BOTSWANA ENVIRONMENT STATISTICS:
CLIMATE CHANGE DIGEST 2021

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STATISTICS BOTSWANA

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CLIMATE CHANGE DIGEST 2021

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PREFACE

Statistics Botswana, through the Environment Statistics Unit (ESU), presents the first edition of the Botswana Environment Statistics: Climate Change Digest. The digest provides reliable and recent statistics together with trends analysis on climate change statistics, focusing on climate (temperature and rainfall), greenhouse gas (GHGs) emissions, hazardous events and disasters (veldt fires, floods, storms, and heavy rains), agricultural production , and water resources. With regard to hazardous events and disasters, reference is made to incidences, impacts and responses.

The Framework for Development of Environmental Statistics (FDES) of the United Nations Statistics Division and the Sendai Framework for Disaster Risk Reduction were used in the preparation of this digest. The statistical information provided in this digest is important for evidence-based decision making with particular reference to adaptation and mitigation against climate change impacts and for disaster risk reduction and disaster management.

I wish to acknowledge the National Disaster Management Office, Water Utilities Corporation, Ministry of Agriculture, and Department of Meteorological Services for their significant contribution by providing the required data. The continued production of this report is dependent on strong collaboration with key stakeholders.

For more information and further enquiries, contact the Directorate of Stakeholder Relations at **3671300**. Statistics Botswana outputs/publications are available on the website at www.statsbots.org.bw and at the Statistics Botswana Resource Centre which is based at the Head-Office in Gaborone.

Dr. Burton S. Mguni
Statistician General
November 2022

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LIST OF ACRONYMS

AFOLU	Agriculture, Forestry and other Land use
CH_4	Methane
CO_2	Carbon Dioxide
DMS	Department of Meteorological Services
Eq	Equivalent
Gg	Giga Grams
GHG	Greenhouse Gas
INC	Initial National Communication
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
LUCF	Land –Use and Forestry
LULUCF	Land Use, Land-Use Change, and Forestry
Mm^3	Million Cubic Metres
MT	Metric Tonne
NCs	National Communications
NDMO	National Disaster Management Office
N_2O	Nitrous Oxide
SASSCAL	Southern African Science Service Centre for Climate Change and Adaptive Land Management

EXECUTIVE SUMMARY

CLIMATE

To examine the climatic variables, this report observes the monthly average maximum and minimum temperatures and rainfall for the years 2014 to 2021.

Temperatures

Except for the winter month of July, all the months show increases in the monthly average maximum temperatures for the period 2014 to 2021. The cold month of July shows a decrease in the monthly average maximum temperatures. All of the monthly average minimum temperatures had a falling trend except for the months of August and September.

Rainfall

Seven (7) months of, March, April, May, June, July, September and December show a decrease in the total monthly rainfall. February and October show increased rainfall.

Emissions of Greenhouse Gas (GHG)

It is evident that Botswana's Greenhouse gas emissions have been on an increasing trend since the year 2000 to 2015. The year 2015 had the highest GHG emissions at 12,622.11 Gg CO_2-eq which was a 71.9 percent increase from the initial year 2000, the Energy sector being the major contributor. Even though AFOLU (without LULUCF) saw a drop from the initial 1,707.11 Gg CO_2eq emissions in 2000 it was the second major contributor to greenhouse gas emissions during the 2000 to 2015 period. The waste sector had the highest increase in emissions (244.82 percent) from the initial year to 2015.

A trend of Botswana's GHGs emissions (without LULUCF) by gas for the inventory years, 2000 – 2015 shows an increase in the total amount of emissions, with the highest emissions recorded in the years 2012 and 2013, with 11,157.81 Gg CO_2-eq and 11,148.07 Gg CO_2-eq respectively.

NATURAL DISASTERS

The information on natural hazards causing disasters focuses on trends of incidences of floods, storms and heavy rains, and their impact on people's livelihoods and the environment they depend on.

Floods

During the period 2019 – 2020 floods affected 145 households with 469 individuals affected/displaced. The impact resulted in a total of 20 tents and 56 food baskets issued to the victims as a form of relief.

Storms Incidences (Hailstorm & Storm)

The most current storm incidences were recorded in the year 2021 at Tamasane and Lesenepole villages in Palapye Sub District affecting 38 households with 227 individuals. Consequently, a total of 38 tents and 36 food baskets were issued to the affected households.

Heavy Rains

From a total of 258 households affected by heavy rains during the period 2019 to 2021, the highest number of households affected (67) were recorded in the Mahalapye District in 2021. During the same year Boteti district recorded the highest number of individuals affected / displaced by heavy rains, followed by Mahalapye district with 286 and 121 respectively.

AGRICULTURAL PRODUCTION

This report observes trends in agricultural production with particular reference to the production and yield of cereal and perennial crops.

National Crop Yield Estimates (Grain)

For the yield per hectare harvested by grain crop in 2012 – 2019 for the traditional sector, millet had the highest yield per hectare harvested during the period 2012 to 2019, followed by sorghum, maize and beans/pulses in that order. The lowest ever recorded annual yield during the review period was for maize with 62 Kg/Ha harvested in 2013. In general, all the annual yields per crop saw a fluctuating trend during the review period with a decline towards the current years.

National Cereal Production

In 2019, 2,709 metric tonnes of grains were produced in Botswana, a decline of about 88.4 percent compared to 2017 (23,283 MT). Maize had the highest production during the 2012 – 2019 period, with almost 54,960 metric tonnes produced followed by sorghum (34,898 metric tonnes) and beans/pulses (14,201 metric tonnes). Together, these three crops account for nearly 93 percent of the national cereal production.

National Perennial Crop Production

The most grown perennial crops during the review period were oranges, followed by mango and pawpaw with total fruit production of 21,779.14 tonnes, 832.75 tonnes and 322.63 tonnes respectively. The total annual perennial crop production saw a fluctuating trend during the 2012/3 – 2018/19 cropping seasons with the highest production recorded in 2015/16 at 5,112.84 tonnes.

WATER

Dam levels

Gaborone dam recorded the lowest point at 1.7 percent in January and February 2016, after the effects of the 2015 drought. The highest annual average dam level was recorded for Dikgatlhong dam followed by Ntimbale dam in 2017. Nationally, the dams held the highest annual average levels in 2017, followed by 2021 and 2018.

The highest seasonal gains were recorded for Gaborone dam during the 2016/17 wet season, when Gaborone dam was recovering from the effects of a drought, followed by Molatedi (in South Africa) and Thune dams. The highest losses were recorded for Bokaa dam followed by Letsibogo dam during the 2021 dry season and Bokaa dam in 2020 during the dry season.

Abstraction

The agriculture sector is the largest user of water abstracted for own use, with more water used for livestock than for irrigation. Mines also extract water for own use, with the main mining activity, diamond mining extracting the most. Water extracted for own use was highest in 2017/18 and lowest in 2016/17.

Water service providers withdrew and distributed the most water for distribution, followed by the diamond and the coal mining industries, and the electricity generating sector. The mines and electricity sectors distribute the water to mining towns and their residential communities. The amount of water abstracted for distribution has declined over the period.

The water providers abstracted the highest volumes of water by industry for the period 2016/17 to 2018/19. The abstraction was highest in 2016/17, followed by 2018/19 and then 2017/18.

1.0. INTRODUCTION

It is evident that climate is changing over geological time. Climate change includes warming temperatures and other phenomena such as extreme weather events, changing ecosystems and wildlife habitats, as well as factors that determine human well-being.

Climate change is caused by both natural and human or anthropogenic factors, with the long term changes explained mainly by human activity (US Global Change Research Program 2022). Human activity contributes to global warming through activities that emit greenhouse gases (GHG). Such activities are largely those that involve combustion of fossil fuels, but also include biological processes. Atmospheric concentrations of carbon dioxide from human activities have increased, and mostly during the years since 1970 (The Royal Society, 2022).

