Masunga		10	
		Kanye	Francistown	10	District Disaster management training
	25-28 Jan 2011	Mabutsane		10	
		Goodhope		10	
		Lobatse		10	
		Mochudi		10	
		Moshupa		10	
		Hukuntsi	Lobatse	20	District Disaster management training
2011	**12-15 Apr 2011**	Tsabong		20	
		Lobatse		20	
	14-15 June 2011		Gaborone	180	Development of Fire management Strategy
	5-7 July 2011	Gaborone	Gaborone	40	Training of trainers for CBDRM
	29-31 Aug 2011	Tutume	Francistown	70	Training of trainers for CBDRM
	12-14 Sep 2011	Tonota	Francistown	70	Training of trainers for CBDRM

Table 4.4 Continued: Training and Capacity Building Programmes, 2010 - 2016

Year	Dates	Districts Trained/ Stakeholders	Location of Training Program	No of participants	Activity
2012		South East	Francistown	10	Training on Societal risk mapping
	21-22 Nov 2012	Gaborone		10	
		Francistown		10	
		Lobatse		10	
		North West		10	
		Kweneng		10	
		Kgatleng		10	
		Central		10	
		Chobe		10	
2014	**7-14 April 2014**	Tutume	Tutume	60	Training on Camp Coordination & Management
		Nata	Nata	60	Training on Camp Coordination & Management
	9-11 April 2014	Nata	Nata	40	Training on Risk and Vulnerability Assessment
	14-Apr-14	Dukwi	Dukwi	60	Training on Camp Coordination & Management
	23-27 June 2014	Ngamiland (DHMT) & Letsholathebe Hospital	Maun	30	Disaster planning for District Health Management Teams
	12-13 Aug 2014	Gaborone (Media practitioners)	Lion's Park	30	Training on basic introduction to disaster risk reduction for media.
2015	**20-24 April 2015**	Molepolole	Francistown	10	Disaster planning for District Health Management Teams
		Mahalapye		20	
		Ngamiland		10	
		Serowe		20	
		Francistown		10	
		Gaborone		20	
	1-5 June 2015	Moshupa	Jwaneng	10	District Disaster management training
		Mogoditshane		10	
		Kanye		10	
		Jwaneng		10	
		Mabutsane		10	
	3-4 Sep 2015	Thamaga	Thamaga	60	Risk, vulnerability training for Community based disaster risk management
	26-30 Oct 2015	Sehitwa	Sehitwa	30	Training on Risk and Vulnerability Assessment
	2-6 Nov 2015	Etsha 13	Etsha 13	30	Training on Risk and Vulnerability Assessment
	16-20 Nov 2015	Department of Geological Survey	Francistown	50	Workshop on Geo- Hazard disaster preparedness plans
2016	**7-11 Nov 2016**	Ghanzi	Ghanzi	10	District Disaster management training
		Charlsehill		10	
		Tsabong		10	
		Hukuntsi		10	
	28Nov- 2Dec 2016	Francistown	Francistown	10	District Disaster management training
		Masunga		10	
		Tutume		10	
		Tonota		10	

Source: National Disaster Management Office

5.0 TECHNOLOGICAL DISASTERS

5.1 Introduction

A technological disaster is an event caused by a malfunction of a technological structure and/or some human error in controlling or handling the technology (Donovan et al. 2011). The example of technologies include but not limited to chemical spills, oil spill, radiation leaks, collapse of mines (mining industry), collapse of bridges, etc. According to Donovan et al. (2011:1), all types of disasters are challenging, but technological disasters present a more complex situation because of the following reasons:

- The threat cannot be anticipated. A technological disaster is sudden, unexpected, and unpredictable.
- People are responsible. Victims of technological disasters tend to feel anger toward people who were responsible for accidents that may have been prevented.
- Community breakdowns and conflict may result. Technological disasters can create disputes within communities.

Technological disasters, just like natural disasters constitute component 4 (extreme events and disasters) of the United Nations Framework for Development of Environment Statistics (UNFDES) 2013. Therefore there is a need to report on this component through its relevant indicators. Component 4 component organizes statistics on the occurrence of extreme events and disasters and their impacts on human wellbeing and the infrastructure of the human sub-system. As for sub-component 4.2 of the UNFDES, countries are expected to report where possible on the occurrence of technological disasters (topic 4.2.1) and on the impact of technological disasters (topic 4.2.2). Figure 5.1 below depicts the wide deepwater horizon/oil spill as a form a technological disaster.

Figure 5.1: Deepwater Horizon/Oil spill

The purpose of this chapter is to present trends and current statistics on technological disasters in Botswana, zeroing into those related to the mining industry. The focus is on labour and accidents statistics, reduction targets, and fatal accidents for the period 1993 – 2016. The availability of data on mining accidents limited this chapter only to mining industry-related technological disasters.

5.2 Mining Industry

The mining industry in Botswana is controlled through binding legislative instruments, with particular reference to the Mines and Mineral Act. This Act regulates the issuance of exploration and mining licenses. Botswana has huge deposits of the following minerals; copper, nickel, diamond, coal, cobalt, gold, salt, soda ash, and uranium, with diamond mining being the dominant one. According to Statistics Botswana (2016a) the mining and quarrying sector constituted about 13.0 percent of the total paid employees in Botswana in 2016. Nonetheless, its percentage contribution to the total GDP is the highest compared to all the sectors in Botswana. The mining sector contributed about 20.0 percent Gross Value Added to GDP during the fourth quarter of 2016 (Statistics Botswana, 2016b). There are two methods of extracting minerals from the ground which are practised in Botswana, shaft/hard rock mining and open pit mining.

The hard rock mining refers to several methods used to mine minerals by tunnelling underground and creating underground rooms supported by pillars of standing rock. Accessing the underground mines is achieved through a shaft. In order to stabilize the structure, metal poles and clamps should be used is stabilize the ground, but in many Sub-Saharan countries, such regulations are not enforced (DRC, 2002). In Botswana this method of mining is used in Selibe Phikwe by Bamangwato Concession Limited (BCL) Company to mine copper and nickel. The hard rock mining presents risks of collapse, which usually leads to fatal accidents leading to death of the miners.

The second type, open-pit diamond mining is a method of extracting minerals from the ground by removal from an open pit or burrow (American Museum of Natural History, 2004). Open pit mines are used when deposits of minerals are found near the surface. This type of mining is also used when the minerals are embedded in structurally unstable earth (cinder, sand, or gravel) that is unsuitable for tunnelling (Real Diamond Facts, 2006). The Jwaneng Mine in Botswana is an example of an established open pit mine. Just like the hard rock mining, the open-pit also presents a threat of collapsing rubble on mining equipment and the workers.

5.2.1 Labour and Accidents Statistics

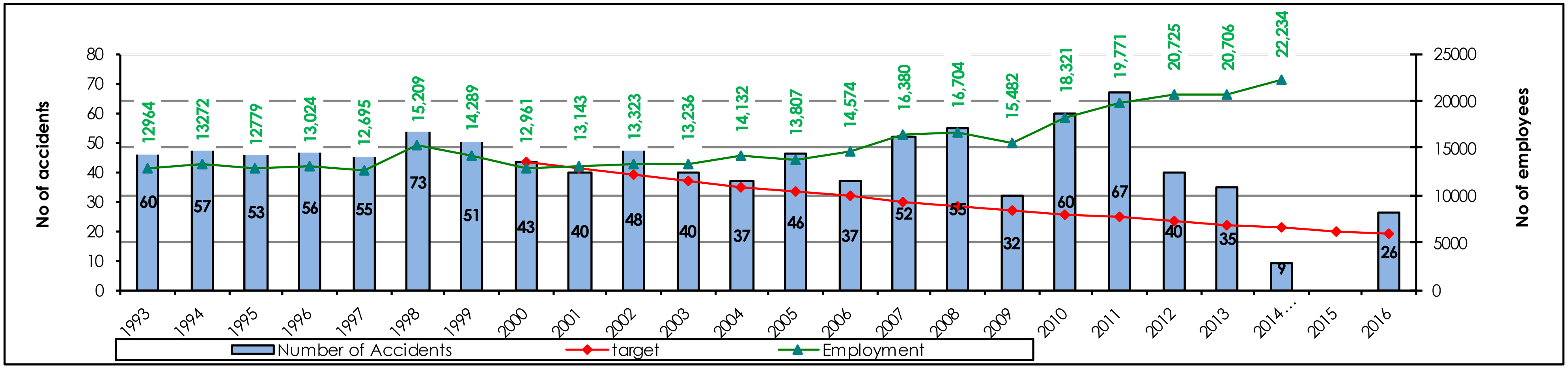
Table 5.1 depicts employment and accidents trends for Botswana during the 1993 – 2016 period. For the employment in the mining industry, the table shows an increasing trend with a slight decrease in the years 1999, 2000, and 2009. The dip in labour statistics recorded in 2009 might have been attributable to the world economic recession. The mining industry was the hardest hit in Botswana, to a point where some workers were retrenched. The highest employment figure was recorded in 2014 with 22,234 employed and the lowest (12,695) was recorded in 1997. The number of accidents fluctuated during the review period. The highest figures were recorded in the year 1998, followed by 2011 and 2010 and 1993 figures with 73, 67, and 60, respectively.

Table 5.1: Employment & Accidents Trends, 1993 - 2016

Accident Type & Employment	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014*	2015	2016
Number of Accidents	60	57	53	56	55	73	51	43	40	48	40	37	46	37	52	55	32	60	67	40	35	9	-	26
Fatal	3	2	3	9	3	10	2	5	3	3	5	2	6	5	2	3	2	3	1	4	3	2	-	3
Accidents Reduction Target								43	41	39	37	35	33	32	30	29	27	26	24	23	22	21	20	19
Employment	12 964	13 272	12 779	13 024	12 695	15 209	14 289	12 961	13 143	13 323	13 236	14 132	13 807	14 574	16 380	16 704	15 482	18 321	19 771	20 725	20 706	22 234	-	-

Source: Department of Mines
Note: *As at April 2014
(-) Data unavailable

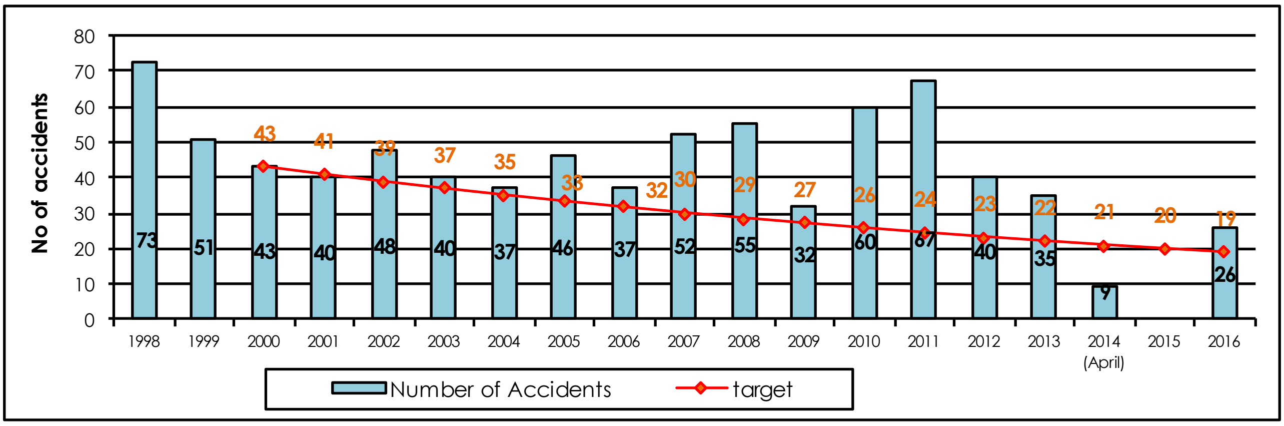
Figure 5.2: Botswana Mining Industry: Employment-Accidents, 1993 – 2016



5.2.2 Accidents trends with reduction targets

Generally the mining-related accidents fluctuated during the years 1993 - 2016, with a slight dip towards the recent years. The reduction targets set from 2000 to date were only realised in 2001 when 40 accidents were recorded, 1 accident less than the 41 set target. About 53.0 percent of the counts during the 2000 - 2016 recorded at least 10 or less number of accidents out of the set targets. While about 47.0 percent of the counts recorded more than 10 number of accidents out of the set targets. The highest variances between the actual records and set targets were recorded in 2011 followed by 2010 and 2008, with variances of 43, 34, and 26, respectively. (Figure 5.3)

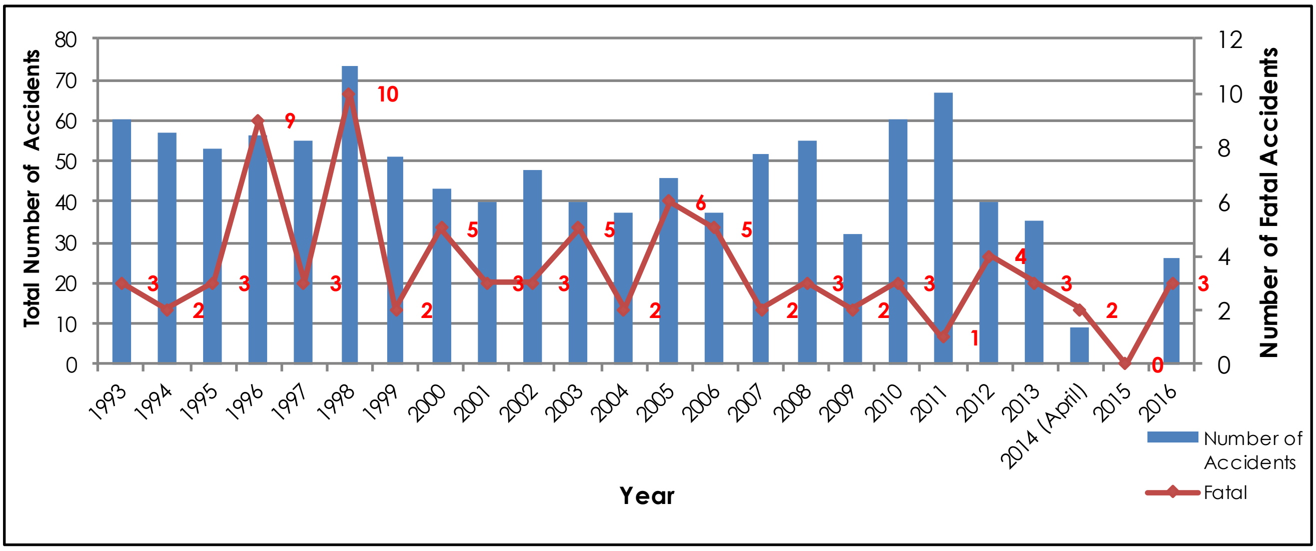
Figure 5.3: Accidents Trends with reduction targets, 1993 - 2016



5.2.3 Fatal Accidents

Figure 5.4 shows that the number of fatal accidents were highest in 1998 with 10 fatal accidents, followed by those recorded in 1996 with 9 fatal accidents, then followed 6 fatal accidents recorded in 2005. Generally, all the fatal accidents constituted less than half of the number of accidents per year.

Figure 5.4: Fatal Accidents Trends, 1993 - 2014



6.0 FORESTRY

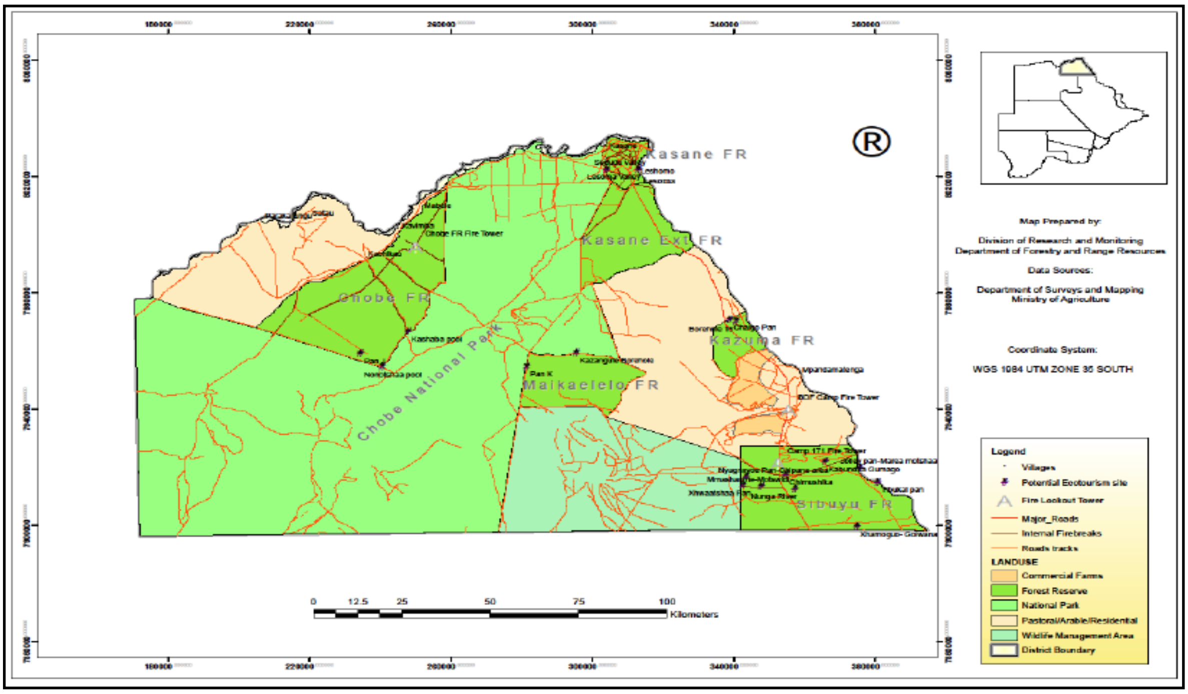
6.1 Introduction

The purpose of this chapter is to present trends and current statistics on Botswana's forest cover and pressures on forests. Pressures on forests include fuel wood harvest, and wild fires incidences and area burnt by district for the period 2010 to 2016.

The forests of Botswana are endowed with natural resources that are important in sustaining the livelihoods of the people and the ecosystems they depend on. The majority of rural populations depend on forests and woodlands for energy source, in providing materials for fencing, construction, building, crafts and maintaining environmental balance. Forests also provide habitats and food for the wildlife, upon which the country depends to a large extent, especially through tourism revenue (Statistics Botswana, 2013). About 45 percent of Botswana's land area is designated for protected areas and they include: forest reserves, game reserves, national monuments, Wildlife Management Areas (WMAs (4th National Report to CBD: 2009: Statistics Botswana, 2013). Botswana's forest reserves are mainly located in the northern part of the country (Figure 6.1a). The largest forest reserve in terms of area is the Chobe Forest Reserve (154,500 ha), followed by Sibuya Forest Reserve and Kasane Forest Reserve with 116,100 ha and 78,100 ha, respectively.

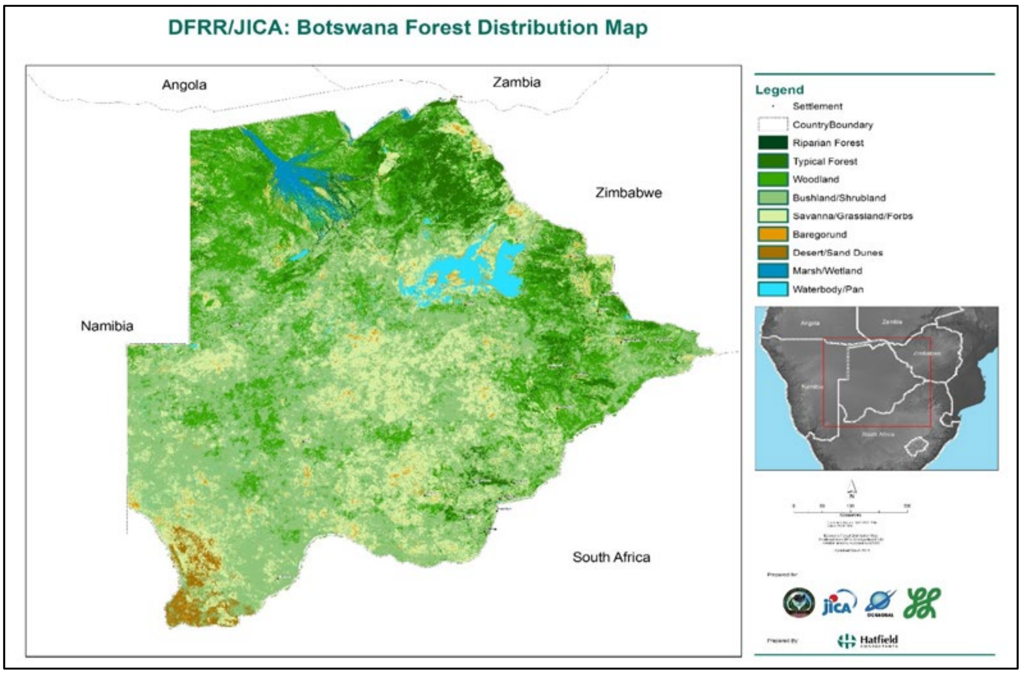
Recently Botswana launched her first Forest Distribution Map in June 8th, 2016. The map is categorized in the following forest cover classes: riparian forest, typical forest, woodland and savanna. The map was developed by Hatfield Consultants Africa, as a component of the Botswana National Forest Management System project, funded by the Japan International Cooperation Agency (JICA), and executed by Oriental Consultants Global (Japan) and the Japan Forest Technology Association, in collaboration with the Department of Forest and Range Resources of the Government of Botswana. (Figure 6.1b)

Figure 6.1a: Botswana's Forest Reserves



Source: Department of Forestry & Range Resources

Figure 6.1b: Forest Distribution Map of Botswana, 2016



Source: Department of Forestry & Range Resources

6.2 Trends in Forest Cover in Botswana

The total land area of Botswana is 582,000 Km2. DFRR (2012) reported a 17 percent decline of forest cover from 13,595 Km2 recorded in 1991 to 11,346 Km2 recorded in 2011. Hatfield Consultants (2016) reported that forests and woodlands areas together cover about 27 percent of the land area of Botswana.

Table 6.1 depicts that the forest cover was on the decline during selected years between 1990 and 2010, then increased in 2016. The total forest area declined from 23.6 percent in 1990 to 19.7 percent in 2010. This decline might have been attributable to deforestation resulting from fuel wood harvesting and land clearing for human settlements. A 38.28 percent increase from 11,448,903 ha recorded in 2010 to 15,831,300 ha in 2016 was due to the fact previously forest cover statistics were sourced from FAO which were default estimates. The 2016 total forest area is country-specific from the Botswana Forestry Distribution Map. The forest distribution map covers typical forests, riparian forests (wooded area of land adjacent to a body of water) and other woodlands (e.g. Mopane trees). The trend in forest cover is also depicted graphically in Figure 6.2a.

Table 6.1: Botswana Forest Cover (ha), 1990 - 2016

Year	1990	1995	2000	2005	2010	2016
Total Forest Area (ha)	13 718 000	13 111 702	12 532 201	11 978 312	11 448 903	15 831 300
Total Area (ha)	58 200 000	58 200 000	58 200 000	58 200 000	58 200 000	58 200 000
% of Total Land Area	23.6	22.5	21.5	20.6	19.7	27.2

Source: Department of Forestry & Range Resources

Figure 6.2a: Forest Cover as a Proportion of Total Land Area, 1990 – 2016

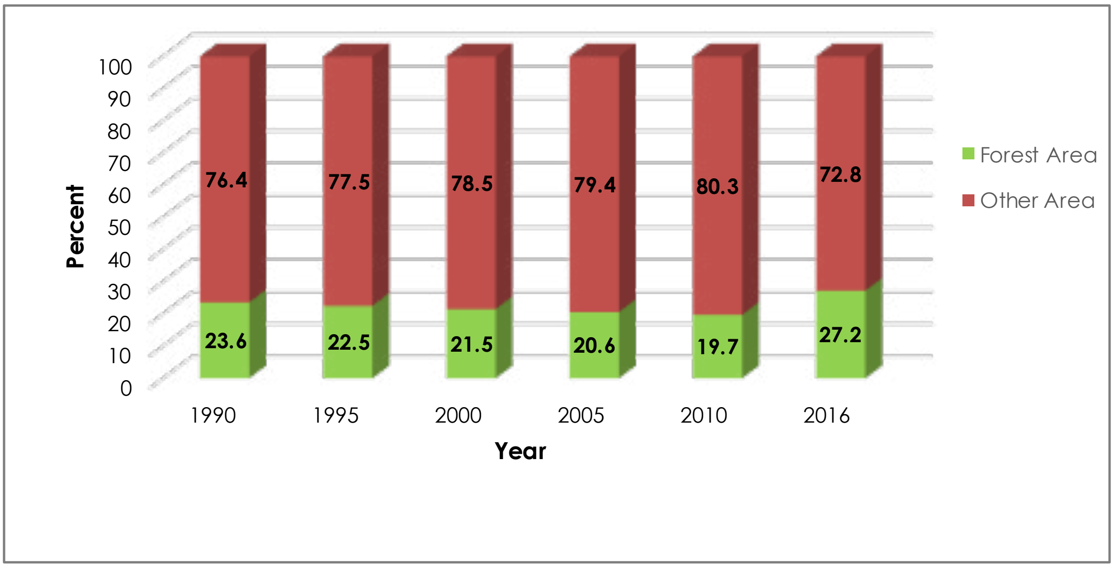
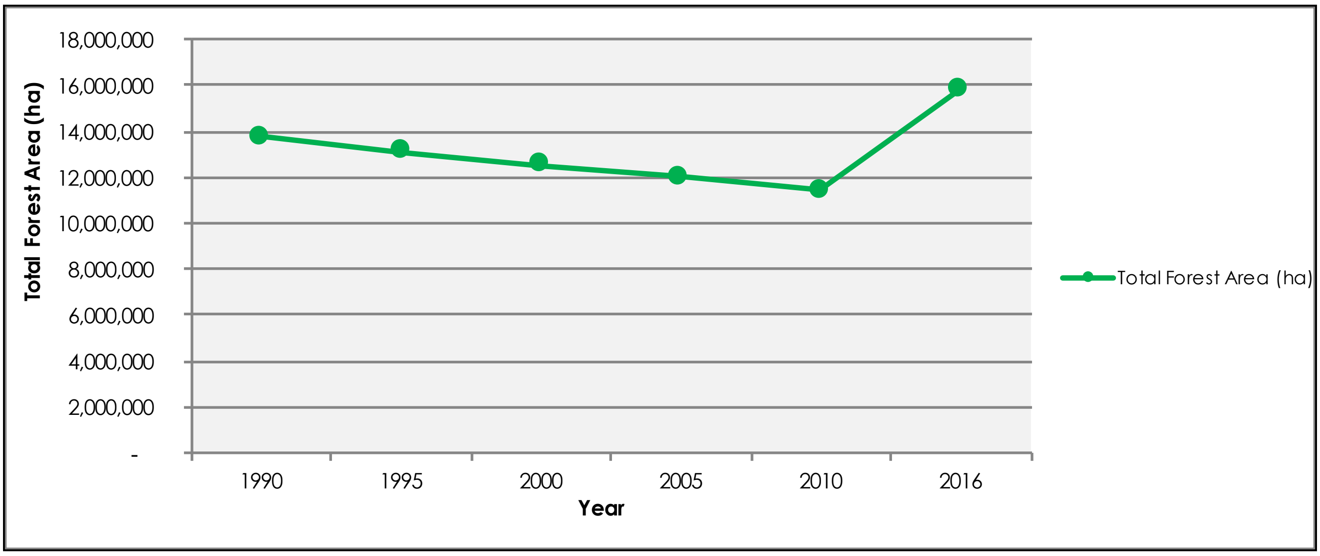


Figure 6.2b: Botswana Forest Cover (ha), 1990 - 2016



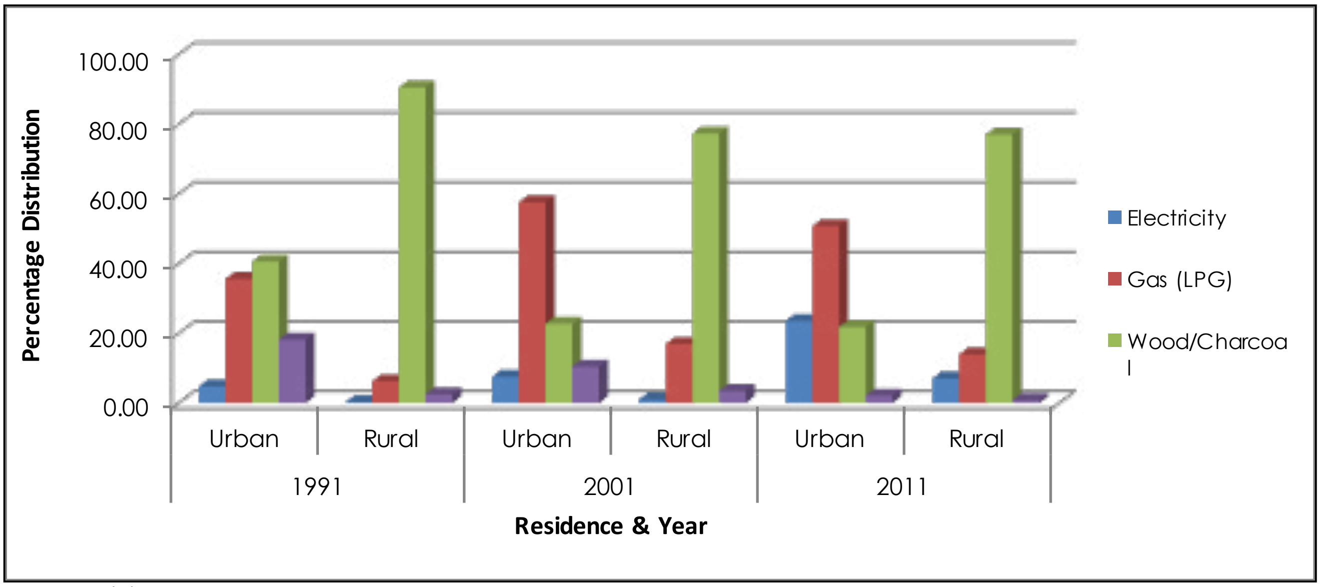
6.3 Pressures on Forests

This sub-section presents pressures that are exerted on forests by humans and other natural forces particularly wild fires.

6.3.1 Fuel Wood

According to Sampa (2011) the household sector is the largest consumer of energy in Botswana particularly fuel wood. Fuelwood is the primary household energy source for cooking in Botswana, especially for rural households, 90 percent of whom primarily depend on fuelwood (Government of Botswana, 2009: Statistics Botswana, 2012). Statistics Botswana (2014) reports that wood/charcoal were mostly used during the three censuses (1991, 2001 and 2011), that is, both in urban and rural areas, followed by gas (LPG) (Figure 6.3). Forest resources can be depleted by fuelwood harvesting, and usually the impact on the forest is considered insignificant. The environmental impacts of fuelwood consumption are somewhat neglected by both authorities and conservationists, probably because this activity constitutes a cryptic and chronic disturbance thought to be of less concern in the face of other major causes of biodiversity loss such as deforestation due to land use shifts (Puyravaud et al. 2010: Specht et al. 2015). Studies on the rate of fuelwood consumption have not been conducted in Botswana for a long time now. If not considered a priority the country is running at a risk of over exploitation of the forest resources.

Figure 6.3: Households in Urban and Rural by Principal Energy Source for Cooking in 1981, 1991, 2001 & 2011 Censuses



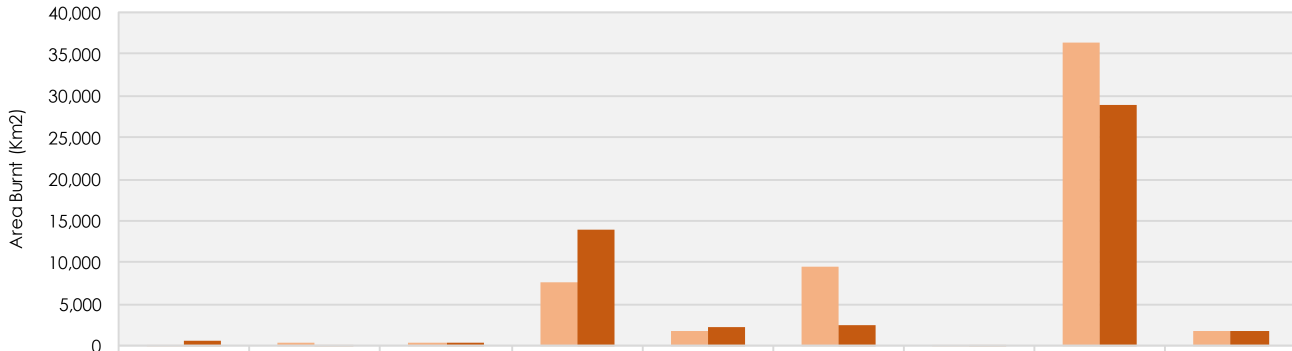
Source: Statistics Botswana (2014)

6.3.2 Fire

In Botswana major threat to forest resources are by wild fires. They threaten and destroy natural biodiversity and ecosystems resulting in ecological balances disruption. Wild fire management in protected areas is hindered by the lack of perceivable incentives for communities to control fires that are within the boundaries of the protected areas (Statistics Botswana, 2013).

Figure 6.4 provides total burnt areas (Km2) per country that were burned during the month of July 2015 as compared to July of the year (2014). In 2015 most parts of the region indicate a decline in burned area except for Mozambique and Zambia. According to MESA (2015), this is the period approaching the peak fire season, hence the increase in areas burned.

Figure 6.4: Total Area Burnt by Fires per Country, July 2014 & July 2015



	Botswana	Lesotho	Malawi	Mozambique	Namibia	South Africa	Swaziland	Zambia	Zimbabwe
July_2014	89	244	304	7,629	1,687	9,578	186	36,439	1,863
July_2015	534	203	327	13,878	2,232	2,520	76	28,982	1,720

Source: MESA (2015

Table 6.2 depicts the extent of area affected by wild fires by district for the period 2012 to 2016. The table shows the decrease in the areal extent of fires over Botswana during the review period. Figures 6.5a - e display the area burnt by district during the years 2012 - 2016. It is evident from the figures that Ngamiland district had the largest area burnt by wild fires during the review period, followed by Ghanzi and Central districts. The afore-mentioned districts constitute the largest percentage share of the total land area of Botswana.