Climate change has implications for human health and wellbeing, and livelihoods. In Botswana, implications of a high emissions scenario are increased temperatures and longer warm and dry spells and increased risk of environment-related diseases such as Malaria (World Health Organisation, 2022). The higher temperatures and longer dry spells would have implications for water scarcity, which is already a problem for the country. The agriculture sector depends on water availability, and is crucial for the livelihoods of many households in the country. Botswana's agriculture is highly dependent on rain-fed grain, a reliance that makes production as unreliable as the rainfall it depends on (Government of Botswana, 2012). This situation has a bearing on the country's food security. According to Statistics Botswana (2020), about 50.8% of the population in the country was affected by moderate to severe food insecurity during the year 2018/2019, while about 22.2% was affected by severe food insecurity.

Climate change also affects the global occurrence of extreme weather events, and Botswana is no exception. Severe droughts in terms of low rainfall and soil conditions are common on south western Botswana, while floods from high rainfall are common in north eastern Botswana. Indications are that for Botswana, rainfall will decrease while the risk of flooding and droughts will increase as a result of climate change (World Bank 2010). With higher temperatures and longer dry spells the surface water reservoirs would suffer from increased losses to evaporation and low recharge rates.

Botswana will need mitigation and adaptation strategies that are led by informed decision making, backed by data rich analysis of the pressure, state and responses to climate change and its associated variables.

The structure of this digest was guided primarily by the scope of the global set of climate change statistics and indicators covering the climate change aspects defined by the five policy areas of the Intergovernmental Panel on Climate Change (IPCC), namely drivers, impacts, vulnerability, mitigation and adaptation. The structure of the global set of climate change indicators and statistics is based on those five areas and the Framework for the Development of Environment Statistics. For this digest the selected policy areas were informed by data availability and they include: i) drivers (total GHG emissions), and ii) impacts (agricultural production impacted by climate change, hazardous events and disasters, fresh water resources, climate change evidence- temperature and rainfall).

1.1. Methodology

The production of the Climate Change Digest was guided by the United Nations Framework for the Development of Environment Statistics (UNFDES), Sendai Framework for Disaster Risk Reduction, and the Global set of Climate Change Statistics and Indicators. The focus was mainly inclined towards indicators categorised under the global set of climate change statistics and indicators because of their direct relevance to issues of climate change.

Subsequent to the adoption of Decisions 47/112 by the Statistical Commission in 2016, the Statistics Division developed the global set of climate change statistics and indicators, in partnership with the secretariat of the United Nations Framework Convention on Climate Change, to promote the policy and statistics interface (UNSC, 2022). One of these Statistical Commission decisions urges countries to develop and strengthen environment statistics, which are necessary for the effective monitoring of key aspects of climate change (UNSC, 2016), hence the justification for the production of this digest. The global set includes primarily the biophysical indicators and statistics, but also human activities, and social and institutional aspects related to climate change (UNSC, 2022).

Administrative records were used for the production of this digest, and were drawn from various agencies and departments namely the Department of Meteorological Services (DMS), National Disaster Management Office (NDMO), Ministry of Agriculture, Water Utilities Corporation (WUC), Southern African Science Service Centre for Climate Change and Adaptive Land Management (SASSCAL) Weather net, together with desk reviews based on the aforesaid international frameworks.

The process of developing this digest started with the identification of agencies producing climate change related data. Formal data request letters were dispatched to the data providers. Data request follow-ups were made to ensure that enough data had been collected to start the analysis and report writing. The review of available data was carried out to ensure data conforms to national requirements, UNFDES, Sendai Framework, Global set of Climate Change Statistics and Indicators, and Inter-Governmental Panel on Climate Change (IPCC) guidelines. Data were captured and analysed in Microsoft Excel software. Subsequent to which validation of the statistics by data providers as well as the rigorous review of the draft report by Statisticians at different hierarchical levels which was done.

2.0. CLIMATE

This report examines temperatures and rainfall, which are climate variables, over eight years. This is a limited assessment, because climate change variables should be observed over much longer periods of time. This report observes these climate variables only for a limited period due to limitations in data availability. This is undertaken by observation of average temperatures and total rainfall for the same monthly period for each of the years. The same rainfall stations are used for each of the comparisons throughout the periods, with only those with incomplete data excluded. Only periods where complete data was available were included.

2.1. Temperatures

2.1.1. Monthly average maximum temperatures

Table 2.0 shows the monthly average maximum temperatures for the years 2014 to 2021.

Table 2.0: Monthly Average Maximum Temperatures (°C)

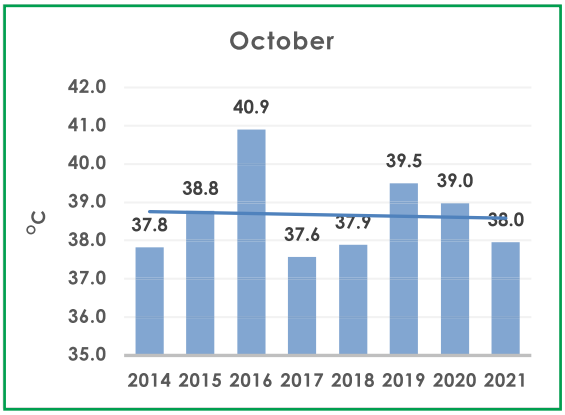
	2014	2015	2016	2017	2018	2019	2020	2021
February	30.0	37.8	39.0	32.9	34.5	37.5	36.0	33.8
March	30.5	36.4	34.6	33.2	34.8	38.4	35.1	34.6
April	28.9	31.4	33.7	33.4	31.8	33.8	33.8	33.1
May	28.0	31.4	29.7	29.3	29.5	31.0	30.0	29.1
June	27.4	27.8	28.1	28.2	28.5	28.5	27.3	29.1
July	27.9	28.8	28.3	29.2	29.0	28.4	27.2	28.6
August	31.2	33.5	31.9	32.6	32.7	33.3	32.8	32.3
September	36.0	36.8	36.1	36.7	37.3	35.5	36.4	36.6
October	37.8	38.8	40.9	37.6	37.9	39.5	39.0	38.0
November	37.0	40.5	39.9	38.0	39.2	38.9	38.6	39.2
December	32.0	35.6	35.3	33.6	34.5	35.1	34.6	34.7

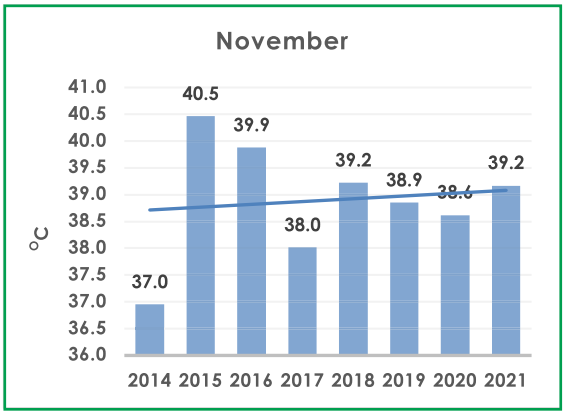
Source: Calculated from SASSCAL data

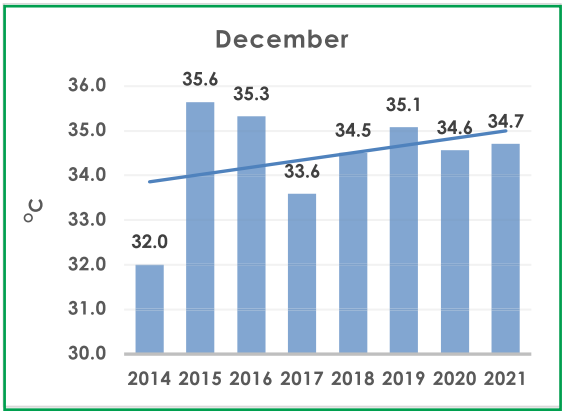
Except for the winter month of July, all the months show increases in the monthly average maximum temperatures for the period 2014 to 2021. The cold month of July shows a decrease in the monthly average maximum temperatures. **Figure 2.0** shows the trends.

Figure 2.0: Monthly Maximum Average Temperatures 2014-2021 (°C)

Figure 2.0 Cont'd: Monthly Maximum Average Temperatures 2014-2021 (°C)







2.1.2. Monthly average minimum temperatures

Table 2.1 shows the monthly average minimum temperatures for the years 2014 to 2021.

Table 2.1: Monthly average minimum temperatures (°C)

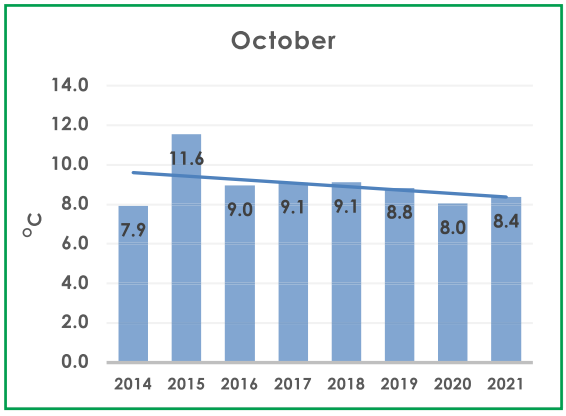
	2014	2015	2016	2017	2018	2019	2020	2021
February	17.8	14.5	16.7	16.8	14.3	14.9	16.3	10.7
March	16.6	13.5	13.5	11.8	13.5	15.5	12.1	12.3
April	15.1	10.6	10.9	9.0	9.8	10.9	8.2	6.4
May	14.9	5.1	4.6	3.6	4.2	6.3	0.0	1.9
June	1.2	-0.5	2.1	0.0	1.5	1.7	-2.3	0.2
July	-2.3	-0.8	-1.7	1.2	-1.0	0.2	-1.4	-3.2
August	0.9	-0.2	1.1	1.5	1.6	5.2	0.4	-0.2
September	4.6	6.1	7.0	6.7	1.8	3.0	5.4	7.8
October	7.9	11.6	9.0	9.1	9.1	8.8	8.0	8.4
November	11.6	10.8	15.5	8.6	10.8	15.7	10.7	11.7
December	16.5	16.4	16.4	13.9	15.2	13.2	11.2	12.4

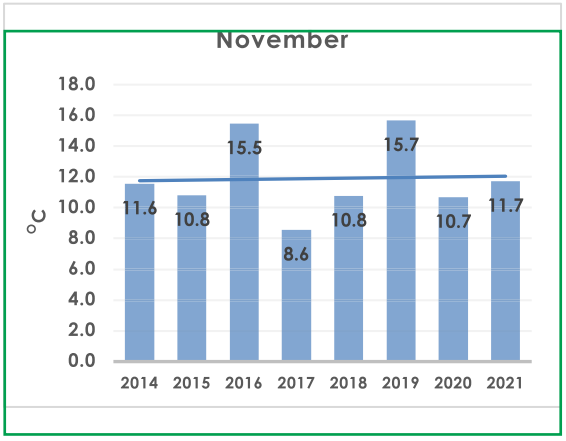
Source: Calculated from SASSCAL data

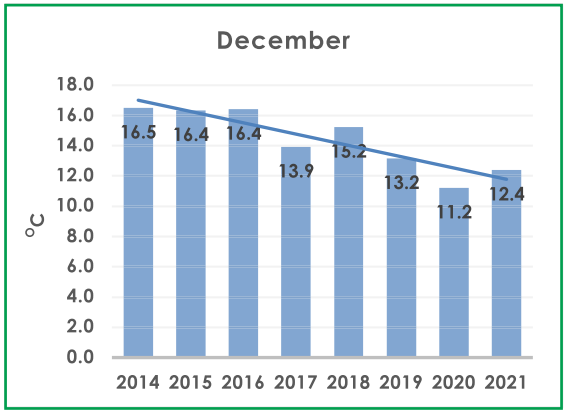
All of the monthly average minimum temperatures had a falling trend except for the month of August and September. **Figure 2.1** shows the trends.

Figure 2.1: Monthly Minimum Average Temperatures 2014-2021 (°C)

Figure 2.1 Cont'd: Monthly Minimum Average Temperatures 2014-2021 (°C)







2.2. Rainfall

2.2.1. Monthly total rainfall

Table 2.2 shows the monthly total rainfall trends for the period 2014 to 2021. This is the monthly total rainfall for stations with full rainfall data. Monthly total rainfall is the summation of rainfall from all collection points over a month. For the annual comparison of monthly total rainfall the stations with data gaps were excluded.

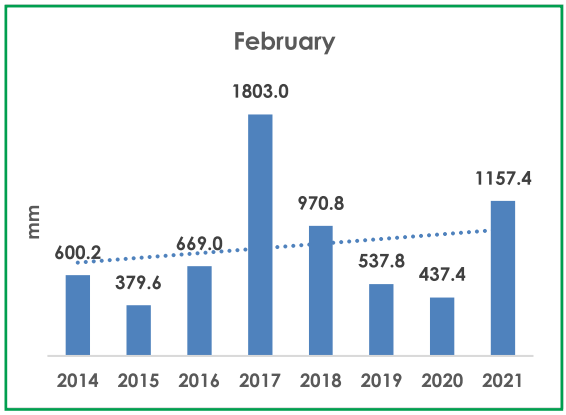
Table 2.2: Monthly total rainfall - 2014 to 2021 (mm)

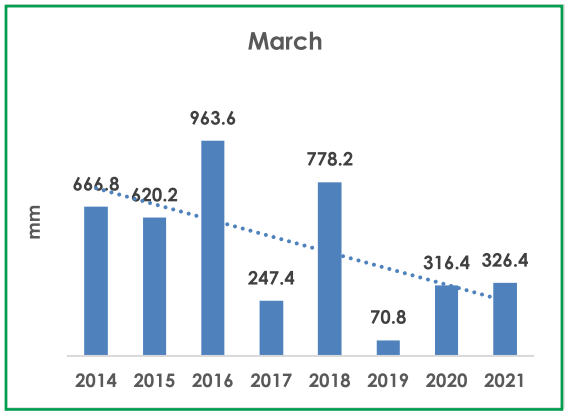
	2014	2015	2016	2017	2018	2019	2020	2021
February	600.2	379.6	669.0	1803.0	970.8	537.8	437.4	1157.4
March	666.8	620.2	963.6	247.4	778.2	70.8	316.4	326.4
April	125.8	411.6	297.8	408.0	324.4	597.8	264.2	104.0
May	61.8	5.6	26.2	1.6	41.8	19.2	0.0	1.6
June	2.8	19.4	39.4	0.6	0.0	0.6	1.8	17.8
July	3.8	13.6	0.8	5.8	40.8	0.4	0.4	0.2
August	15.4	1.4	0.4	6.6	4.6	0.2	4.4	13.4
September	43.2	117.4	7.4	39.2	9.0	0.4	65.2	40.8
October	68.6	81.4	195.0	426.8	103.2	14.8	307.8	242.4
November	570.2	283.8	588.0	364.4	193.2	480.0	665.0	389.4
December	946.4	536.6	829.0	696.2	553.2	701.0	657.2	670.8