Table 6.2: Area Burnt by District, 2012 - 2016

District	2012	2013	2014	2015	2016	District Size (Hectares)
Ngamiland	5 120 500	3 862 011	1 180 793	473 396	225 380	11 134 421
Chobe	649 600	546 135	427 815	55 349	67 446	2 101 920
Central	1 345 400	430 677	281 256	473 060	20 126	14 637 419
Ghanzi	1 951 300	2 676 749	1 118 966	122 500	15 232	11 472 587
Kgalagadi	1 290 000	482 742	358 947	11 649	6 562	10 491 604
Kweneng	437 700	532 819	18 462	27 853	4 342	3 696 345
Southern	506 800	37 600	16 006	643	116	2 723 320
North East	5 000	1 633	57	404	24	514 619
South East	4 500	200	-	3 493	8	5 800
Kgatleng	5 000	47 613	535	15	-	761 943
Grand Total	**11 327 500**	**8 620 279**	**3 402 837**	**1 168 362**	**339 234**	**57 539 978**

Source: Department of Forestry & Range Resources

Figure 6.5a: Area Burnt by District, 2012 - 2016

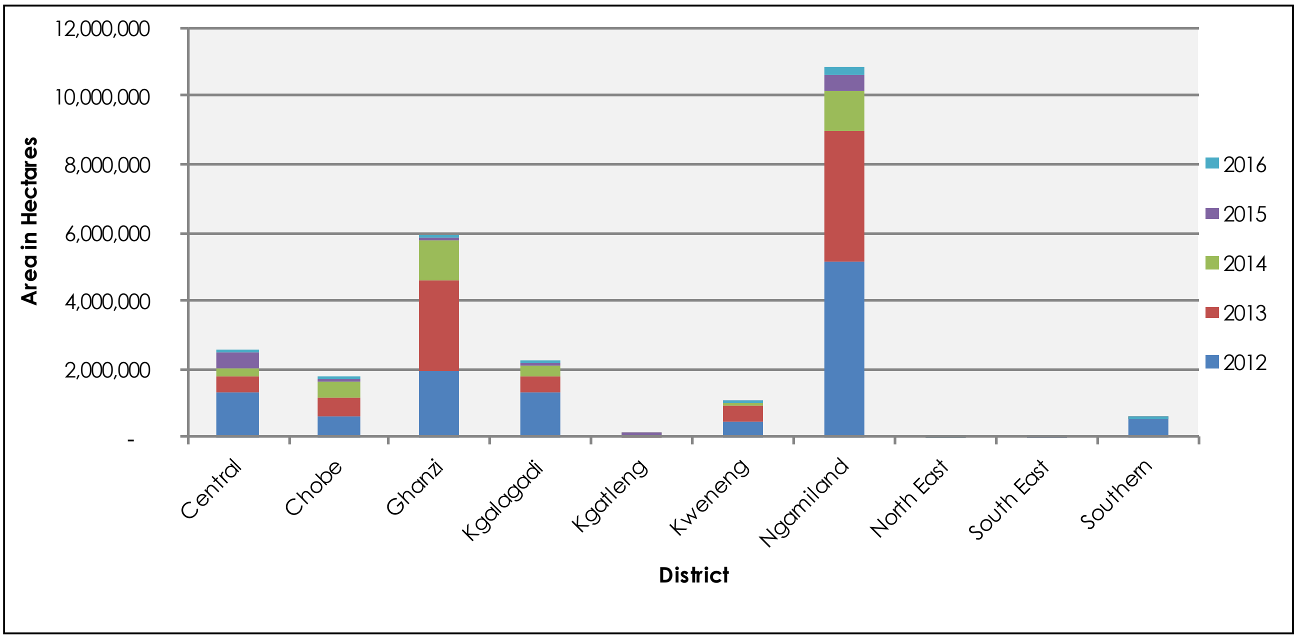
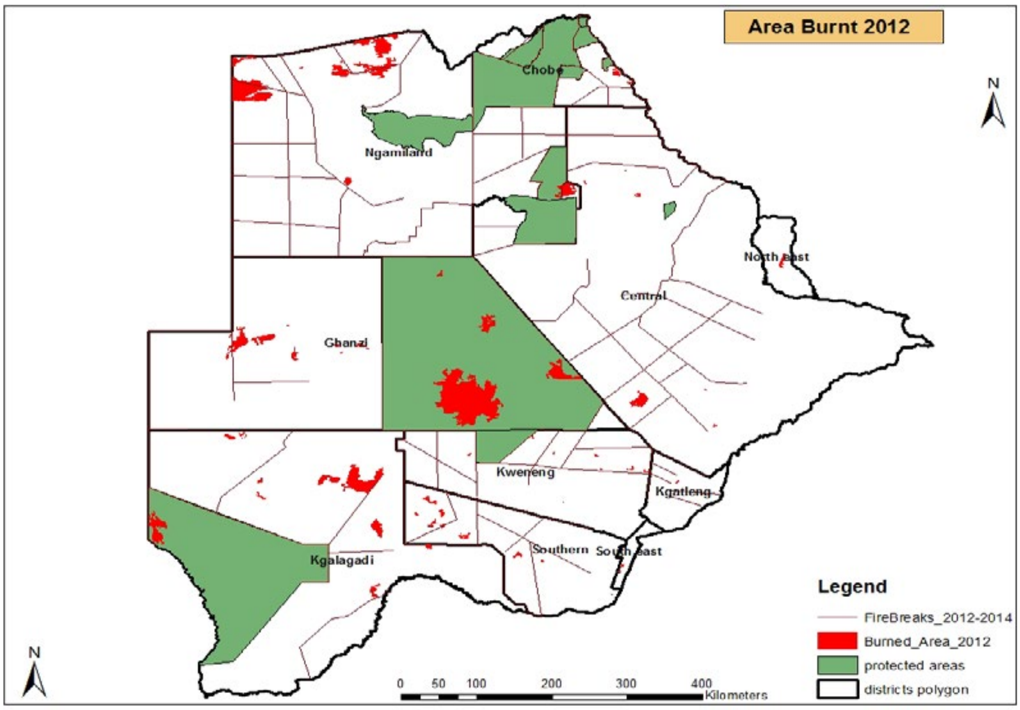
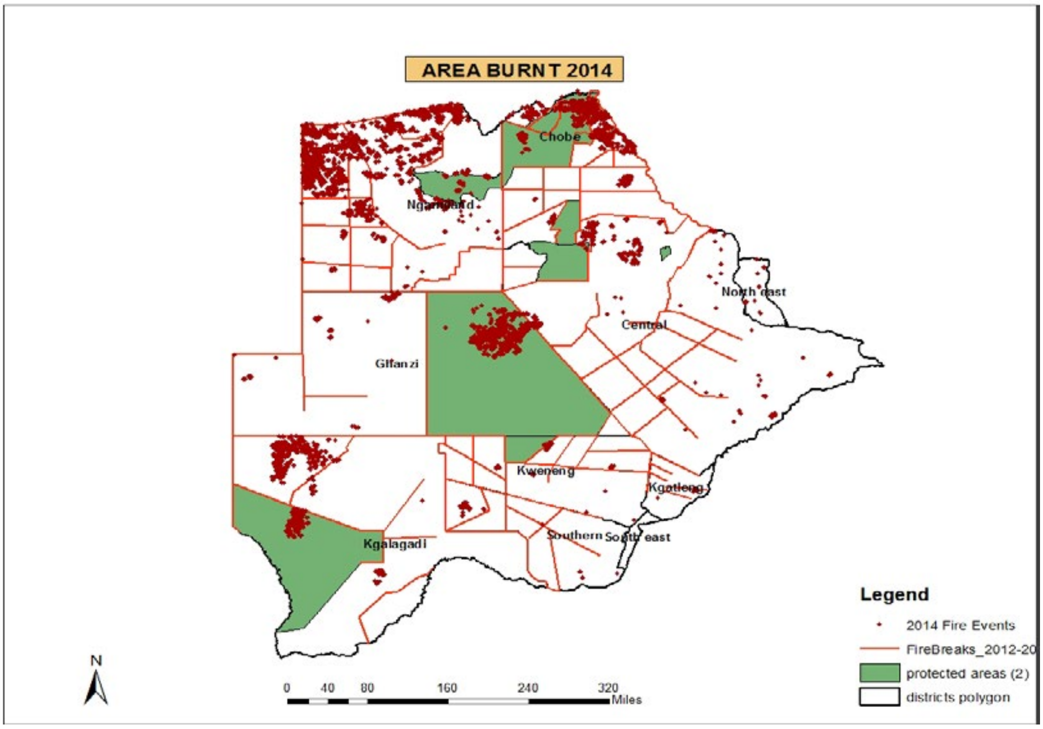


Figure 6.5b: Burnt Scars by District, 2012



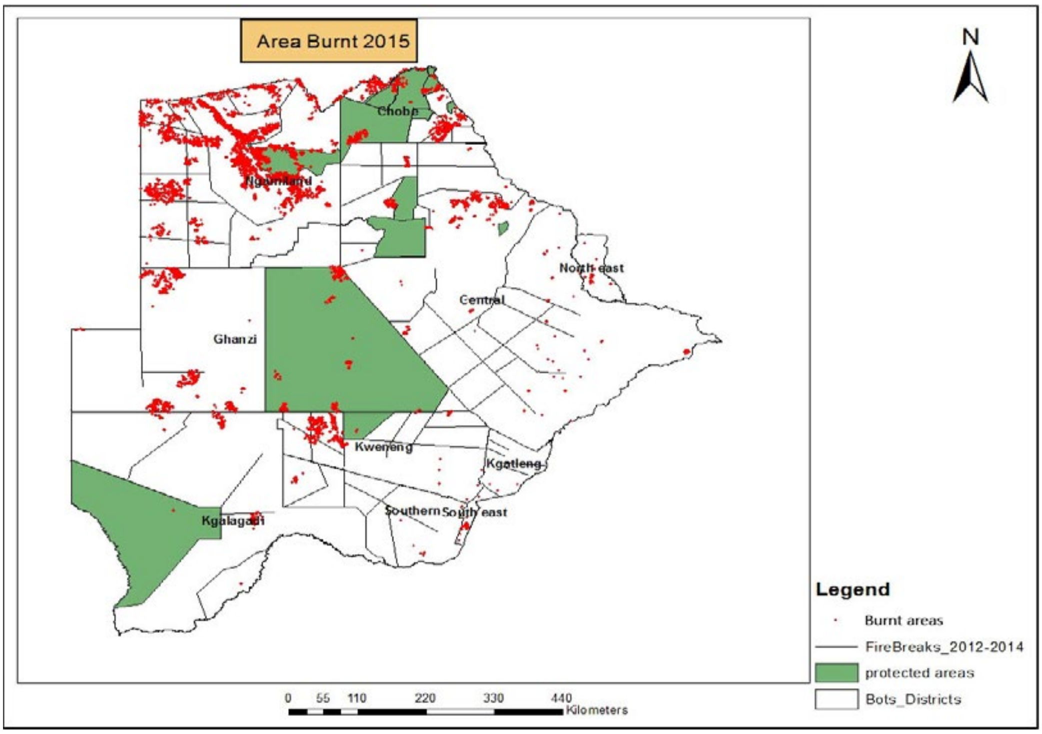
Source: Department of Forestry & Range Resources

Figure 6.5c: Burnt Scars by District, 2014



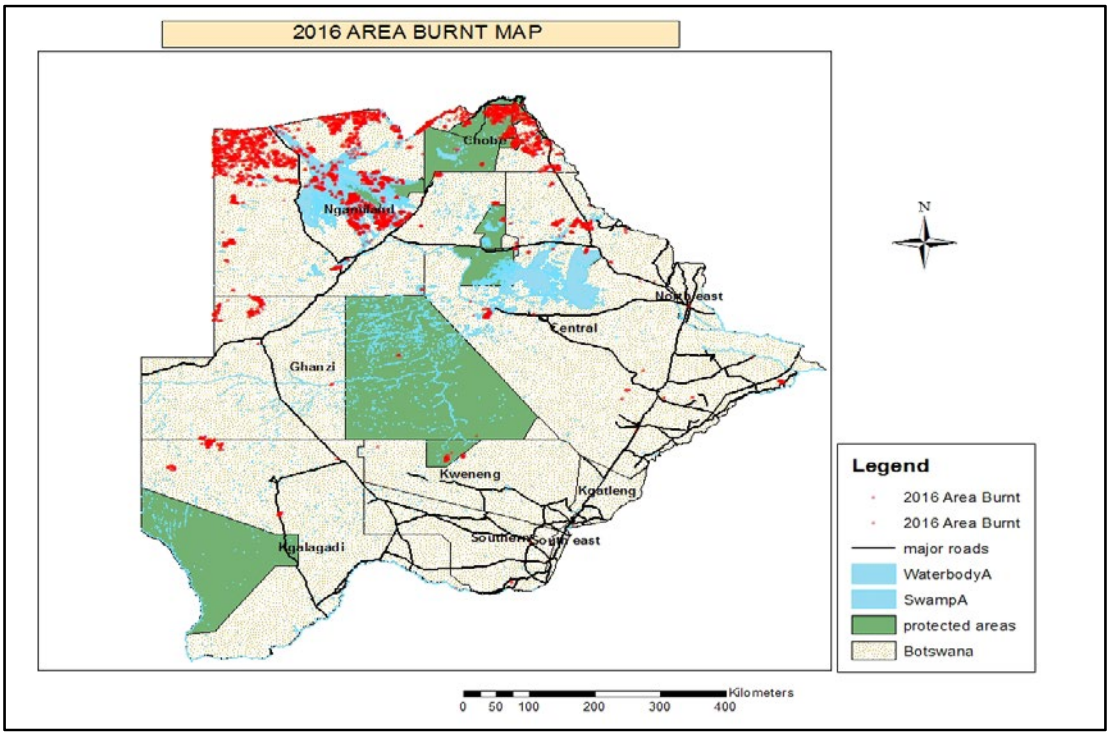
Source: Department of Forestry & Range Resources

Figure 6.5d: Burnt Scars by District, 2015



Source: Department of Forestry & Range Resources

Figure 6.5e: Burnt Scars by District, 2016



Source: Department of Forestry & Range Resources

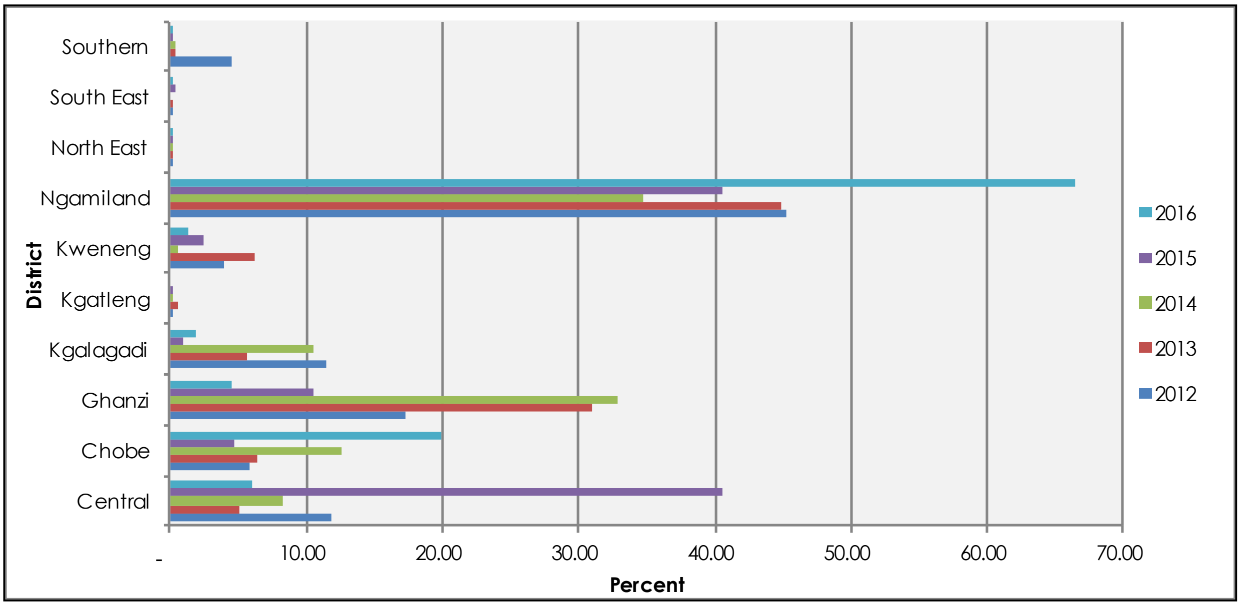
Table 6.3a shows the proportion of areas burnt in each of the districts during the years 2012 to 2016. Proportionately, Ngamiland District, Ghanzi District and Central District show more burnt areas. On the other hand, the Kgatleng, South East, and North East Districts' small sizes resulted in lower proportionate burnt areas. Figure 6.6a graphically illustrates the areas burnt in proportion to the district size.

Table 6.3a: Proportion of Areas Burnt by District, 2012 - 2016

District	2012	2013	2014	2015	2016	District Size (Hectares)
Central	11.88	5	8.27	40.49	5.93	**14 637 419**
Chobe	5.73	6.34	12.57	4.74	19.88	**2 101 920**
Ghanzi	17.23	31.05	32.88	10.48	4.49	**11 472 587**
Kgalagadi	11.39	5.6	10.55	1	1.93	**10 491 604**
Kgatleng	0.04	0.55	0.02	0	-	**761 943**
Kweneng	3.86	6.18	0.54	2.38	1.28	**3 696 345**
Ngamiland	45.2	44.8	34.7	40.52	66.44	**11 134 421**
North East	0.04	0.02	0	0.03	0.01	**514 619**
South East	0.04	0	-	0.3	0	**5 800**
Southern	4.47	0.44	0.47	0.06	0.03	**2 723 320**
Grand Total	**11 327 500**	**8 620 279**	**3 402 837**	**1 168 362**	**339 234**	**57 539 978**
	-19.66%	**-14.96%**	**-5.91%**	**-2.03%**	**-0.59%**	

Source: Department of Forestry & Range Resources

Figure 6.6a: Proportion of Areas Burnt by District, 2006 - 2016



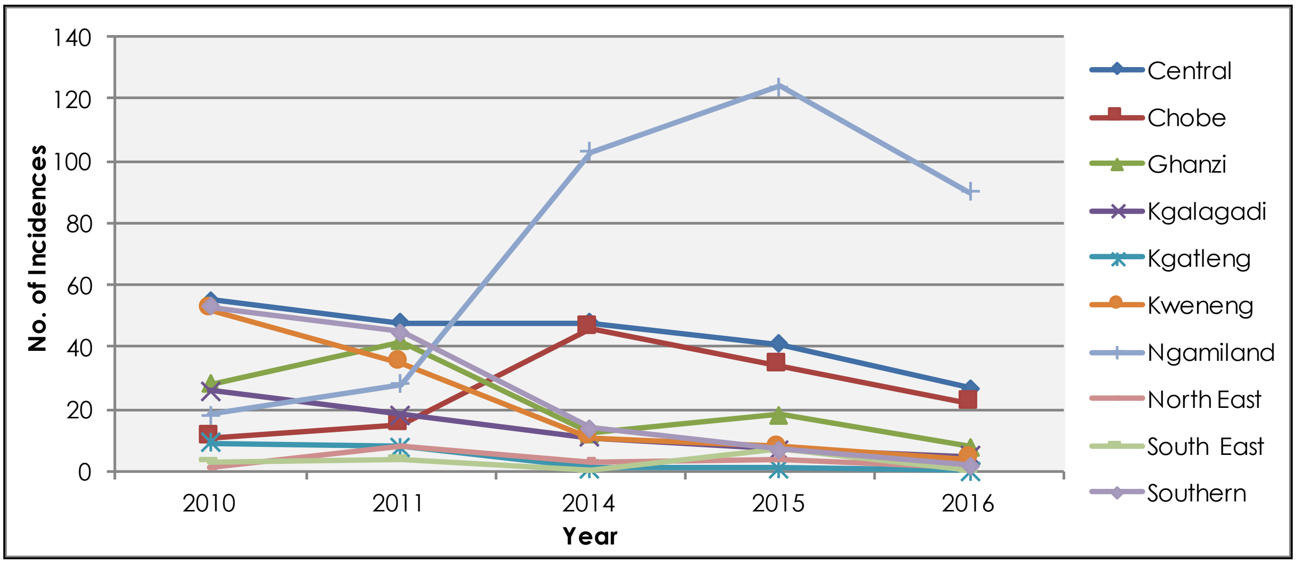
Presented in Table 6.3b are the incidence of fires by district for the years 2010 and 2011, and 2014 to 2016. Ngamiland, Central and Chobe districts recorded the highest incidences during the review period, while South East had the least incidences. Generally the national incidence of fires followed a downward trend, with the highest incidences recorded in 2010.

Table 6.3b: Incidence of Fires by District, 2010 - 2016

District	2010	2011	2014	2015	2016	Total
Central	55	48	48	41	27	**219**
Chobe	11	15	46	34	22	**128**
Ghanzi	28	42	12	18	8	**108**
Kgalagadi	26	18	11	7	5	**67**
Kgatleng	9	8	1	1	0	**19**
Kweneng	52	35	11	8	4	**110**
Ngamiland	18	28	103	124	90	**363**
North East	1	8	3	4	1	**17**
South East	3	4	0	7	0	**14**
Southern	53	45	14	7	2	**121**
Grand Total	**256**	**251**	**249**	**247**	**159**	**1 162**

Source: Department of Forestry & Range Resources
Note: No data are available for the years 2012 and 2013.

Figure 6.6b: Number of fire incidences by District, 2010 - 2016



6.4 Alien Invasive Species (AIS)

The Alien Invasive Species (AIS) are species that spread outside their natural distribution, consequently presenting a threat to biological diversity (CBD, 2013). The commonly known alien invasive species in Botswana is the Prosopis known locally as Sexanana. This species is mainly found in the Kgalagadi and Ghanzi districts with the area coverage of 4,018ha and 1,095ha, respectively. Table 5.4 shows that the estimated coverage area affected by Prosopis invasive species has remained constant over the years 2009 – 2016. The IAS inventory in Botswana has not yet been developed, therefore there is need for the Government of Botswana through DFRR to develop this inventory in order to monitor and control possible increase of invasive species in area coverage in Botswana. This will reduce threats to the biological diversity.

Table 6.4: Estimated Coverage in Areas (Hectares) Affected by Prosopis (Sexanana) Invasive Species by District, 2009 – 2016

District	Location	Area (ha)							
		2009	2010	2011	2012	2013	2014	2015	2016
Ghanzi	Ghanzi	1 095	1 095	1 095	1 095	1 095	1 095	1 095	1 095
Kgalagadi	Sturisendum, Tshane, Bokspits, Vaalhoek, lokgwabe, Werda, Rapplespan,Lehututu, Khuis, Gakhibana,Welwerdiened,Hukuntsi	4 018	4 018	4 018	4 018	4 018	4 018	4 018	4 018
Southern	Mabule, Tshidilamolomo	41	41	41	41	41	41	41	41

Source: Department of Forestry & Range Resources

The Department of Forestry and Range Resources reports a total of eight threatened plant species as at end of 2016 (Table 6.5).

Table 6.5: Threatened Plant Species in Botswana, 2000 - 2016

No.	Species	Local Name
1	Adenium boehianum	n/a
2	Adenium oleifolium	Mooka
3	Hoodia lugardi	n/a
4	Huernia levyi	n/a
5	Orbea tapscottii	n/a
6	Orbea knobelii	n/a
7	Euphorbia venteri	n/a
8	Aloe spp.	Mekgwapha

Source: Department of Forestry & Range Resources
n/a - No Setswana name for the collective group

7.0 WILDLIFE STATISTICS

The purpose of this chapter is to provide and discuss reliable statistics and trends on fauna (animal life), predominantly mammals and birds. It does that by presenting the incidences of poaching, mortality, problem animal control incidences, and fish statistics up to the year 2016, where possible. The inclusion of these selected indicators was informed by data availability. Some of the indicators of importance to environment statistics not included due to data unavailability include, among others, hunting license and quotas, population estimates and densities, and animal biomass.

As this country's attractive natural resources, wildlife serves as a cornerstone of Botswana's tourism industry and source of rural livelihoods support. The government is therefore committed to conserving and protecting these resources. The commitments are shown through many initiatives including, among others: i) passing of the 2007 Community Based Natural Resource Management, ii) conserving and protecting 17 percent of the total land area for wildlife management, iii) establishing both the Anti-poaching Unit and Research and Statistics Office under the Department of Wildlife and National Parks, iv) introducing hunting quotas to regulate hunting of wild animals. The Government of Botswana tasked both the Department of Wildlife and National Parks (DWNP) through the Anti-Poaching Unit and the Botswana Defence Force (BDF) with the responsibility of fighting and controlling poaching.

In spite of the afore-mentioned efforts by the government in conserving the natural resources base, wildlife still face pressure from humans. People continue to poach or illegally kill wildlife as an alternative source of food, and benefit from the sale of ivory. This had led to high mortality incidences. Therefore documentation of wildlife statistics comes in handy, particularly for purposes of monitoring and evaluation in order to inform policies and programmes aimed at environmental conservation.

7.1 Poaching

Poaching is killing of wildlife without a hunting license, as well as killing outside regulated hunting season. These activities are illegal and are not tolerated by local and international law. Poaching contributes to biodiversity loss, shown by a reduction in numbers of some wildlife species. According to Kajevu and Disang (2013) the most problematic poaching in Botswana is commercial poaching because of its unsustainable nature. Elephants are mostly at the receiving end.

The purpose of this section is to present levels and trends of national poaching incidences by species for the period 2010 to 2015, as well as the poaching incidences for the 2010 to 2013 by district and species (refer to the Appendix I since these tables were produced in the Environment Statistics Report 2014). Some data for the poaching incidences by species and district for the period 2014 to 2016 are missing.

7.1.1 Poaching Incidences

Incidences of poaching at both national and district levels in the period 2009 to 2015 are presented in Table 7.1 and Figure 7.1.

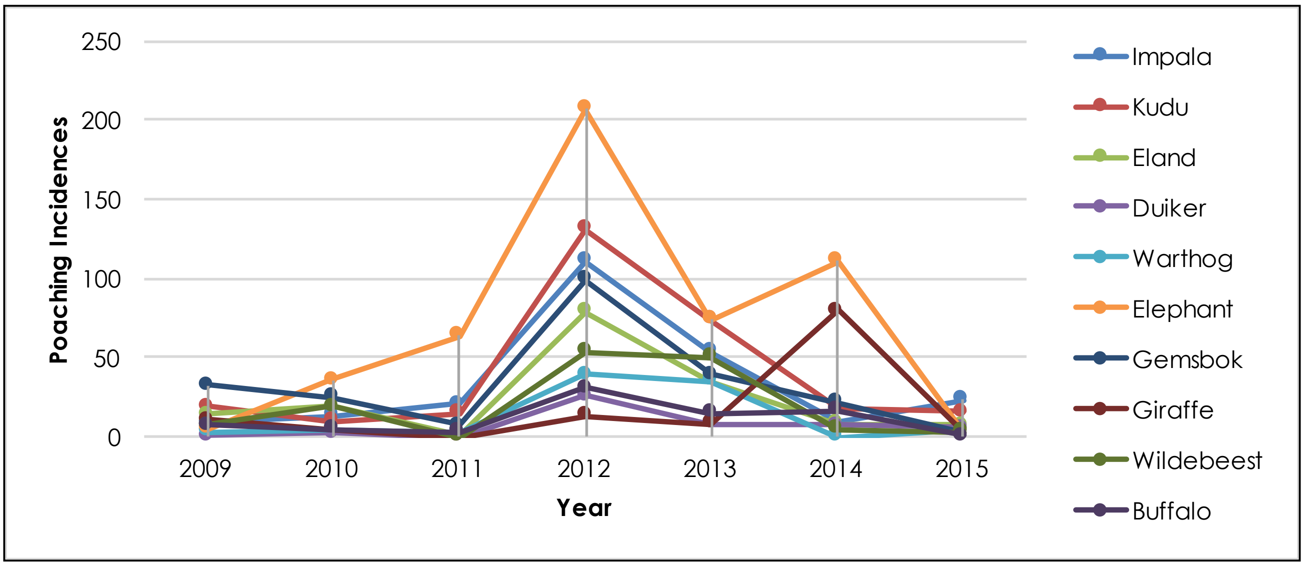
The Countrywide poaching incidences reveals that over the review period elephant (20.0 percent), kudu (10.9 percent), impala (9.3 percent) and gemsbok (8.8 percent) incurred the highest number of poaching incidences in their descending order. Poaching incidences for all species followed an erratic trend during the period 2009 to 2015, with the highest incidences reported in 2012, 2013, and 2014, in that order. (Table 7.1 and Figure 7.1)

Table 7.1: National Poaching Statistics (2009 - 2015)

Species	2009	2010	2011	2012	2013	2014	2015
Impala	9	13	21	111	54	9	23
Kudu	19	10	15	131	74	18	16
Guinea Fowl	0	0	0	0	0	1	13
Eland	14	19	1	79	35	8	7
Duiker	1	2	0	26	8	7	6
Civet	0	0	0	0	0	18	4
Python	1	1	0	2	8	12	4
Warthog	3	5	3	39	35	0	4
Aardwolf	0	0	0	0	0	0	3
Elephant	0	36	64	207	74	111	3
Gemsbok	33	25	7	99	39	22	3
Genet	0	0	0	0	0	11	3
Giraffe	11	5	0	13	8	80	3
Wildebeest	7	19	0	54	50	5	3
Hartebeest	13	4	0	27	12	3	2
Lion	4	0	0	7	8	4	2
Aardvark	0	0	0	0	0	0	1
Buffalo	7	5	3	31	15	17	1
Kori Bastard	0	0	0	0	1	0	1
Leopard	3	0	1	20	20	0	1
Porcupine	0	0	0	0	0	0	1
Roan	0	0	0	0	0	1	1
Steenbok	3	6	0	14	1	0	1
Ant Bear	0	0	0	0	0	2	0
Bat Eared Fox	3	0	0	2	5	0	0
Bat Eared Fox	0	0	0	0	0	1	0
Black-Backed Jackal	0	6	0	1	1	0	0
Blessbok	0	0	0	10	18	0	0
Brown Hyaena	1	0	2	3	4	0	0
Brown Hyaena	0	0	0	0	0	8	0
Cheetah	21	5	1	4	9	4	0
Crocodile	0	0	0	5	8	26	0
Hedge Hog	0	0	0	0	0	1	0
Hippo	0	1	1	4	6	1	0
Jackal	0	0	0	0	0	2	0
Lechwe	0	4	0	9	2	0	0
Monitor Lizard	0	0	0	0	0	1	0
Ostrich	2	2	2	26	20	3	0
Reedbuck	0	0	0	0	1	0	0
Rock Rabbit	0	0	0	0	0	1	0
Sable	0	0	0	0	0	1	0
Sitatunga	0	0	0	3	2	0	0
Spotted Hyaena	0	0	0	0	0	4	0
Springbok	5	4	0	34	9	2	0
Tsessebe	0	0	1	10	12	0	0
Waterbuck	0	0	0	10	4	0	0
White Rhino	0	0	0	0	1	0	0
Wild Cat	0	0	0	0	0	17	0
Zebra	7	0	1	25	38	8	0
Leopard	3	0	1	7	20	2	0

Source: Department of Wildlife & National Parks

Figure 7.1: National Poaching Statistics of Selected Species (2009 - 2015)



7.2 FISH STATISTICS

This section elicits information on fish capture production (1996 to 2016) and value of gross catch/harvest of fishery (2010 to 2016) in Botswana.

The fishing industry is governed by the Fish Protection Act of 1975 in Botswana. The Act mainly ensures management, conservation and sustainable utilization of fish resources. The problem of over-fishing which leads to biodiversity loss has aroused the need to monitor and document fish resources statistics in order to sustainably reduce food insecurity without depleting the existing resources.

Commercial fishing in Botswana is still at infancy stage, and only practised in Gaborone, Bokaa, Shashe, Letsibogo and Nnywane dams. Otherwise, the majority of fishermen practise traditional fishing. It is mostly practised at aquatic systems, e.g. Chobe River, Okavango Delta, Thamalakane River, and Boteti River, and Limpopo River, among others.

7.2.1 Fish capture production by species in Botswana, 1996-2016

Table 7.2 reveals that fish capture production or volume of fish catches of Bream, Barbel, S/barbel, Tiger fish, Carp, and Labeo followed inconsistent trends over the period 1996 to 2016. On average, Bream species (160,426.36 kilograms) experienced the highest annual catch followed by Barbel and Tiger Fish with 38,805.63 and 4,149.86 kilograms, respectively. On the other hand, the least captured fish species was Carp, averaging a catch of 1,024.82 Kilograms per year. It is also evident from Table 7.2 that the highest total capture production was recorded in 2014/15 with 1,168,169.80 kilograms while the lowest total capture of 45,331.90 kilograms was recorded in 2007/08.

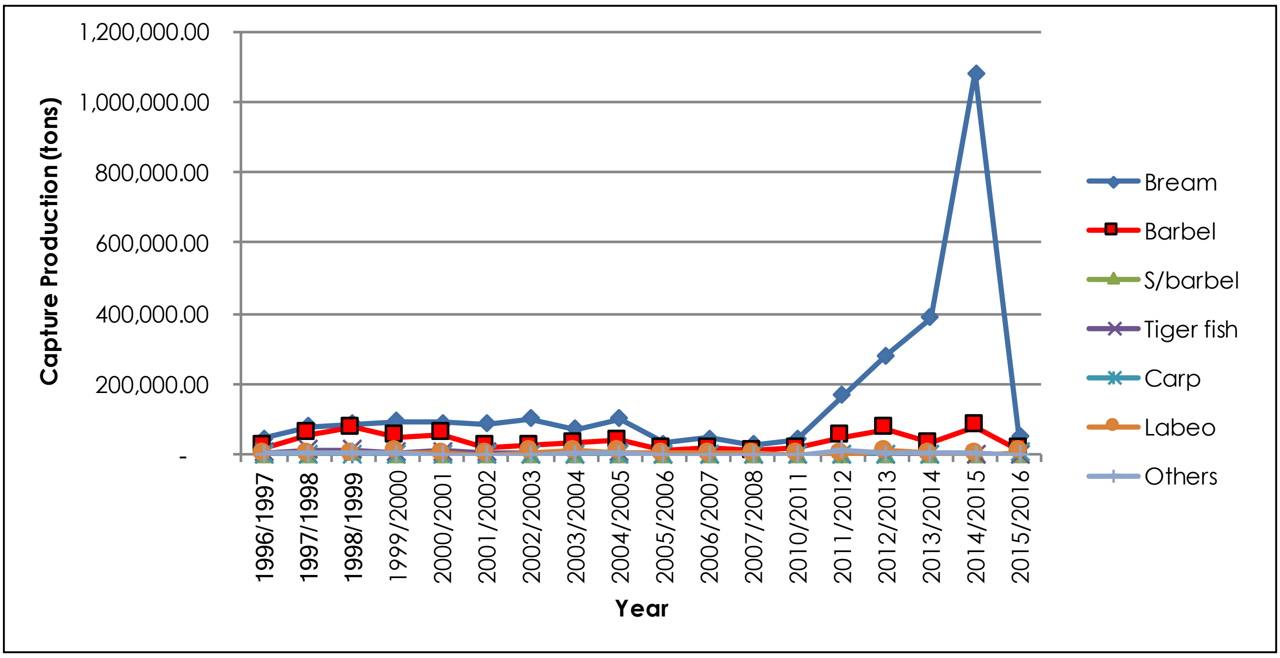
Generally, total fish capture increased slightly from 81,269.30 kilograms in 1996 to 81,391.74 kilograms in 2016 (0.2 percentage increase) though there are high spikes of fish capture in between the years 1996 and 2016 (e.g. during 2014/15). This result does not imply that fish resources are not getting depleted. The reduction in fish capture might be because of the fishing ban at Lake Ngami issued by the Department of Wildlife and National Parks (DWNP) during the period 2015/2016. According to the DWNP most of the fish production is from Lake Ngami.