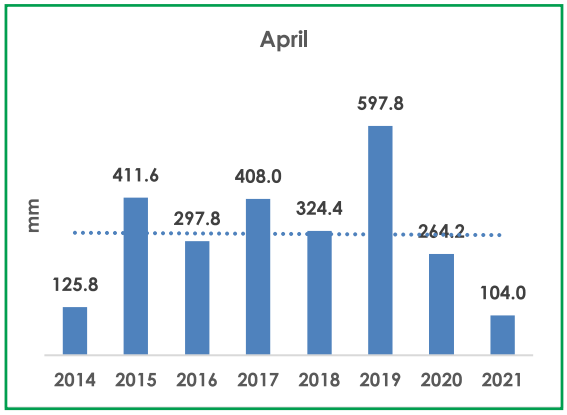
Source: Calculated from SASSCAL data

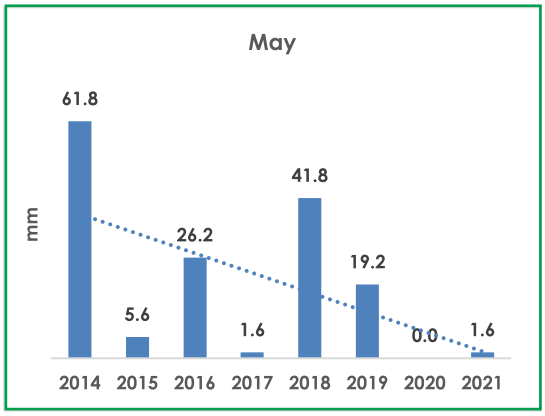
Seven (7) of the months; March, April, May, June, July, September and December show a decrease in the total monthly rainfall. February and October show increased rainfall. This may have implications for intense rainfall over shorter periods of time and floods. **Figure 2.2** shows the trends.

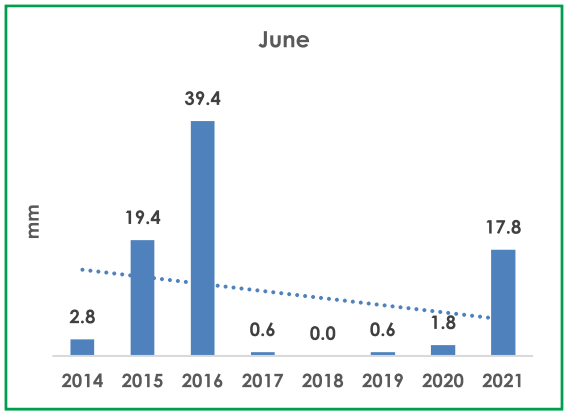
Figure 2.2: Monthly total rainfall - 2014 to 2021 (mm)

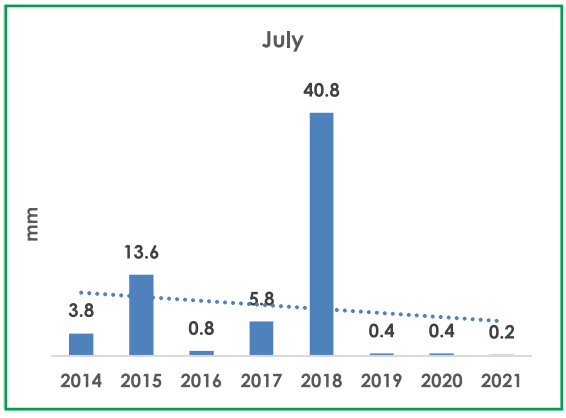


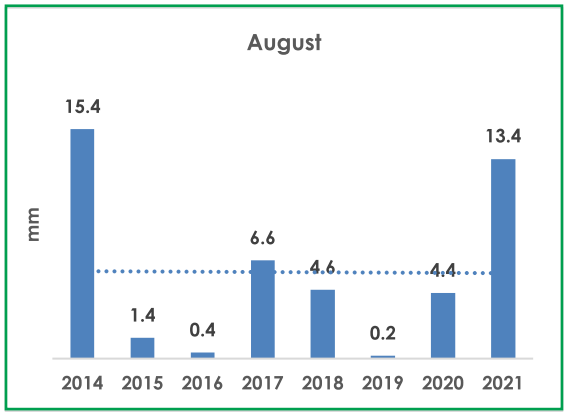












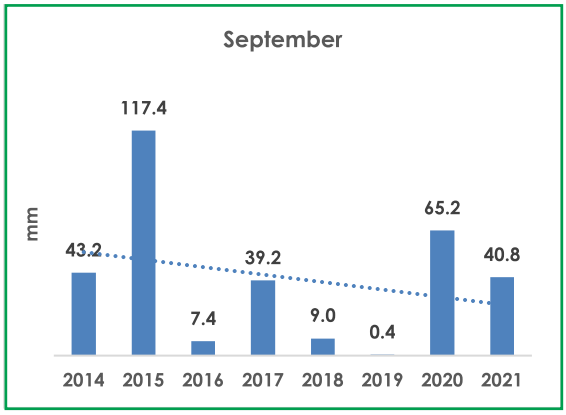
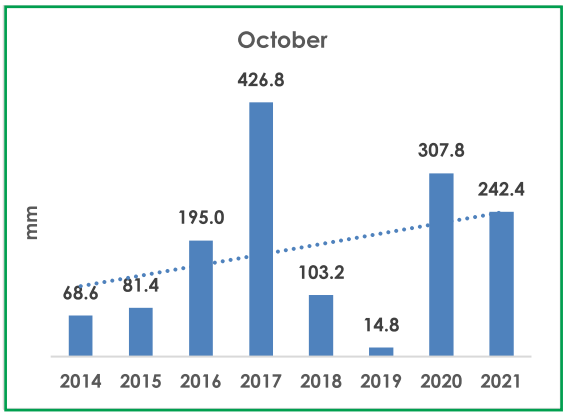
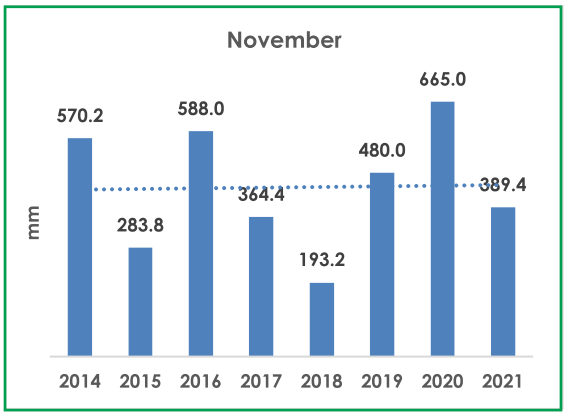
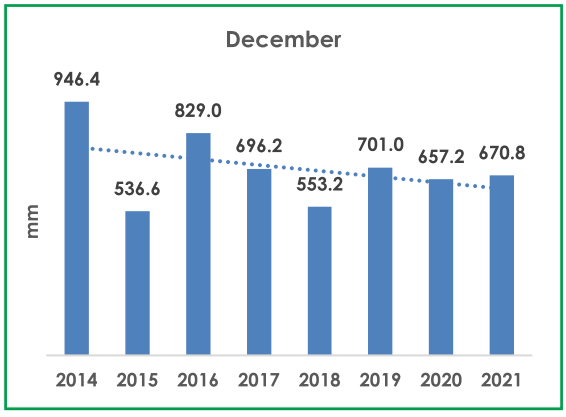


Figure 2.2 Cont'd: Monthly total rainfall - 2014 to 2021 (mm)







3.0. EMISSIONS OF GREENHOUSE GAS (GHG)

Any gas that has the ability to trap heat/ infrared radiation from the earth's surface is referred to as a greenhouse gas (US EPA, 2020). Greenhouse gases (GHGs) are gases that trap heat in the atmosphere and make the planet warmer (Statistics Botswana, 2020). The main gases are either emitted to or removed from the atmosphere. These greenhouse gases include Carbon dioxide (CO_2), Nitrous Oxide (N_2O), Methane (CH_4) and Fluorinated gases. Greenhouse gas concentrations are influenced by a number of processes, human activities such as the burning of fossil fuels, tectonic activities as well as other agricultural activities just to name a few (Mann, 2021). After ratifying the United Nations Framework Convention on Climate Change (UNFCCC) in 1994, the Government of Botswana has met the expectations set by the climate change secretariat to conduct the country situation assessment regarding its position, national circumstances and responses to climate change.