Table 7.2: Fish capture production by species in Botswana, 1996-2016 (Kilograms)

Year	Bream	Barbel	S/barbel	Tiger fish	Carp	Labeo	Others	Total
1996/1997	47 741.40	22 823.60	1 495.00	5 633.30	96.10	1 438.70	2 041.20	**81 269.30**
1997/1998	80 012.90	59 446.20	2 175.00	12 222.10	274.10	1 866.40	4 357.20	**160 353.90**
1998/1999	88 397.10	75 139.00	5 186.50	12 725.40	74.60	4 518.50	5 724.90	**191 766.00**
1999/2000	92 915.40	50 219.50	1 116.90	5 718.60	-	4 935.20	2 191.30	**157 096.90**
2000/2001	92 067.50	57 001.40	2 209.10	9 378.00	105.00	3 584.60	-	**166 456.50**
2001/2002	87 841.70	21 086.50	1 883.20	5 345.00	18.00	895.50	883.40	**117 953.20**
2002/2003	100 775.36	26 662.70	1 521.30	3 851.60	2.00	5 033.50	757.90	**138 604.36**
2003/2004	72 065.00	33 643.60	1 286.24	4 214.70	-	8 640.90	1 801.50	**121 651.94**
2004/2005	102 288.60	40 302.40	3 835.40	4 824.20	226.90	7 250.00	2 095.90	**160 823.40**
2005/2006	32 596.42	12 843.21	1 222.23	1 537.33	72.31	2 310.37	667.90	**51 249.77**
2006/2007	48 603.68	19 150.18	1 822.44	2 292.28	107.81	3 444.93	995.89	**76 417.20**
2007/2008	28 832.47	11 360.19	1 081.10	1 359.82	63.96	2 043.58	590.78	**45 331.90**
2010/2011	42 731.97	16 442.37	729.40	24.70	-	-	331.60	**60 260.40**
2011/2012	166 200.90	50 758.61	3 986.00	1 305.70	0.04	1.39	12 142.50	**237 803.00**
2012/2013	282 981.25	73 861.30	2 331.56	628.30	4 558.80	11 599.30	1 721.10	**377 681.61**
2013/2014	387 944.40	33 100.00	1 281.90	2 178.00	1 747.40	3 240.90	1 284.40	**430 777.00**
2014/2015	1,081,422.80	80,943.50	725.90	1,363.50	-	503.00	3,211.10	**1,168,169.80**
2015/2016	52,255.65	13,717.09	2,616.90	95.00	7,000.40	5,703.70	3.00	**81,391.74**

Source: Department of Wildlife & National Parks

Figure 7.2: Fish capture production by species in Botswana, 1996-2016 (kilograms)



7.2.2 Value of Gross Catch/Harvest of Fish in Botswana, 2010 – 2016

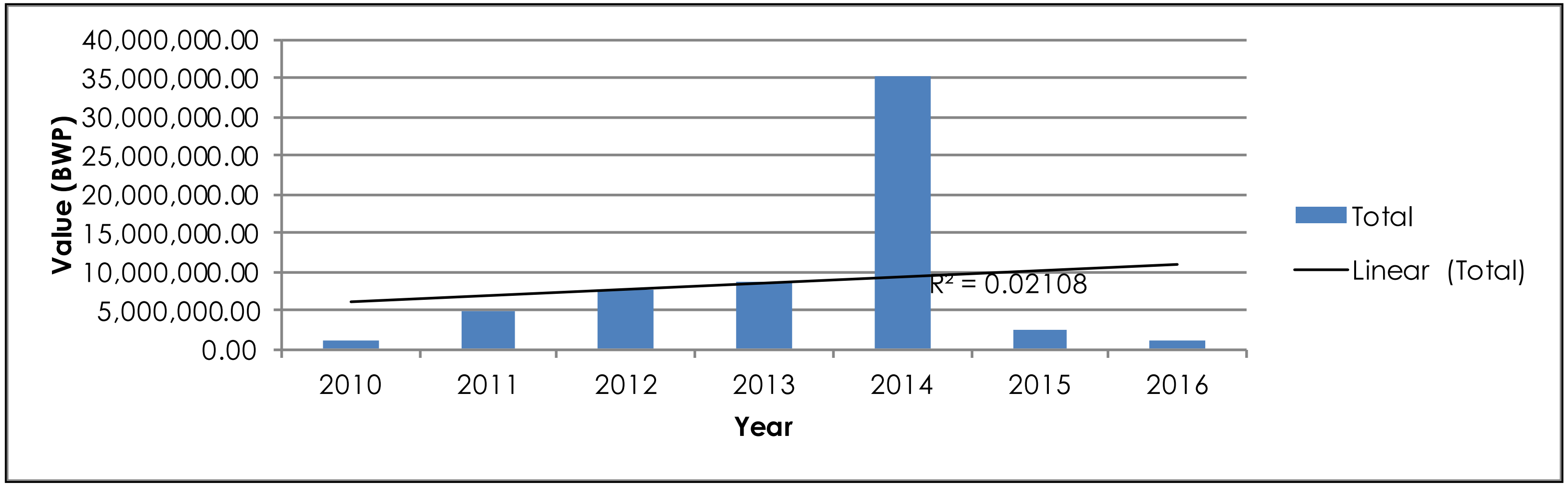
Table 7.3 and Figure 7.3 depict the value of gross catch/harvest of fish in Botswana during the period 2010 to 2013. The value of gross catch can also be referred to as gross income from fishing derived from catching or harvesting, calculated as 1kilogram: 20 BWP for the years 2010 to 2013, while for the years 2014 to 2016 it is calculated as 1kilogram: 40 BWP. The value of gross catch of fish followed an upward trend during the years 2010 to 2014, then saw a significant dip in the years 2015 and 2016. It increased from 1,205,208 BWP in 2014 to 35,045,115 BWP in 2014 (a six fold increase), then dropped in the years 2015 and 2016 with 2,252,750 BWP and 1,110,903 BWP, respectively. The drop in the value of gross catch/harvest experienced in 2015 and 2016 is attributable to the fishing ban at Lake Ngami issued by the Department of Wildlife and National Parks (DWNP) in 2015/2016. It is also evident from the Table 7.3 that the bream species contributed the highest in terms of value of gross catch followed by Barbel and then S/Barbel. The total catch production of fish also followed the same trend evident under the value of gross catch/harvest of fish during this period.

Table 7.3: Value of Gross Catch/Harvest of Fish in Botswana, 2010 – 2016

Species	2010		2011		2012		2013		2014		2015		2016	
	Catch (Tons)	Value (BWP)	Catch (Tons)	Value (BWP)	Catch (Tons)	Value (BWP)	Catch (Tons)	Value (BWP)	Catch (Tons)	Value (BWP)	Catch (Tons)	Value (BWP)	Catch (Tons)	Value (BWP)
Bream	42,731.97	854639.4	166,200.90	3,324,018.00	282,981.25	5,659,625.00	387,944.40	7,758,888.00	1,081,423.00	32,442,690.00	52,255.65	1,567,670.00	34,492.80	1,034,784.00
Barbel	16,442.37	328847.4	50,758.61	1,015,172.20	73,861.30	1 477,226.00	33,100.00	662,000.00	80,953.50	2,428,305.00	13,717.10	411,513.00	1,654.80	49,644.00
S/barbel	729.4	14588	3,986.00	79,720.00	2,331.56	46,631.20	1,281.90	25,638.00	726.00	21,780.00	2,616.90	78,507.00	0.20	6.00
Tiger fish	24.7	494	1,305.70	26,114.00	628.3	12,566.00	2,178.00	43,560.00	1,364.00	40,920.00	95.00	2,850.00	0.80	24.00
Carp	-	0	0.04	0.8	4,558.80	91,176.00	1,747.40	34,948.00	-	-	700.00	21,000.00	310.50	9,315.00
Labeo	-	0	1.39	27.8	11,599.30	231,986.00	3,240.90	64,818.00	503.00	15,090.00	5,704.00	171,120.00	120.40	3,612.00
Others	331.6	6632	12,142.50	242,850.00	1,721.10	34,422.00	1,284.40	25,688.00	3,211.00	96,330.00	3.00	90.00	450.60	13,518.00
Total	**60,260.40**	**1,205,208.00**	**237,803.00**	**4,756,060.00**	**377,681.61**	**7,553,632.20**	**430,777.00**	**8,615,540.00**	**1,168,180.50**	**35,045,115.00**	**75,091.65**	**2,252,750.00**	**37,030.10**	**1,110,903.00**

Source: Department of Wildlife & National Parks
1 Kilogram: 20 BWP from years 2010 – 2013 & 1 Kilogram: 40 BWP from years 2014 – 2016

Figure 7.3: Value of Gross Catch/Harvest of Fish in Botswana, 2010 – 2016



7.3 PROBLEM ANIMAL CONTROL (PAC) INCIDENCES

The problem animal incidences are predominantly caused by the competition between the increasing human populations and wildlife for the same dwindling habitat and other natural resources. Statistics Botswana (2013) asserts that "in pursuance of development, people have expanded agricultural and other activities to marginal areas thus encroaching and fragmenting hitherto wildlife habitats…paths have been opened in areas that were once the preserve of wildlife thus increasing contact between people and wildlife" (p.81). The conflict comes in a form of animals damaging property that belong to the people, and in response the people then kill the animals in an attempt to protect themselves and their property.

The animals involved in these conflicts are termed problem animals and their incidents are recorded to see the trend of the conflict (Statistics Botswana, 2013). The purpose of this section is to present trends of problem animal incidences for the period 2010 to 2014, particularly those attracting compensation. This is because of data gaps for other species not captured.

7.3.1 Trends in Problem Animal Incidences

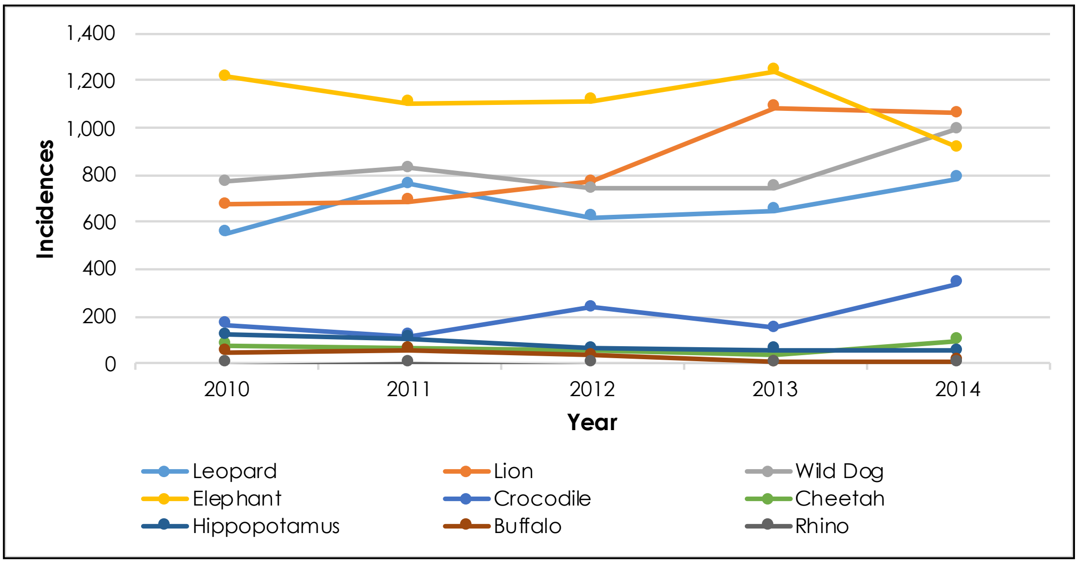
Table 7.4a reveals that the estimated national number of problem animal incidents attracting compensation was highest in the years 2013 and 2014 with 3,964 and 4,254, respectively. They increased by approximately 17.3 percent between 2010 and 2014. The species mostly involved in the incidents during the review period are Elephant, Lion, Wild Dog and Leopard, in that order. (Table 7a and Figure 7.4)

Table 7.4a: National Problem Animal Incidents by Species Attracting Compensation (2010-2014)

Species	2010	2011	2012	2013	2014
Leopard	554	762	619	647	785
Lion	673	689	770	1,085	1,062
Wild Dog	769	826	743	746	991
Elephant	1,217	1,106	1,116	1,238	917
Crocodile	166	118	235	149	341
Cheetah	78	62	53	39	96
Hippopotamus	121	107	60	55	51
Buffalo	48	56	31	5	11
Rhino	0	1	0	0	0
Total	**3,626**	**3,727**	**3,627**	**3,964**	**4,254**

Source: Department of Wildlife & National Parks

Figure 7.4: Estimated Number of Problem Animal Incidents for Selected Species, 2010 – 2014



It is evident from Tables 7.4b to 7.4h that elephant problem incidents were highest compared to all wildlife species during the review period in Ngamiland District. The tables further show that the incidents were either absent or lowest in all other areas outside the elephant range (Kgalagadi, Kgatleng, Kweneng and Southern Districts). Ngamiland District had the highest lion incidences in 2013 compared to other districts. Lion incidences were absent in the Southern District during the review period, except for the year 2011; and they were totally absent in Kgatleng District. Leopard incidents were highest in 2014 in Ngamiland District with a total of 307 incidents. There was only one rhino incident recorded in 2011 in Kgatleng District. On the other hand wild dog incidences were highest in 2013; Ngamiland and Ghanzi Districts constituted the majority of the incidents.

Table 7.4b: Problem Animal Incidents by District (2010-2014) - Chobe

Species	2010	2011	2012	2013	2014
Crocodile	10	60	73	0	170
Lion	92	70	74	29	69
Elephant	30	5	0	120	37
Buffalo	44	54	27	0	9
Leopard	8	17	3	0	8
Wild dog	0	0	1	0	3
Cheetah	8	4	0	0	2
Hippo	3	3	1	3	0
Total	**195**	**213**	**179**	**152**	**298**

Source: Department of Wildlife & National Parks

Table 7.4c: Problem Animal Incidents by District (2010-2014) - Ngamiland

Species	2010	2011	2012	2013	2014
Lion	469	422	569	925	767
Elephant	1,187	1,096	1,114	1,115	706
Wild Dog	341	312	365	451	407
Leopard	151	247	217	291	307
Crocodile	155	57	158	147	170
Hippo	118	102	57	45	45
Cheetah	24	3	4	9	14
Buffalo	4	1	4	5	2
Total	**2,449**	**2,240**	**2,488**	**2,988**	**2,418**

Source: Department of Wildlife & National Parks

Table 7.4d: Problem Animal Incidents by District (2010-2014) – Kweneng

Species	2010	2011	2012	2013	2014
Wild Dog	47	103	64	70	254
Elephant	0	0	0	0	154
Leopard	148	167	107	64	153
Lion	43	91	11	11	85
Cheetah	16	15	5	1	26
Buffalo	0	0	0	0	0
Crocodile	0	0	0	0	0
Hippopotamus	0	0	0	0	0
Total	**254**	**376**	**187**	**146**	**672**

Source: Department of Wildlife & National Parks

Table 7.4e: Problem Animal Incidents by District (2010-2014) - Kgatleng

Species	2010	2011	2012	2013	2014
Leopard	54	62	101	123	65
Wild Dog	2	5	6	12	33
Hippopotamus	0	2	2	7	6
Elephant	0	0	0	0	5
Crocodile	0	1	4	2	1
Buffalo	0	0	0	0	0
Cheetah	0	0	2	0	0
Rhino	0	1	0	0	0
Lion	0	0	0	0	0
Total	**56**	**71**	**115**	**144**	**110**

Source: Department of Wildlife & National Parks

Table 7.4f: Problem Animal Incidents by District (2010-2014) - Southern

Species	2010	2011	2012	2013	2014
Cheetah	1	5	0	0	2
Leopard	2	2	0	1	1
Buffalo	0	1	0	0	0
Crocodile	0	0	0	0	0
Elephant	0	0	0	0	0
Hippopotamus	0	0	0	0	0
Lion	0	1	0	0	0
Wild Dog	3	1	1	4	0
Total	6	10	1	5	3
Total	**6**	**10**	**1**	**5**	**3**

Source: Department of Wildlife & National Parks

Table 7.4g: Problem Animal Incidents by District (2010-2014) - Ghanzi

Species	2010	2011	2012	2013	2014
Wild Dog	279	285	185	121	130
Leopard	89	164	100	80	104
Lion	33	52	28	41	50
Cheetah	15	17	27	22	21
Elephant	0	5	2	3	14
Buffalo	0	0	0	0	0
Crocodile	1	0	0	0	0
Hippopotamus	0	0	0	0	0
Total	**417**	**523**	**342**	**267**	**319**

Source: Department of Wildlife & National Parks

Table 7.4h: Problem Animal Incidents by District (2010-2014) - Kgalagadi

Species	2010	2011	2012	2013	2014
Wild Dog	97	120	121	88	164
Leopard	102	103	91	88	147
Lion	36	53	88	79	91
Cheetah	14	18	15	7	31
Elephant	0	0	0	0	1
Buffalo	0	0	0	0	0
Crocodile	0	0	0	0	0
Hippopotamus	0	0	0	0	0
Total	**249**	**294**	**315**	**262**	**434**

Source: Department of Wildlife & National Parks

7.3.2 Compensation for Problem Animal Incidents

Compensation for problem animal incidents is "paid to people whose property has been damaged by problem animals as a way of reducing consequences of the damage and encouraging tolerance for the animals" (Statistics Botswana, 2013: 83). This compensation is paid for damages caused by nine animals which are considered dangerous to lives of human beings. They include Buffalo, Cheetah, Crocodile, Elephant, Hippopotamus, Lion, Leopard, Rhinoceros and Wild dog.

Table 7.5a depicts only the number of reports due to wild animals attracting compensation from the years 2010 to 2014 and the amount of compensation paid for the damages. It is worth noting that some of the reports did not attract compensation, while others from previous years were paid during the years when funds were available. The table indicates that the largest amount of compensation was paid for damages by Elephant (P9, 334,240.87) followed by Lion (P5, 781,647.50) and Wild Dog (P2, 972,748.20). The highest compensation in the four years under review was paid by Ngamiland District (Appendix II).

Table 7.5a: Summary National Problem Animal Reports & Amount of Compensation (2010-2014)

Species	Number of Reports	Amount Paid Out(BWP)
Elephant	6,154	9,334,240.87
Lion	4,183	5,781,647.50
Wild Dog	3133	2,972,748.20
Leopard	4,223	2,087,415.95
Crocodile	550	414,134.50
Hippo	336	275,261.20
Cheetah	293	159,577.80
Buffalo	15	6,939.90
Rhino	1	157.50
Total	**18,888**	**21,032,123.42**

Source: Department of Wildlife & National Parks

Figure 7.5a: Amount of Compensation (2010-2014)

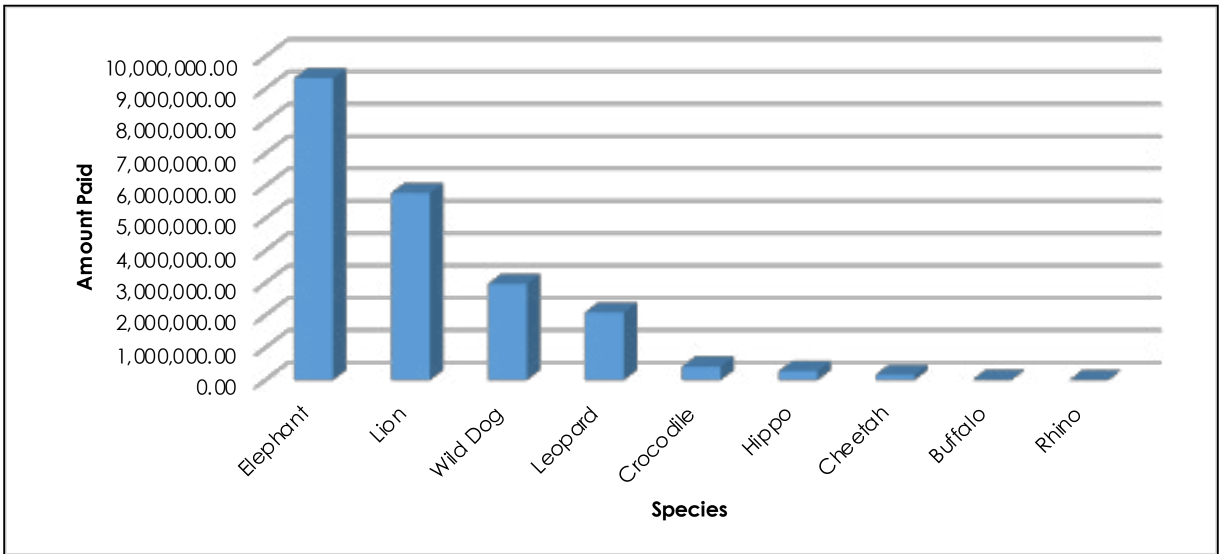


Table 7.5b: National Problem Animal Reports and Amount of Compensation (2010-2014)

Species	2010		2011		2012		2013		2014	
	Number of Reports	Amount Paid Out (BWP)	Number of Reports	Amount Paid Out (BWP)	Number of Reports	Amount Paid Out (BWP)	Number of Reports	Amount Paid Out(BWP)	Number of Reports	Amount Paid Out(BWP)
Lion	619	349,081.75	741	280,248.50	954	1,194,462.50	1,036	1,379,312.10	833	2,578,542.65
Leopard	964	212,877.10	605	624,864.90	821	419,304.50	974	559,736.30	859	270,633.15
Wild dog	630	641,828.50	30	11,515.50	679	754,684.70	932	904,202.50	862	660,517.00
Buffalo	2	-	-	-	1	669.00	10	6,009.60	2	261.30
Elephant	898	873,629.47	1,213	993,122.97	1,517	5,339,841.93	1,373	978,790.35	1,153	1,148,856.15
Cheetah	67	24,485.80	30	11,515.50	64	31,114.50	37	17,360.00	95	75,102.00
Hippo	59	48,851.45	51	39,007.30	76	45,720.75	69	82,959.30	81	58,722.40
Crocodile	104	34,195.00	49	32,957.50	187	194,084.50	105	124,075.00	105	28,822.50
Rhino	-	-	1	157.5	-	-	-	-	-	-
Total	**3,343**	**2,184,949.07**	**2,720**	**1,993,389.67**	**4,299**	**7,979,882.38**	**4,536**	**4,052,445.15**	**3,990**	**4,821,457.15**

Source: Department of Wildlife & National Parks

7.4 MORTALITY

This section presents information on wildlife mortality for the years 2010 to 2014 by species and district in Botswana. Data for the years 2015 and 2016 were not available.

The main causes of wildlife mortality in Botswana are poaching, drought (water shortage and lack of grazing), diseases and natural causes. According to Statistics Botswana (2013) "human-wildlife conflict sometimes results in mortalities of wildlife as farmers protect themselves or when Wildlife Officers control them in a bid to reduce conflict" (p.87).

Table 7.6a indicates national mortality incidences of species that experienced significant levels of mortality during the period 2010 to 2014. Elephant, kudu, leopard, buffalo, and lion, in that order, had the highest mortality incidences.

Table 7.6a further shows that the highest mortality incidences were recorded during the year 2012, followed by mortality incidences experienced in 2011 and 2014 with 566, 536, and 488, respectively.

District differential in wildlife mortality shows that Central, Ngamiland, and Chobe had the highest mortality incidences during the period 2010 to 2014. This might be attributable to the fact that the aforesaid district cover large areas and have higher wildlife population sizes compared to other districts. The opposite is true for other districts like Kgatleng. (Tables 7.6b to 7.6i)

Table 7.6a: National Wildlife Mortality Incidences, 2010 – 2014

Species	2010	2011	2012	2013	2014
Elephants	29	114	202	132	123
Leopard	50	25	38	64	89
Kudu	50	40	98	113	73
Lion	30	39	33	43	35
Impala	12	9	16	9	23
Warthog	7	49	44	24	21
Buffalo	32	96	49	15	20
Steenbok	8	6	14	19	14
Python	9	5	7	9	11
Cape Vulture	0	51	0	0	10
Zebra	3	2	7	4	10
Crocodile	3	27	6	3	9
Wild dog	2	1	5	2	9
Baboon	7	10	12	9	7
Black-backed Jackal	1	0	3	2	7
Cheetah	2	8	3	4	7
Giraffe	2	2	1	2	6
Bushbuck	1	1	1	2	4
Wildebeest	4	0	3	0	4
B/hyena	1	5	3	2	2
Hippo	5	5	3	5	2
Bat eared fox	8	1	0	0	1
Jackal	8	7	1	0	1
Eland	2	1	0	0	0
Gemsbok	0	11	0	0	0
Hartebeest	3	2	1	0	0
Hyena (unknown)	4	1	2	0	0
Puff Adder	4	0	0	0	0
Porcupine	0	15	11	2	0
Snake	3	0	1	0	0
Tsessebe	9	0	0	0	0
Waterbuck	2	3	2	0	0
Total	**301**	**536**	**566**	**465**	**488**

Source: Department of Wildlife & National Parks

Figure 7.6: National Wildlife Mortality Incidences, 2010 – 2014

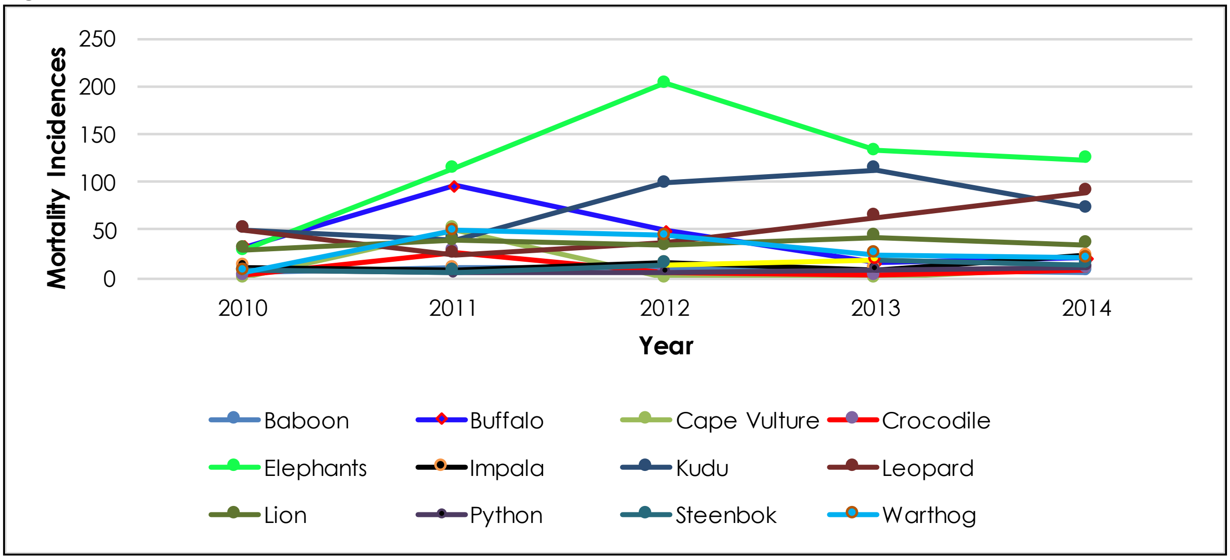


Table 7.6b: Wildlife Mortality Incidents Summary for Kweneng (2010-2014)

Species	2010	2011	2012	2013	2014
Leopard	16	13	0	4	3
Kudu	9	2	2	0	2
Lion	4	2	0	2	1
Python	1	0	1	0	1
Cheetah	1	0	1	0	0
B/Hyaena	0	0	0	0	0
Porcupine	1	0	0	0	0
Warthog	2	0	0	0	0
Gemsbok	0	0	0	0	0
Springbok	0	0	0	2	0
Steenbok	0	0	0	1	0
Wildebeest	1	0	0	0	0
Baboon	1	0	0	0	0
Hartebeest	0	0	0	0	0
Gemsbok	0	0	0	0	0
Total	**36**	**17**	**4**	**9**	**7**

Source: Department of Wildlife & National Parks

Table 7.6c: Wildlife Mortality Summary for Kgalagadi (2010-2014)

Species	2010	2011	2012	2013	2014
Leopard	3	7	7	3	21
Lion	8	10	7	10	10
Wild dog	0	0	0	0	9
Brown hyena	0	1	2	0	1
Hartebeest	1	1	0	0	0
Cheetah	0	3	0	0	0
Bat Eared Fox	8	7	0	0	0
Steenbok	5	0	0	0	0
Kudu	1	1	0	2	0
Kori Bustard	1	0	0	0	0
Jackal	8	0	0	0	0
Ostrich	0	0	0	0	0
Shrub hare	0	1	0	0	0
Gemsbok	0	0	0	0	0
Total	**35**	**31**	**16**	**15**	**41**

Source: Department of Wildlife & National Parks

Table 7.6d: Wildlife Mortality Summary for Kgatleng (2010-2014)

Species	2010	2011	2012	2013	2014
Leopard	5	4	8	4	5
Python	1	3	1	1	3
Kudu	1	7	16	2	1
Bushbuck	0	0	0	0	1
Guinea Fowl	0	0	0	0	0
Black Backed Jackal	1	0	0	0	0
Hyaena- Unknown	1	3	0	1	0
Monkey	1	0	1	0	0
Squirrel	0	0	0	0	0
Impala	2	1	0	0	0
Cheetah	0	0	1	0	0
Giraffe	0	0	1	0	0
Hippo	1	0	0	0	0
Ostrich	0	0	2	0	0
Aardwolf	0	1	0	0	0
Steenbok	0	2	0	0	0
Baboon	0	1	0	0	0
Hartebeest	0	0	0	0	0
Total	**13**	**22**	**30**	**8**	**10**

Source: Department of Wildlife & National Parks

Table 7.6e: Wildlife Mortality Summary for Central (2010-2014)

Species	2010	2011	2012	2013	2014
Eagle	1	0	62	0	47
Genets	0	0	1	0	46
Giraffe	0	1	11	49	40
Gemsbok	0	11	0	0	19
Porcupine	4	13	2	4	18
Springbok	0	45	3	1	12
Buffalo	0	52	5	0	8
Kudu	1	15	7	0	7
Lion	0	2	10	0	7
Wildebeest	0	0	1	0	7
Bushbuck	0	1	6	0	4
Elephant	5	48	0	0	4
Wild cat	0	1	1	5	4
African Civet	0	0	0	0	3
Jackal	1	2	3	11	3
Vulture	0	4	2	6	3
Zebra	0	0	4	4	3
Baboon	2	1	9	0	2
Steenbok	1	1	39	8	2
B/Hyaena	2	4	2	0	1
Eland	1	0	0	0	0
Impala	1	4	45	22	0
Leopard	5	6	5	1	0
Ostrich	2	0	0	0	0
Python	0	2	22	4	0
Warthog	13	46	4	2	0
Total	**39**	**259**	**244**	**117**	**240**

Source: Department of Wildlife & National Parks

Table 7.6f: Wildlife Mortality Summary for Southern (2010-2014)

Species	2010	2011	2012	2013	2014
Kudu	0	4	28	12	15
Cape Vulture	0	51	0	0	10
Jackal	3	5	1	0	5
Warthog	0	0	0	0	4
Leopard	2	2	0	0	2
Bush buck	0	0	0	0	2
Cheetah	1	5	0	0	1
Snake	0	0	1	2	1
Baboon	0	1	12	0	1
Python	0	0	0	0	0
Bat eared fox	2	0	0	0	0
Lion	0	1	0	0	0
Hyena	0	0	0	0	0
Brown hyena	0	1	0	0	0
Steenbok	0	0	0	0	0
Monkey	0	0	0	0	0
Hartebeest	7	1	1	0	0
Leopard	0	0	0	0	0
Python	0	0	2	3	0
Kudu	0	0	0	0	0
Porcupine	1	2	1	0	0
Green mamba	0	0	0	0	0
Monkey	0	0	0	2	0
Wild cat	1	0	0	0	0
wild dog	3	1	1	0	0
Wildebeest	0	0	2	0	0
Ostrich	2	3	5	0	0
Steenbok	0	2	3	1	0
Total	**22**	**79**	**57**	**20**	**41**

Source: Department of Wildlife & National Parks

Table 7.6g: Wildlife Mortality Summary for Ngamiland (2010-2014)

Species	2010	2011	2012	2013	2014
Elephant	11	17	71	95	58
Buffalo	0	16	21	4	9
Leopard	0	0	6	11	4
Lion	0	2	12	4	4
Giraffe	0	0	0	1	2
Hippo	1	5	1	5	2
Zebra	0	0	0	0	2
Ostrich	0	0	1	0	1
Impala	0	4	3	3	1
Steenbok	0	0	7	0	1
Crocodile	0	27	6	3	1
Cheetah	0	0	0	2	0
Kudu	1	1	1	9	0
Black backed Jackal	0	7	0	0	0
Brown hyena	7	0		1	0
Monkey	0	0	3	0	0
Python	3	0	1	0	0
Porcupine	0	0	0	1	0
Eland	0	0	0	0	0
Total	**23**	**79**	**133**	**139**	**85**

Source: Department of Wildlife & National Parks

Table 7.6h: Wildlife Mortality Summary for Ghanzi (2010-2014)

Species	2010	2011	2012	2013	2014
Lion	9	15	7	12	19
Leopard	11	6	13	13	14
Kudu	1	7	5	3	7
Elephant	1	4	3	1	6
Cheetah	3	1	1	2	6
Kori Bastard	0	0	0	0	1
Steenbok	0	0	0	0	1
Wildebeest	0	0		0	1
Black backed Jackal	0	0	3	0	0
Ostrich	0	0	0	1	0
Brown hyena	0	0	1	0	0
Impala	0	0	0	0	0
Duiker	0	1	0	1	0
Warthog	1	0	0	0	0
Gemsbok	0	0	0	0	0
Giraffe	0	0	0	0	0
Total	**26**	**34**	**33**	**33**	**55**