Botswana has managed to submit three National Communications (NCs) to the UNFCCC, the Initial National Communication (INC) in 2001, Second National Communication (SNC) in 2012, and Third National Communication (TNC) in 2019. The inventory of GHG emissions and removals forms a chapter in the NCs.

This chapter presents the national inventory of greenhouse gas (GHG) emissions and removals across four sectors during the period 2000 - 2015; Energy sector, Industrial Processes and Product Use (IPPU), Agriculture, Forestry and other Land use (AFOLU) and Waste sector. The inventory of GHG emissions in Botswana has only been estimated up to the year 2015. The compilation of inventories for the years 2016 forth is dependent on the availability of financial support from the UNFCCC to the National Focal Point (NFP), the Department of Meteorological Services (DMS).

3.1. Summary of GHG Emissions & Removals

Table 3.0 presents the trend of Botswana's GHG emissions without Land Use, Land-Use Change and Forestry (LULUCF) by sector during the period 2000 – 2015. It is evident from the table that Botswana Greenhouse gas emissions have been on an increasing trend since the year 2000 to 2015. During the year 2000 Botswana's greenhouse gas emissions were at a total of 7,342.80 Gg CO_2 eq. The year 2015 had the highest GHG emissions at 12,622.11 Gg CO_2 eq, which was a 71.9 percent increase from the initial year 2000 by an average of 4.8 percent a year. The Energy sector was the major contributor to the total greenhouse gas emissions in Botswana; they had their highest contribution during the year 2015 which was 9,310.72 Gg CO_2 eq. Even though AFOLU (without LULUCF) saw a drop from the initial 1,707.11 Gg CO_2eq emissions in 2000 to 1,403.78 Gg CO_2 eq during the year 2015 (-17.77 percent increase), it was the second major contributor to greenhouse gas emissions during the 2000 to 2015 period. However, the waste sector had the highest increase in emissions from the initial year to 2015 which was by 244.82 percent though it contributed the least to the national total GHG emissions.

Table 3.1 shows a trend of Botswana's GHGs emissions (without LULUCF) by gas for the inventory years, 2000 - 2015. Generally, the total amount of emissions followed an increasing trend with the highest emissions recorded in the years 2012 and 2013 with 11,157.81 Gg CO_2-eq and 11,148.07 Gg CO_2-eq respectively. It is also evident from the table that there was a 40.39 percent increase in the total GHG emissions from the year 2000 (7,342.68 Gg CO_2-eq) to 2015 (10,308.71 Gg CO_2-eq). The most emitted GHG during the review period was Carbon Dioxide (CO_2) with a total of 101,862.78 Gg CO_2-eq followed by Methane (CH_4) and Nitrous oxide (N_2O) with totals of 46,253.58 Gg CO_2-eq and 3,065.04 Gg CO_2-eq respectively. Differentials in GHG emissions by gas reveal that N_2O recorded the highest percentage change from the year 2000 to 2015 with 258.47 percent followed by CO_2 with 44.65 percent. However, it's worth noting that the CO_2 annual emissions were the highest during the review compared to other gases.

Table 3.0: Trend of Botswana GHG Emissions (without LULUCF) by sector: 2000– 2015

YEAR	ENERGY	IPPU	AFOLU (without LULUCF)	WASTE	TOTAL	%Δ FROM BASE YEAR
	Gg CO_2eq					
2000	4,574.30	862.47	1,707.11	198.92	**7,342.80**	–
2001	5,807.18	1,210.54	2,016.87	241.10	**9,275.69**	26.32
2002	5,954.59	1,265.32	2,385.87	254.48	**9,860.26**	34.28
2003	5,423.09	1,076.72	1,669.24	271.66	**8,440.71**	14.95
2004	5,319.21	1,302.12	1,760.61	296.44	**8,678.38**	18.19
2005	5,859.98	1,251.48	1,731.21	325.70	**9,168.37**	24.86
2006	6,017.78	1,381.20	1,701.80	357.16	**9,457.94**	28.81
2007	5,971.85	1,319.31	1,495.13	387.83	**9,174.12**	24.94
2008	6,320.37	1,254.01	1,834.35	420.24	**9,828.97**	33.86
2009	5,676.26	1,131.19	1,962.33	450.92	**9,220.70**	25.57
2010	5,979.11	761.13	2,112.10	479.23	**9,331.57**	27.08
2011	5,576.13	1,271.80	2,043.76	520.78	**9,412.47**	28.19
2012	7,503.62	1,278.25	1,808.94	566.99	**11,157.80**	51.96
2013	7,607.17	1,252.27	1,692.28	606.35	**11,158.07**	51.96
2014	8,351.60	1,294.08	1,586.28	644.42	**11,876.38**	61.74
2015	9,310.72	1,221.69	1,403.78	685.92	**12,622.11**	71.90
TOTAL	**101,252.96**	**19,133.58**	**28,911.66**	**6,708.14**	**156,006.34**	
Δ (2000–2015)%	**103.54**	**41.65**	**-17.77**	**244.82**	**71.90**	

Source: Department of Meteorological Services

Figure 3.0: Trend of Botswana GHG Emissions (without LULUCF) by sector: 2003 – 2015

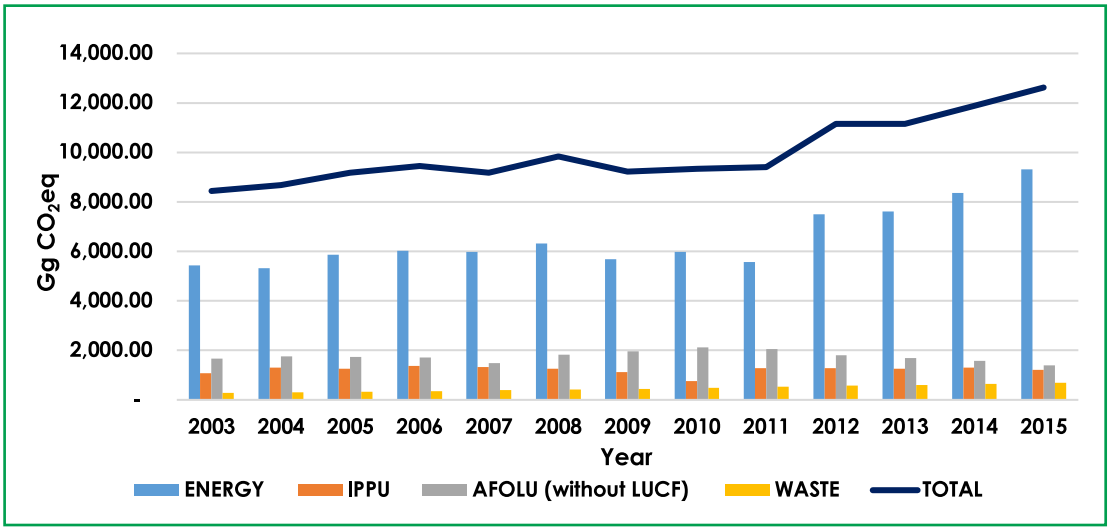
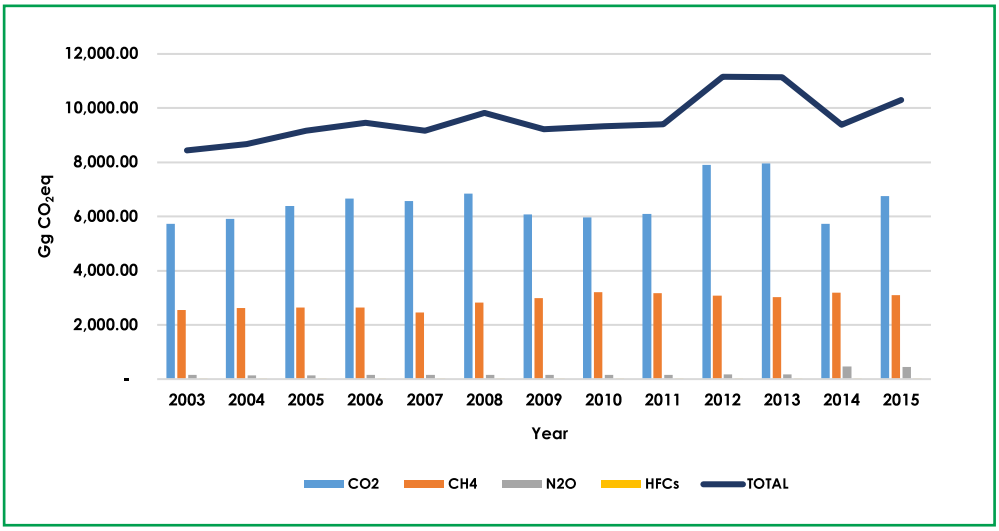