Source: Department of Wildlife & National Parks

Table 7.6i: Wildlife Mortality Summary for Chobe (2010-2014)

Species	2010	2011	2012	2013	2014
Warthog	2	3	5	18	14
Elephant	17	45	66	36	12
Zebra	0	2	3	3	5
Buffalo	30	28	19	11	4
Baboon	4	7	0	7	4
Impala	7	5	2	4	3
Kudu	6	4	1	1	2
Roan	0	0	0	0	1
Sable	1	0	1	1	1
Waterbuck	1	3	2	2	1
Lion	2	8	0	3	1
Bushbuck	0	0	0	2	1
Hippo	4	0	1	0	0
Giraffe	1	1	0	1	0
Eland	0	1	0	0	0
Gemsbok	0	0	0	0	0
Lechwe	0	0	0	0	0
Wildebeest	0	0	0	0	0
Duiker	0	0	0	0	0
Steenbok	0	0	0	5	0
Ostrich	0	0	0	0	0
Total	**75**	**107**	**100**	**94**	**49**

Source: Department of Wildlife & National Parks

APPENDIX I

Table AI 1: Poaching Statistics – Chobe (2009-2013)

Species	2009	2010	2011	2012	2013
Buffalo	2	1	0	6	3
Duiker	0	0	1	5	0
Eland	1	0	1	6	1
Elephant	22	25	54	163	4
Impala	0	0	2	16	5
Jackal	0	1	0	2	0
Crocodile	0	0	0	3	4
Kudu	0	0	2	12	6
Lion	0	0	0	2	3
Sable	0	0	0	2	0
Steenbok	0	0	2	3	0
Tsessebe	0	0	1	5	3
Warthog	0	1	0	9	5
Waterbuck	0	0	0	3	0
Zebra	0	0	0	3	3

Source: Department of Wildlife & National Parks

Table AI 2: Poaching Statistics - Ghanzi (2009-2013)

Species	2009	2010	2011	2012	2013
Eland	2	3	0	12	15
Kudu	1	0	0	18	11
Gemsbok	6	2	0	32	16
Warthog	0	2	0	9	3
Porcupine	0	1	1	4	1
Impala	2	1	0	9	3
Wildebeest	4	17	21	12	14
Ostrich	0	0	0	17	15

Source: Department of Wildlife & National Parks

Table AI 3: Poaching Statistics - Kgalagadi (2009 - 2013)

Species	2009	2010	2011	2012	2013
Gemsbok	13	22	5	47	17
Caracal	1	1	0	2	1
Cheetah	3	5	0	4	4
Civet	0	0	0	0	1
Duiker	0	0	0	6	2
Eland	0	0	0	35	8
Hartebeest	3	4	1	7	6
Steenbok	3	4	0	6	1
Springbok	5	3	0	32	6
Kudu	0	0	0	38	9
Ostrich	2	2	0	9	3
Eland	8	15	0	31	40
Jackal (Black Backed)	0	6	0	1	1
Wildebeest	0	0	0	10	23
Lion	4	0	0	4	2
Genet	1	0	0	0	1
Bat Eared Fox	3	0	0	2	5
Blessbok	0	0	0	10	8
Honey burger	0	0	0	0	2
Impala	0	0	0	12	20
Kori Bustard	0	0	0	0	1
Zebra	0	0	0	2	3
Pole cat	0	0	0	0	1
leopard	0	0	0	3	0

Source: Department of Wildlife & National Parks

Table AI 4: Poaching Statistics - Kgatleng (2009-2013)

Species	2009	2010	2011	2012	2013
Brown Hyaena	0	0	1	3	2
Kudu	0	6	5	22	7
Steenbok	0	2	0	5	0
Warthog	0	0	3	7	4
Duiker	1	2	0	9	1
Wildebeest	0	1	0	13	5
Impala	4	10	16	23	4
Blue Hartebeest	0	0	1	8	0
Leopard	0	0	1	4	1

Source: Department of Wildlife & National Parks

Table AI 5: Poaching Statistics - Kweneng (2009-2013)

Species	2009	2010	2011	2012	2013
Leopard	3	0	0	5	4
Eland	0	1	0	8	3
Kudu	1	3	1	15	8
Python	1	0	0	2	1
Gemsbok	3	0	0	7	3
Warthog	0	2	0	9	4
Hartebeest	6	0	0	13	6
Impala	0	0	0	13	7

Source: Department of Wildlife & National Parks

Table AI 6: Poaching Statistics – Ngamiland (2009-2013)

Species	2009	2010	2011	2012	2013
Bush Buck	0	1	0	5	2
Buffalo	5	4	3	11	5
Eland	1	0	0	8	4
Elephant	9	11	10	19	31
Gemsbok	1	0	1	3	0
Giraffe	4	5	0	6	2
Hyaena	0	0	0	1	1
Hippo	0	1	1	4	6
Impala	3	2	3	19	5
Kudu	2	1	3	11	7
Lechwe	0	4	0	9	2
Leopard	0	0	0	5	5
Lizard	0	0	0	0	0
Python	1	0	0	0	3
Puff Adder	0	0	0	3	1
Reedbuck	0	0	0	0	1
Rhino	0	0	0	0	1
Sitatunga	0	0	0	3	2
Springbok	0	0	0	2	3
Warthog	0	0	0	2	6
Waterbuck	0	0	0	6	3
Wildebeest	3	1	0	19	8
Zebra	3	0	1	10	6

Source: Department of Wildlife & National Parks

Table AI 7: Poaching Statistics - Southern (2009, 2010, 2011 & 2013)

Species	2009	2010	2011	2013
Leopard	0	0	0	6
Cheetah	2	0	1	5
Kudu	0	0	4	11
B/hyena	1	0	1	0
Python	0	1	0	4
Gemsbok	0	1	1	0
Warthog	0	0	0	5
Duiker	0	0	0	2
Springbok	0	1	0	0
Turtle	0	1	0	0
Pangolin	0	0	0	2
Aardwolf	0	0	0	1
Civet	0	0	0	1
Spotted Genet	0	0	0	1
Silver Fox	0	0	0	1
Ostrich	0	0	2	2

Source: Department of Wildlife & National Parks

Table AI 8: Poaching Statistics – Central (2012-2013)

Species	2012	2013
Buffalo	14	7
Duiker	6	5
Eland	10	4
Elephant	25	11
Gemsbok	10	3
Impala	21	10
Jackal	1	2
Crocodile	2	4
Kudu	15	15
Lion	1	3
Ant bear	1	4
Steenbok	3	2
Tsessebe	5	9
Warthog	3	8
Waterbuck	1	1
Zebra	10	6
Brown hyena	0	2
Giraffe	7	6

Source: Department of Wildlife & National Parks

APPENDIX II

Table AII 1: Number of PAC Incidents & Compensation by Species & District, 2010

Species	Ghanzi		Kgalagadi		Ngamiland		Kweneng		Kgatleng		Central		Chobe	
	Number of Reports	Amount Paid Out (BWP)	Number of Reports	Amount Paid Out(BWP)	Number of Reports	Amount Paid Out (BWP)	Number of Reports	Amount Paid Out(BWP)	Number of Reports	Amount Paid Out(BWP)	Number of Reports	Amount Paid Out(BWP)	Number of Reports	Amount Paid Out(BWP)
Lion	31.00	29 890.00	36.00	28437.00	374.00	161482.25	63.00	57855.00	0.00	0.00	101.00	47477.50	14.00	23940.00
Leopard	55	20 002.5	102.00	36,172.50	129	48,873.50	125	47,547.50	43	16,730.50	509	43,200.60	1	350
Wild dog	220	204 002.00	97	28,437	217	317,635.00	51	42,560	1	350	44	48,844.50	0	0
Buffalo	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0	0.00		0.00	0	0.00
Elephant	0.00	0.00	0.00	0.00	821.00	581,449.95	0.00	0.00	0	0.00	33	236,319.15	44	55,860.37
Cheetah	10.00	4,098.30	14.00	4,270	18.00	7,927.50	23.00	8,032.50	0	0.00	2	157.50	0	0.00
Hippo	0.00	0.00	0.00	0.00	57.00	48,700.45	0.00	0.00	0	0.00	0.00	0.00	2	151.00
Crocodile	0.00	0.00	0.00	0.00	104.00	34,195.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00
Rhino	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00
Total	**316**	**257,992.50**	**249**	**97,316.50**	**1722**	**1,200,263.65**	**262**	**155995**	**44**	**17,080.50**	**689**	**375,999.25**	**61**	**80,301.37**

Note: No data was available for Southern

Table AII 2: Number of PAC Incidents & Compensation by Species & District, 2011

Species	Ghanzi		Kgalagadi		Ngamiland		Kweneng		Kgatleng		Central		Chobe	
	Number of Reports	Amount Paid Out (BWP)	Number of Reports	Amount Paid Out(BWP)	Number of Reports	Amount Paid Out (BWP)	Number of Reports	Amount Paid Out(BWP)	Number of Reports	Amount Paid Out(BWP)	Number of Reports	Amount Paid Out(BWP)	Number of Reports	Amount Paid Out(BWP)
Leopard	66	27,965.00	103.00	40,862.50	177	68,282.00	93	45,982.00	41	15,137.50	260	81,669.50	1	350.00
Wild dog	111.00	108,082.50	120	101692.5	260	291,397.40	39.00	36,050.00	2	1,400.00	73	86,242.50	0	0.00
Cheetah	6.00	1,994.00	16.00	5,337.50	6	3,046.50	2.00	1,137.50	0	0.00	0	0.00	0	0.00
Lion	49.00	45,060.00	53.00	40,530.00	379	423,265.00	41.00	54,895.00	0	0.00	214	239,049.50	53	69,230.00
Buffalo	0.00	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0	0.00	0	0.00
Elephant	0.00	0.00	0.00	0.00	903	496,678.87	0.00	0.00	0	0.00	243	454,580.85	67	41,863.25
Hippo	0.00	0.00	0.00	0.00	26	31,691.70	0.00	0.00	1	1,192.00	0.00	0.00	24	6,123.60
Crocodile	0.00	0.00	0.00	0.00	49	32,957.50	0.00	0.00	0	0.00	0.00	0.00	0	0.00
Rhino	0.00	0.00	0.00	0.00	0	0.00	0.00	0.00	1	157.50	0.00	0.00	0	0.00
Total	**232**	**183,101.50**	**292**	**188,422.50**	**1800**	**1,347,318.97**	**175**	**138064**	**45**	**17,887.00**	**790**	**861,542.35**	**145**	**117,566.85**

Note: No data was available for Southern

Table AII 3: Number of PAC Incidents & Compensation by Species & District, 2012

Species	Ghanzi		Kgalagadi		Ngamiland		Kweneng		Kgatleng		Central		Chobe	
	Number of Reports	Amount Paid Out (BWP)	Number of Reports	Amount Paid Out(BWP)	Number of Reports	Amount Paid Out (BWP)	Number of Reports	Amount Paid Out(BWP)	Number of Reports	Amount Paid Out(BWP)	Number of Reports	Amount Paid Out(BWP)	Number of Reports	Amount Paid Out(BWP)
Lion	17	11,900.00	88	116,655.00	454	571,162.50	46	15,470.00	0	0.00	302	423,015.00	47	56,260.00
Wild dog	66	49,314.50	121	107800	309	394,591.00	94.00	96,355.00	5	3,850.00	84	102,774.20	0	0.00
Cheetah	13	7,542.50	15	11,917.50	10	5,355.00	15.00	5,284.50	2	315.00	9	700.00	0	0.00
Crocodile	0	0.00	0	0.00	185	193,577.00	0.00	0.00	2	507.50	0	0.00	0	0.00
Buffalo	0	0.00	0	0.00	0	0.00	0.00	0.00	0	0.00	0	0.00	1	669.00
Elephant	0	0.00	0	0.00	935	4,919,049.30	0.00	0.00	0	0.00	483	342,208.45	99	78,584.18
Hippo	0	0.00	0	0.00	49	28,939.45	0.00	0.00	2	2,448.80	0	0.00	25	14,332.50
Leopard	14	13,822.50	91	37,152.50	178	76,475.50	142.00	55,858.00	80	31,130.00	312	203,852.00	4	1,014.00
Rhino	0	0.00	0	0.00	0	P0.00	0.00	0.00	0	0.00	0	0.00	0	0.00
Total	**110**	**82,579.50**	**315**	**273,525.00**	**2120**	**6,189,149.75**	**297**	**172968**	**91**	**38,251.30**	**1190**	**1,072,549.65**	**176**	**150,859.68**

Note: No data was available for Southern

Table AII 4: Number of PAC Incidents & Compensation by Species & District, 2013

Species	Ghanzi		Kgalagadi		Ngamiland		Kweneng		Kgatleng		Central		Chobe	
	Number of Reports	Amount Paid Out (BWP)	Number of Reports	Amount Paid Out(BWP)	Number of Reports	Amount Paid Out (BWP)	Number of Reports	Amount Paid Out(BWP)	Number of Reports	Amount Paid Out(BWP)	Number of Reports	Amount Paid Out(BWP)	Number of Reports	Amount Paid Out(BWP)
leopard	46	27,337.50	88	110,827.50	273	159,802.50	99	47,459.00	70	23,095.50	385	183,146.00	13	8,068.30
Wild dog	68	75,412.00	88	47,250.00	357	364,305.00	133.00	133,243.00	5	3,150.00	281	280,842.50	0	0.00
Cheetah	9	4,217.50	7	3,622.50	9	3 377.50	6.00	3,867.50	0	0.00	6	2,275.00	0	0.00
crocodile	0	0.00	0	0.00	104	123,025.00	0.00	0.00	0	0.00	0	0.00	1	1,050.00
Buffalo	0	0.00	0	0.00	1	112.10	0.00	0.00	0	0.00	0	0.00	9	5,897.50
Elephant	0	0.00	0	0.00	956	740,908.84	1.00	314.00	0	0.00	333	164,365.10	83	73,202.41
Hippo	0	0.00	0	0.00	55	78,309.85	0.00	0.00	2	544.50	0	0.00	12	4,104.95
Lion	18	13,107.50	79	107,852.50	687	956,694.00	11.00	13,895.00	0	0.00	188	211,813.10	53	75,950.00
Rhino	0	0.00	0	0.00	0	0.00	0.00	0.00	0	0.00	0	0.00	0	0.00
Total	**141**	**120,074.50**	**262**	**269,552.50**	**2442**	**2,423,045.19**	**250**	**198778**	**77**	**26,790.00**	**1193**	**842,441.70**	**171**	**168,273.16**

Note: No data was available for Southern

Table AII 5: Number of PAC Incidents & Compensation by Species & District, 2014

Species	Ghanzi		Kgalagadi		Ngamiland		Kweneng		Kgatleng		Central		Chobe	
	Number of Reports	Amount Paid Out (BWP)	Number of Reports	Amount Paid Out(BWP)	Number of Reports	Amount Paid Out (BWP)	Number of Reports	Amount Paid Out(BWP)	Number of Reports	Amount Paid Out(BWP)	Number of Reports	Amount Paid Out(BWP)	Number of Reports	Amount Paid Out(BWP)
leopard	115	15,892.00	147	52,517.50	129	41,392.90	46	16835	30	14,262.50	384	125,311.75	8	4,421.50
Wild dog	134	42,535.00	164	125,510.00	198	153,329.50	99.00	92,197.50	17	17,675.50	250	229,269.50	0	0.00
Cheetah	32	51,250.00	31	10,325.00	3	1,732.50	18.00	9,712.00	0	0.00	11	2,082.50	0	0.00
crocodile	0	0.00	0	0.00	103	27,615.00	0.00	0.00	1	157.50	0	0.00	1	1,050.00
Buffalo	0	0.00	0	0.00	1	261.30	0.00	0.00	0	0.00	0	0.00	1	0.00
Elephant	0	0.00	0	0.00	497	452,504.20	86.00	91,680.50	1	442.30	435	365,151.35	134	239,077.80
Hippo	0	0.00	0	0.00	36	32,153.60	0.00	0.00	3	8,118.95	0	0.00	42	18,449.85
Lion	58	47,300.00	91	216,065.00	354	1,598,473.20	23.00	81,400.00	0	0.00	193	431,804.45	114	203,500.00
Rhino	0	0.00	0	0.00	0	P0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00
Total	**339**	**156,977.00**	**433**	**404,417.50**	**1321**	**2,307,200.90**	**272**	**291825**	**52**	**40,656.75**	**1,273.00**	**1,153,619.55**	**300**	**466,499.15**