Table 3.1: Trend of Botswana GHG Emissions (without LULUCF) by gas: 2000 – 2015

YEAR	CO_2	CH_4	N_2O	HFCs	TOTAL
	Gg CO_2-eq				
2000	4,667.80	2,549.14	125.74	—	**7,342.68**
2001	6,208.83	2,906.93	159.93	—	**9,275.69**
2002	6,419.77	3,286.53	153.96	—	**9,860.26**
2003	5,733.48	2,556.51	150.70	0.01	**8,440.70**
2004	5,913.58	2,624.17	140.61	0.02	**8,678.38**
2005	6,385.56	2,636.30	145.55	0.95	**9,168.36**
2006	6,667.64	2,642.36	147.10	0.84	**9,457.94**
2007	6,569.15	2,454.37	149.64	0.96	**9,174.12**
2008	6,843.54	2,828.34	155.82	1.27	**9,828.97**
2009	6,079.05	2,987.76	153.27	1.08	**9,221.16**
2010	5,959.81	3,210.76	157.89	0.99	**9,329.45**
2011	6,087.16	3,163.28	161.13	0.90	**9,412.47**
2012	7,897.46	3,086.80	172.75	0.80	**11,157.81**
2013	7,956.12	3,016.95	174.28	0.72	**11,148.07**
2014	5,721.91	3,197.88	465.93	0.64	**9,386.36**
2015	6,751.92	3,105.50	450.74	0.55	**10,308.71**
TOTAL	**101,862.78**	**46,253.58**	**3,065.04**	**9.73**	**151,191.13**
Δ(2000–2015)%	**44.65**	**21.83**	**258.47**	—	**40.39**

Source: Department of Meteorological Services

Figure 3.1: Trend of Botswana GHG Emissions (without LULUCF) by gas: 2003 - 2015

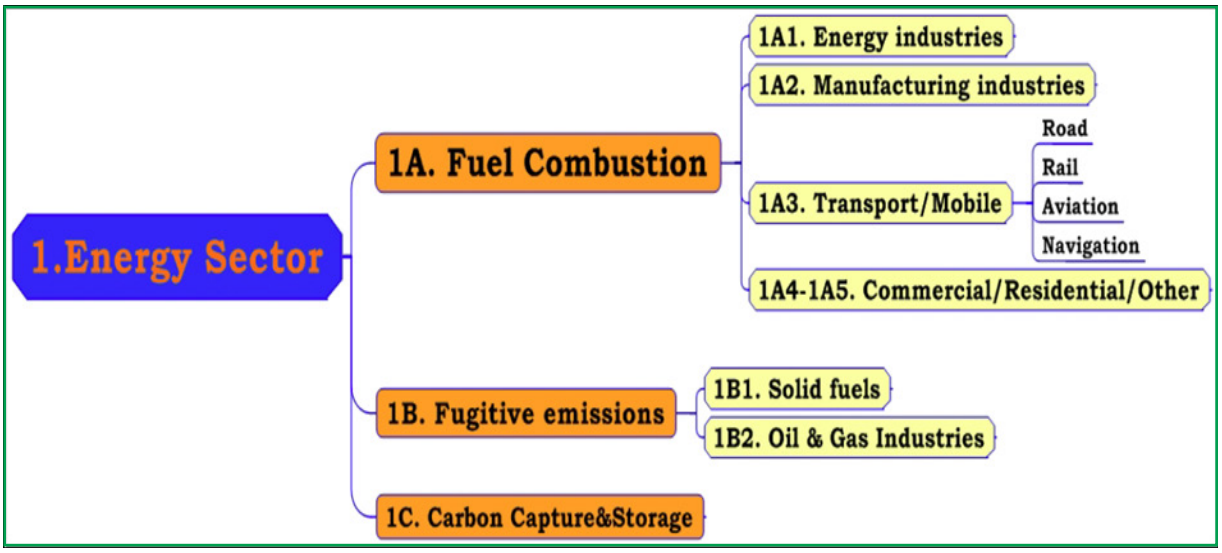


3.2. Inventory of GHG Emissions from the Energy Sector

Emissions from the energy sector consist of two main categories: fuel combustion and fugitive emissions from fuels. Fuel combustion includes emissions released into the atmosphere when fossil fuels (e.g., coal, oil products, and natural gas) are combusted, and Fugitive emissions are intentional or unintentional releases of gases from fossil fuels by anthropogenic activities (NIR Japan, 2020).

This section presents the emissions of greenhouse gases from the energy sector from the year 2000 to the year 2015. **Figure 3.1a** represents a summary of the sources of GHG emissions from the energy sector.

Figure 3.2: Sources of GHG emissions from the Energy Sector



Source: Shermanau (2017a)

Table 3.2 depicts time series energy sector emissions by categories for the years 2000 – 2015. The table shows that the major energy consumers in Botswana were the energy industries followed by other sectors (e.g., commercial/institutional, residential, and agriculture/forestry/fishing). The main sources of emissions during the period under review were fuel combustion activities as well as fugitive emissions from fuels. Fuel combustion activities were the major contributors to greenhouse gas emissions, and during the year 2000 fuel combustion activities contributed over 90 percent of the total emissions and the fugitive emissions from fuels only contributing 3.2 percent with 146.61 Gg CO_2-eq. During the year 2015 fugitive emissions from fuels had their highest emissions at 319.84 Gg CO_2-eq, which was only a 3.4 percent contribution to the total emissions and 96.6 percent was from fuel combustion activities. The year 2015 saw an increase of 84.7 percent in emissions from the transport industry from the volume of 1,315.57 in 2000 to 2,429.52 Gg CO_2-eq. The energy sector also saw almost a four-fold increase in emissions in 2015 (5,114.96 Gg CO_2-eq) from the initial 1,310.02 Gg CO_2-eq in 2000.

The trend identified within the period from 2000 to 2015 for both fuel combustion activities and fugitive emissions was a fluctuating trend, which was generally on the increase. The year 2015 saw the highest energy total GHG emissions at 9,310.72 Gg CO_2-eq which was an increase of more than 100 percent from the year 2000 (4,574.3 Gg CO2-eq). The year 2014 had the second highest GHG emissions which was 8,351.59 Gg CO_2-eq. Fugitive emissions had their highest volume recorded in the year 2015 (319.84 Gg CO_2-eq) which was a 118 percent increase in emissions from the year 2000 (**Figure 3.2**).