Note: No data was available for Southern

APPENDIX II

Table AIII 1: Oceanic Nino Index

Season	JJA	JAS	ASO	SON	OND	NDJ	DJF	JFM	FMA	MAM	AMJ	MJJ
1950/51	-0.6	-0.6	-0.5	-0.6	-0.7	-0.8	-0.8	-0.6	-0.2	0.2	0.2	0.4
1951/52	0.5	0.7	0.8	0.9	0.7	0.6	0.5	0.4	0.4	0.4	0.4	0.2
1952/53	0	0.1	0.2	0.2	0.2	0.3	0.5	0.6	0.7	0.7	0.7	0.7
1953/54	0.7	0.7	0.8	0.8	0.8	0.7	0.7	0.4	0	-0.4	-0.5	-0.5
1954/55	-0.5	-0.7	-0.7	-0.6	-0.5	-0.5	-0.6	-0.6	-0.7	-0.7	-0.7	-0.6
1955/56	-0.6	-0.6	-1	-1.4	-1.6	-1.4	-0.9	-0.6	-0.6	-0.5	-0.5	-0.4
1956/57	-0.5	-0.5	-0.4	-0.4	-0.5	-0.4	-0.3	0	0.3	0.6	0.7	0.9
1957/58	1	1.2	1.1	1.2	1.3	1.6	1.7	1.5	1.2	0.8	0.7	0.6
1958/59	0.5	0.4	0.4	0.5	0.6	0.6	0.6	0.5	0.4	0.2	0.1	-0.2
1959/60	-0.3	-0.3	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.1	0	-0.1	-0.2
1960/61	0	0.1	0.2	0.1	0	0	0	0	-0.1	0	0.1	0.2
1961/62	0.1	-0.1	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.2
1962/63	-0.1	-0.2	-0.2	-0.3	-0.3	-0.4	-0.4	-0.2	0.1	0.2	0.2	0.4
1963/64	0.7	1	1.1	1.2	1.2	1.1	1	0.6	0.1	-0.3	-0.6	-0.6
1964/65	-0.7	-0.7	-0.8	-0.8	-0.8	-0.8	-0.5	-0.3	-0.1	0.1	0.4	0.7
1965/66	1	1.3	1.6	1.7	1.8	1.5	1.3	1	0.9	0.6	0.3	0.2
1966/67	0.2	0.1	0	-0.1	-0.1	-0.3	-0.4	-0.5	-0.5	-0.5	-0.2	0
1967/68	0	-0.2	-0.3	-0.4	-0.4	-0.5	-0.7	-0.8	-0.7	-0.5	-0.1	0.2
1968/69	0.5	0.4	0.3	0.4	0.6	0.8	0.9	1	0.9	0.7	0.6	0.5
1969/70	0.4	0.5	0.8	0.8	0.8	0.7	0.6	0.4	0.4	0.3	0.1	-0.3
1970/71	-0.6	-0.8	-0.8	-0.8	-0.9	-1.2	-1.3	-1.3	-1.1	-0.9	-0.8	-0.7
1971/72	-0.8	-0.7	-0.8	-0.8	-0.9	-0.8	-0.7	-0.4	0	0.3	0.6	0.8
1972/73	1.1	1.3	1.5	1.8	2	1.9	1.7	1.2	0.6	0	-0.4	-0.8
1973/74	-1	-1.2	-1.4	-1.7	-1.9	-1.9	-1.7	-1.5	-1.2	-1	-0.9	-0.8
1974/75	-0.6	-0.4	-0.4	-0.6	-0.7	-0.6	-0.5	-0.5	-0.6	-0.6	-0.7	-0.8
1975/76	-1	-1.1	-1.3	-1.4	-1.5	-1.6	-1.5	-1.1	-0.7	-0.4	-0.3	-0.1
1976/77	0.1	0.3	0.5	0.7	0.8	0.8	0.7	0.6	0.4	0.3	0.3	0.4
1977/78	0.4	0.4	0.5	0.6	0.8	0.8	0.7	0.4	0.1	-0.2	-0.3	-0.3
1978/79	-0.4	-0.4	-0.4	-0.3	-0.1	0	0	0.1	0.2	0.3	0.3	0.1
1979/80	0.1	0.2	0.3	0.5	0.5	0.6	0.6	0.5	0.3	0.4	0.5	0.5
1980/81	0.3	0.2	0	0.1	0.1	0	-0.2	-0.4	-0.4	-0.3	-0.2	-0.3
1981/82	-0.3	-0.3	-0.2	-0.1	-0.1	0	0	0.1	0.2	0.5	0.6	0.7
1982/83	0.8	1	1.5	1.9	2.1	2.1	2.1	1.8	1.5	1.2	1	0.7
1983/84	0.3	0	-0.3	-0.6	-0.8	-0.8	-0.5	-0.3	-0.3	-0.4	-0.4	-0.4
1984/85	-0.3	-0.2	-0.3	-0.6	-0.9	-1.1	-0.9	-0.7	-0.7	-0.7	-0.7	-0.6
1985/86	-0.4	-0.4	-0.4	-0.3	-0.2	-0.3	-0.4	-0.4	-0.3	-0.2	-0.1	0
1986/87	0.2	0.4	0.7	0.9	1	1.1	1.1	1.2	1.1	1	0.9	1.1
1987/88	1.4	1.6	1.6	1.4	1.2	1.1	0.8	0.5	0.1	-0.3	-0.8	-1.2
1988/89	-1.2	-1.1	-1.2	-1.4	-1.7	-1.8	-1.6	-1.4	-1.1	-0.9	-0.6	-0.4
1989/90	-0.3	-0.3	-0.3	-0.3	-0.2	-0.1	0.1	0.2	0.2	0.2	0.2	0.3
1990/91	0.3	0.3	0.4	0.3	0.4	0.4	0.4	0.3	0.2	0.2	0.4	0.6
1991/92	0.7	0.7	0.7	0.8	1.2	1.4	1.6	1.5	1.4	1.2	1	0.8
1992/93	0.5	0.2	0	-0.1	-0.1	0	0.2	0.3	0.5	0.7	0.8	0.6
1993/94	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.2	0.3	0.4	0.4
1994/95	0.4	0.4	0.4	0.6	0.9	1	0.9	0.7	0.5	0.3	0.2	0
1995/96	-0.2	-0.5	-0.7	-0.9	-1	-0.9	-0.9	-0.7	-0.6	-0.4	-0.2	-0.2
1996/97	-0.2	-0.3	-0.3	-0.4	-0.4	-0.5	-0.5	-0.4	-0.2	0.1	0.6	1
1997/98	1.4	1.7	2	2.2	2.3	2.3	2.1	1.8	1.4	1	0.5	-0.1
1998/99	-0.7	-1	-1.2	-1.2	-1.3	-1.4	-1.4	-1.2	-1	-0.9	-0.9	-1
1999/2000	-1	-1	-1.1	-1.2	-1.4	-1.6	-1.6	-1.4	-1.1	-0.9	-0.7	-0.7
2000/01	-0.6	-0.5	-0.6	-0.7	-0.8	-0.8	-0.7	-0.6	-0.5	-0.3	-0.2	-0.1
2001/02	0	-0.1	-0.1	-0.2	-0.3	-0.3	-0.2	-0.1	0.1	0.2	0.4	0.7
2002/03	0.8	0.9	1	1.2	1.3	1.1	0.9	0.6	0.4	0	-0.2	-0.1

Table AIII 1 Cont: Oceanic Nino Index

Season	JJA	JAS	ASO	SON	OND	NDJ	DJF	JFM	FMA	MAM	AMJ	MJJ
2003/04	0.1	0.2	0.3	0.4	0.4	0.4	0.3	0.2	0.1	0.1	0.2	0.3
2004/05	0.5	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.5	0.5	0.4	0.2
2005/06	0.1	0	0	-0.1	-0.4	-0.7	-0.7	-0.6	-0.4	-0.2	0	0.1
2006/07	0.2	0.3	0.5	0.8	0.9	1	0.7	0.3	0	-0.1	-0.2	-0.2
2007/08	-0.3	-0.6	-0.8	-1.1	-1.2	-1.3	-1.4	-1.3	-1.1	-0.9	-0.7	-0.5
2008/09	-0.3	-0.2	-0.2	-0.3	-0.5	-0.7	-0.8	-0.7	-0.4	-0.1	0.2	0.4
2009/10	0.5	0.6	0.7	1	1.2	1.3	1.3	1.1	0.8	0.5	0	-0.4
2010/11	-0.8	-1.1	-1.3	-1.4	-1.3	-1.4	-1.3	-1.1	-0.8	-0.6	-0.3	-0.2
2011/12	-0.3	-0.5	-0.7	-0.9	-0.9	-0.8	-0.7	-0.6	-0.5	-0.4	-0.3	-0.1
2012/13	0.1	0.3	0.4	0.4	0.2	-0.2	-0.4	-0.5	-0.3	-0.2	-0.2	-0.2
2013/14	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.5	-0.6	-0.4	-0.2	0	0
2014/15	0	0	0.2	0.4	0.6	0.6	0.5	0.4	0.5	0.7	0.9	1
2015/16	1.2	1.4	1.7	2	2.2	2.3	2.2	1.9	1.6	1.1	0.6	0.1
2016/17	-0.3	-0.6	-0.8	-0.8	-0.8	-0.7	-0.4					

Figure AIII 1: Mean monthly minimum temperatures by location 2015/16

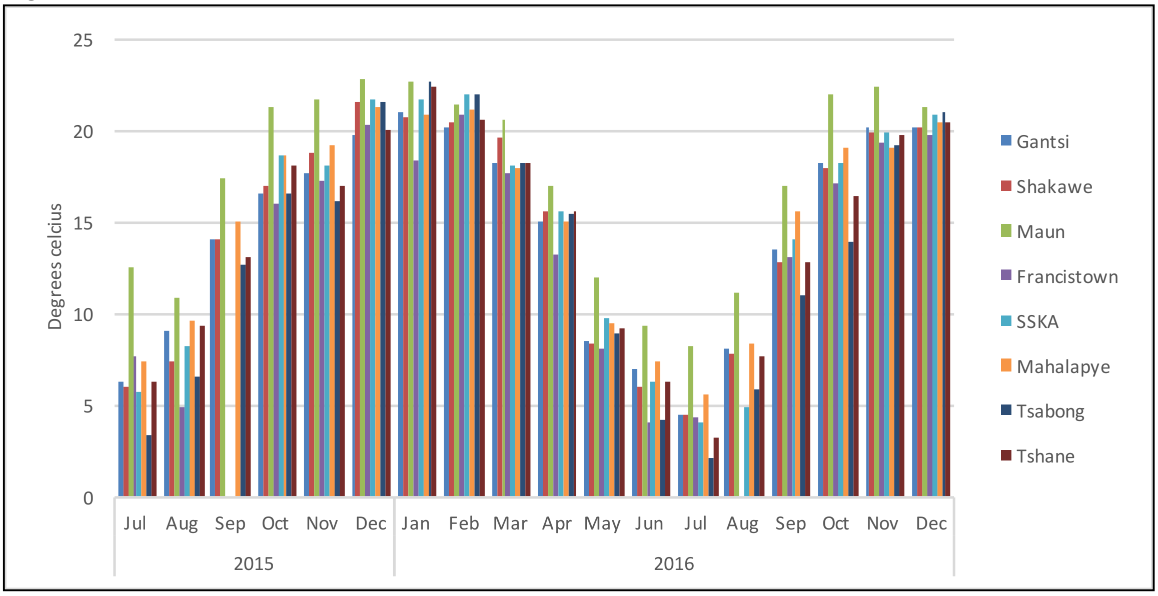


Figure AIII 2: Mean monthly maximum temperatures by location 2015/16

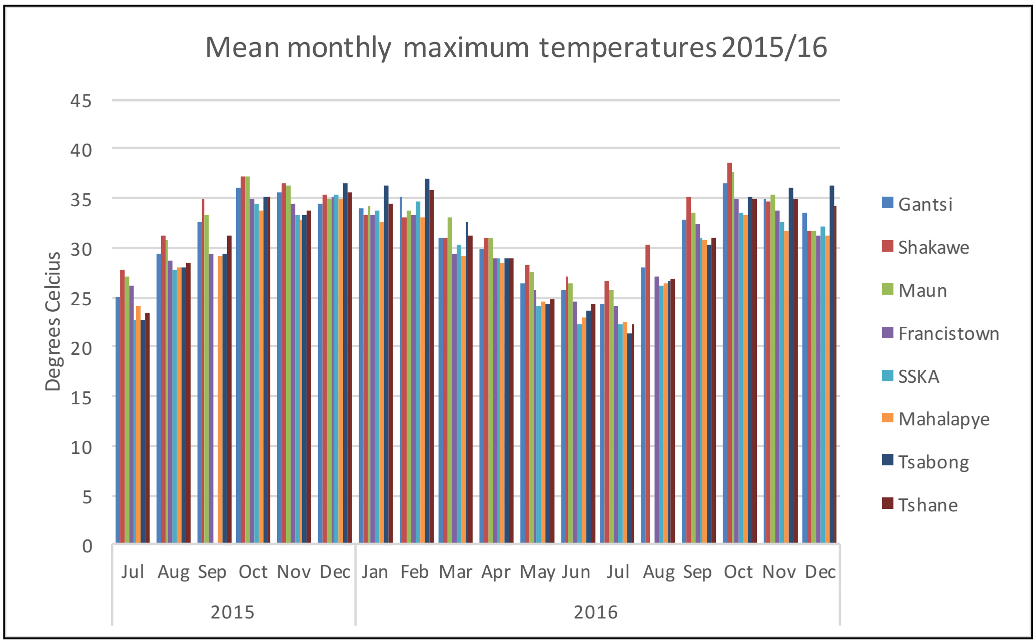
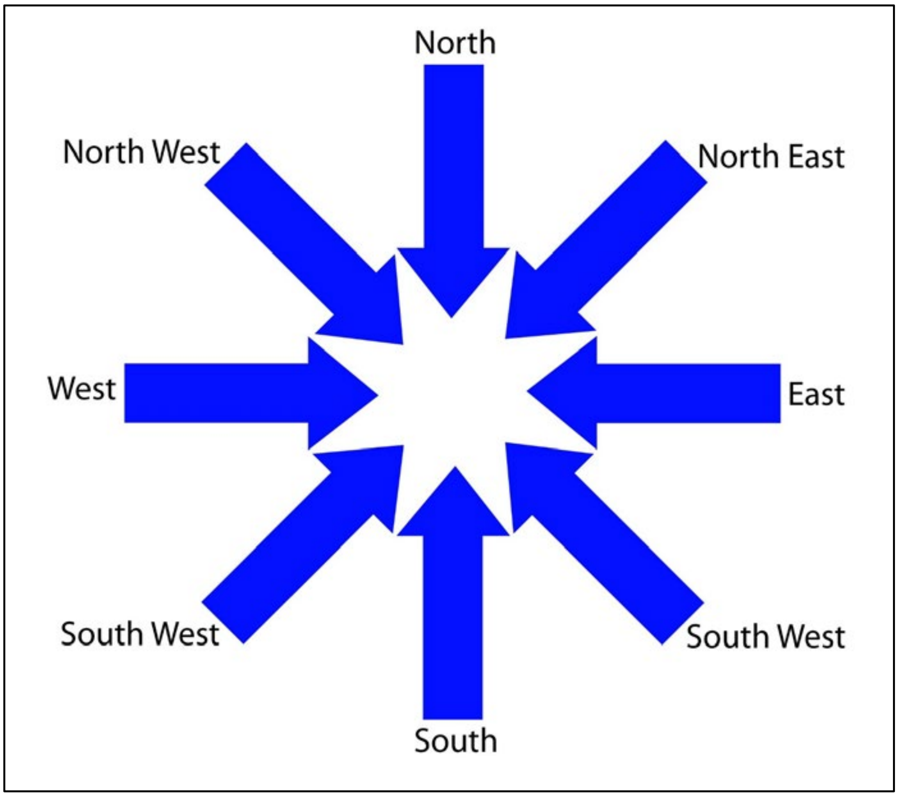


Table A III 2: Winds Scale

m/s	Km/h	Beaufort scale	Label	Effects
0 - 0.2	1	0	Calm	Calm. Smoke rises vertically.
0.3-1.5	1-May	1	Light Air	Wind motion visible in smoke.
1.6-3.3	6-Nov	2	Light Breeze	Wind felt on exposed skin. Leaves rustle.
3.4-5.4	Dec-19	3	Gentle Breeze	Leaves and smaller twigs in constant motion.
5.5-7.9	20-28	4	Moderate Breeze	Dust and loose paper raised. Small branches begin to move.
8.0-10.7	29-38	5	Fresh Breeze	Branches of a moderate size move. Small trees begin to sway.
10.8-13.8	39-49	6	strong Breeze	Large branches in motion. Whistling heard in overhead wires. Umbrella use becomes difficult. Empty plastic garbage cans tip over.
13.9-17.1	50-61	7	Near Gale	Whole trees in motion. Effort needed to walk against the wind. Swaying of skyscrapers may be felt, especially by people on upper floors.
17.2-20.7	62-74	8	Gale	Twigs broken from trees. Cars veer on road.
20.8-24.4	75-88	9	Severe Gale	Larger branches break off trees, and some small trees blow over. Construction/temporary signs and barricades blow over. Damage to circus tents and canopies.
24.5-28.4	89-102	10	Storm	Trees are broken off or uprooted, saplings bent and deformed, poorly attached asphalt shingles and shingles in poor condition peel off roofs.
28.5-32.6	103-117	11	Violent Storm	Widespread vegetation damage. More damage to most roofing surfaces, asphalt tiles that have curled up and/or fractured due to age may break away completely.
>32.7	>118	12	Hurricane	Considerable and widespread damage to vegetation, a few windows broken, structural damage to mobile homes and poorly constructed sheds and barns. Debris may be hurled about.

Figure AIII 3: Winds Direction illustration



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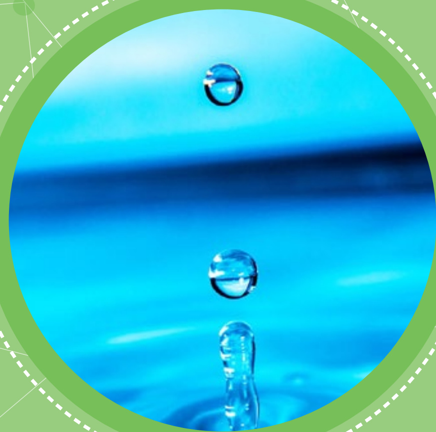

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