[1] **Fugitive emissions:** are unmonitored, unintended and/or uncontrolled releases of gas into the atmosphere, e.g. emissions from leaking valves, seals and fittings, evaporation losses, and process faults and failures (IPCC, 2006).

Table 3.2: Time series Energy sector emissions by categories (Gg CO2-eq)

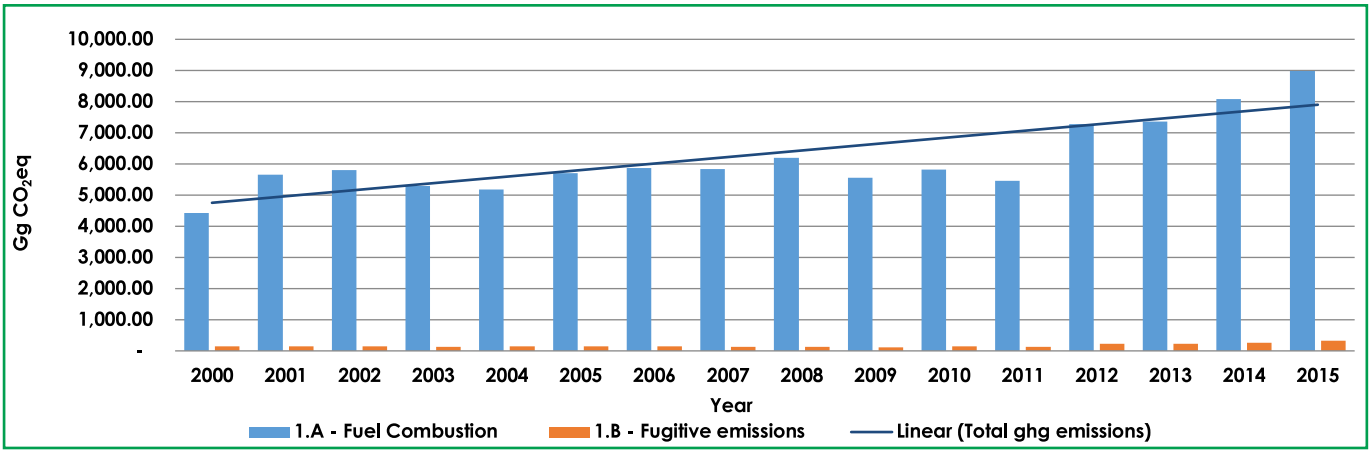
GHG Categories	GHG Sub-categories	2000	2001	2002	2003	2004	2005	2006	2007
1.A - Fuel Combustion Activities	1.A.1-Energy Industries	1,310.02	2,281.49	2,337.92	2,019.00	2,239.79	2,416.42	2,360.00	2,031.27
	1.A.3-Transport	1,315.57	1,390.03	1,330.24	1,425.95	1,551.27	1,606.77	1,726.30	1,786.59
	1.A.4-Other Sectors	1,802.11	1,991.61	2,138.87	1,850.75	1,387.11	1,674.85	1,782.48	2,025.77
Sub-Total		4,427.70	5,663.13	5,807.03	5,295.70	5,178.17	5,698.04	5,868.78	5,843.63
1.B - Fugitive emissions from fuels	1.B.1-Solid Fuels	146.61	144.05	147.56	127.39	141.04	152.49	149.01	128.22
TOTAL		**4,574.30**	**5,807.18**	**5,954.59**	**5,423.09**	**5,319.21**	**5,850.53**	**6,017.78**	**5,971.85**
1.A - Fuel Combustion Activities **(%)** contribution		96.80	97.52	97.52	97.65	97.35	97.39	97.52	97.85
1.B - Fugitive emissions from fuels **(%)** contribution		3.21	2.48	2.48	2.35	2.65	2.61	2.48	2.15

Table 3.2 Cont'd: Time series Energy sector emissions by categories (Gg CO_2-eq)

GHG Categories	GHG Sub-categories	2008	2009	2010	2011	2012	2013	2014	2015
1.A - Fuel Combustion Activities	1.A.1-Energy Industries	2,232.43	1,810.48	2,423.78	1,933.14	3,608.68	3,670.02	4,199.91	5,114.96
	1.A.3-Transport	2,032.60	1,885.91	2,055.34	2,141.86	2,184.05	2,221.34	2,310.70	2,429.52
	1.A.4-Other Sectors	1,934.11	1,866.10	1,346.99	1,379.08	1,485.71	1,474.25	1,575.99	1,446.40
Sub-Total		6,199.14	5,562.49	5,826.11	5,454.08	7,278.44	7,365.61	8,086.60	8,990.88
1.B - Fugitive emissions from fuels	1.B.1-Solid Fuels	121.23	114.23	153.01	122.06	225.18	231.57	264.99	319.84
TOTAL		**6,320.37**	**5,676.71**	**5,979.11**	**5,576.13**	**7,503.63**	**7,597.17**	**8,351.59**	**9,310.72**
1.A - Fuel Combustion Activities **(%)** contribution		98.08	97.99	97.44	97.81	97.00	96.95	96.83	96.56
1.B - Fugitive emissions from fuels **(%)** contribution		1.92	2.01	2.56	2.19	3.00	3.05	3.17	3.44

Source: Department of Meteorological Services

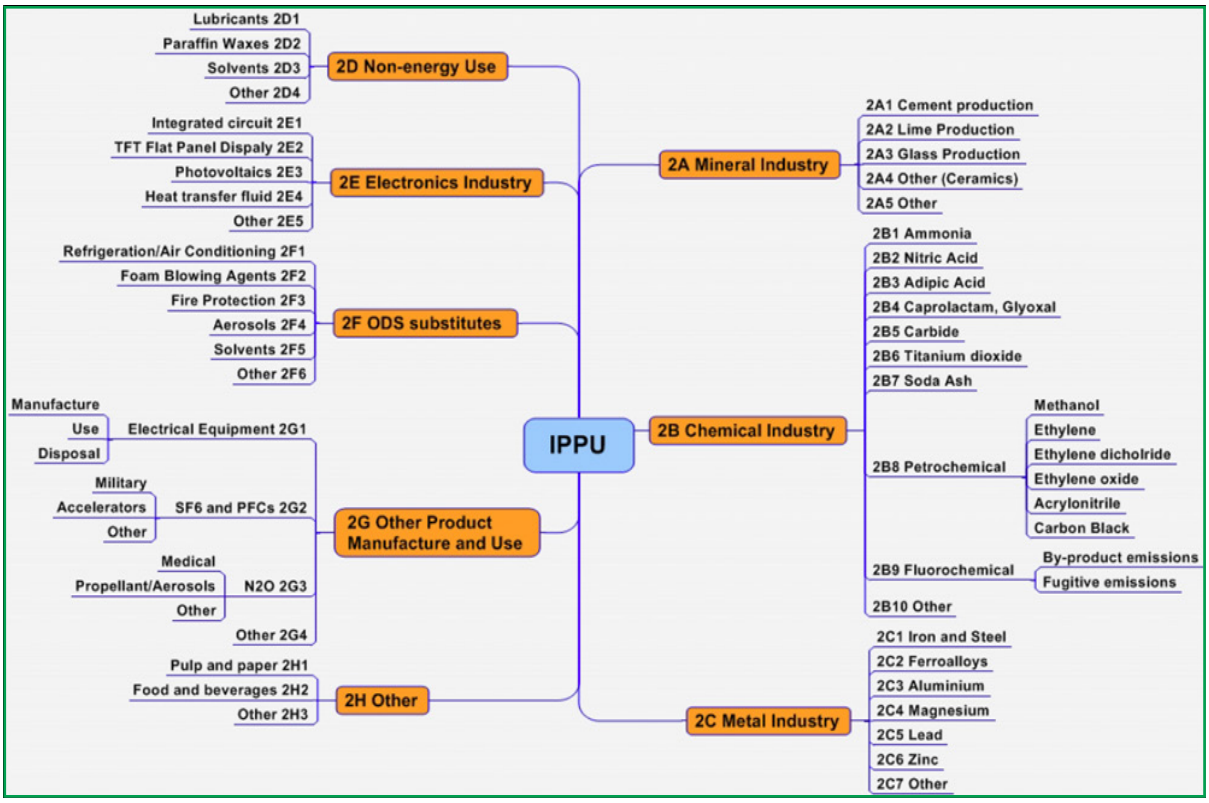
Figure 3.3: Trend of GHG emissions from Energy by category, 2000 – 2015



3.3. Inventory of GHG Emissions from IPPU Sector

The Industrial Processes and Product Use (IPPU) covers greenhouse gas emissions occurring from industrial processes, the use of greenhouse gases in products, and non-energy uses of fossil fuel carbon (IPCC, 2019). Examples of industrial processes include the blast furnace in the iron and steel industry, ammonia and other chemical products manufactured from fossil fuels used as chemical feedstock, the cement industry, and aluminium production, among others **(see Figure 3.3a)**. During these processes, many different greenhouse gases, including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and other fluorinated compounds such as trifluoromethyl sulphur pentafluoride (SF5CF3) can be produced and emitted (IPCC, 2019). Though Botswana is less industrialized, it contributes to the global GHG emissions and measures should be put in place to help in the mitigation against this problem.

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



Source: Shermanau (2017b)

Table 3.3 presents the emissions of greenhouse gases from industrial processes and product use, for the years 2000 to 2015. The chemical industry proved to be Botswana's major GHG emissions contributor from the IPPU, followed by the mineral industry and the product uses and substitutes for ozone depleting substances (Refrigeration and air conditioning) in that order. From the years 2000 to 2015 GHG emissions from the chemical industry had a fluctuating trend with the highest emission of 1,339.71 Gg CO_2–eq recorded in 2006. On the other hand the mineral industry production (cement production) showed an increasing trend over the years. This shows an increase in industrialization in Botswana since more cement is being produced and used for construction. The year 2011 saw the highest volume of CO2 emissions from cement production (130.18 Gg CO_2–eq) while the lowest emissions of 17.38 Gg CO_2–eq was recorded in 2000. From the chemical industry, soda ash production had the highest volume of emissions in 2006 at 1,339.71 Gg CO_2–eq which was a 58 percent increase from 845.09 Gg CO_2–eq in the year 2000. Furthermore, there was an 18.29 percent decrease from the year 2006 which had the highest emission volume to the year 2015.

Table 3.3: Time series IPPU sector emissions by categories (Gg CO2-eq), 2000 - 2015

GHG Categories	GHG Sub-categories	2000	2001	2002	2003	2004	2005	2006	2007
2.A - Mineral Industry	2.A.1 Cement Production	17.38	21.26	25.14	29.02	32.90	36.78	40.66	118.73
2.B - Chemical Industry	2.B.7 Soda Ash Production	845.09	1,189.27	1,240.18	1,047.69	1,269.20	1,213.75	1,339.71	1,199.62
2.F - Product Uses as Substitutes for ODS	2.F.1 Refrigeration and Air Conditioning	-	-	-	0.01	0.02	0.95	0.84	0.96
TOTAL		**862.47**	**1,210.54**	**1,265.32**	**1,076.72**	**1,302.12**	**1,251.48**	**1,381.20**	**1,319.31**
2.A - Mineral Industry **(%)** contribution		2.02	1.76	1.99	2.70	2.53	2.94	2.94	9.00
2.B - Chemical Industry **(%)** contribution		97.98	98.24	98.01	97.30	97.47	96.99	97.00	90.93
2.F - Product Uses as Substitutes for ODS **(%)** contribution		-	-	-	0.00	0.00	0.08	0.06	0.07

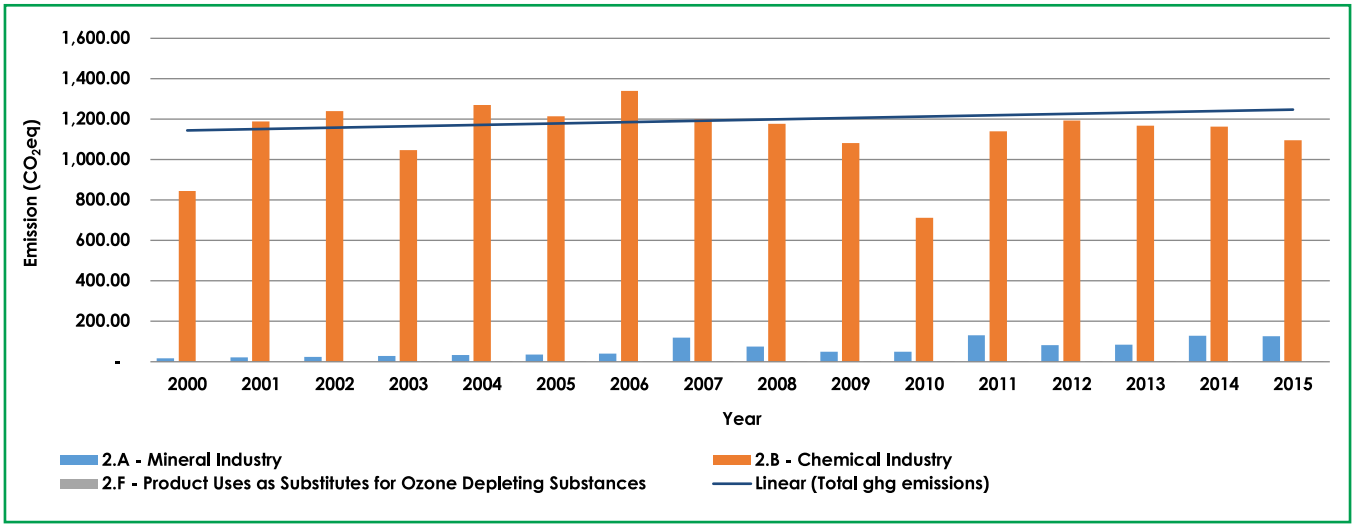
Source: Department of Meteorological Services
Note: (-) No data

Table 3.3 Cont'd: Time series IPPU sector emissions by categories (Gg CO2-eq), 2000 - 2015

GHG Categories	GHG Sub-categories	2008	2009	2010	2011	2012	2013	2014	2015
2.A - Mineral Industry	2.A.1 Cement Production	75.27	48.74	48.74	130.18	83.20	84.40	129.27	126.42
2.B - Chemical Industry	2.B.7 Soda Ash Production	1,177.47	1,081.37	711.40	1,140.73	1,194.25	1,167.15	1,164.17	1,094.72
2.F - Product Uses as Substitutes for ODS	2.F.1 Refrigeration and Air Conditioning	1.27	1.08	0.99	0.90	0.80	0.72	0.64	0.55
TOTAL			**1,131.19**	**761.13**	**1,271.80**	**1,278.25**	**1,252.27**	**1,294.08**	**1,221.69**
2.A - Mineral Industry **(%)** contribution		6.00	4.31	6.40	10.24	6.51	6.74	9.99	10.35
2.B - Chemical Industry **(%)** contribution		93.90	95.60	93.47	89.69	93.43	93.20	89.96	89.61
2.F - Product Uses as Substitutes for ODS **(%)** contribution		0.10	0.10	0.13	0.07	0.06	0.06	0.05	0.05

Source: Department of Meteorological Services
Note: (-) No data

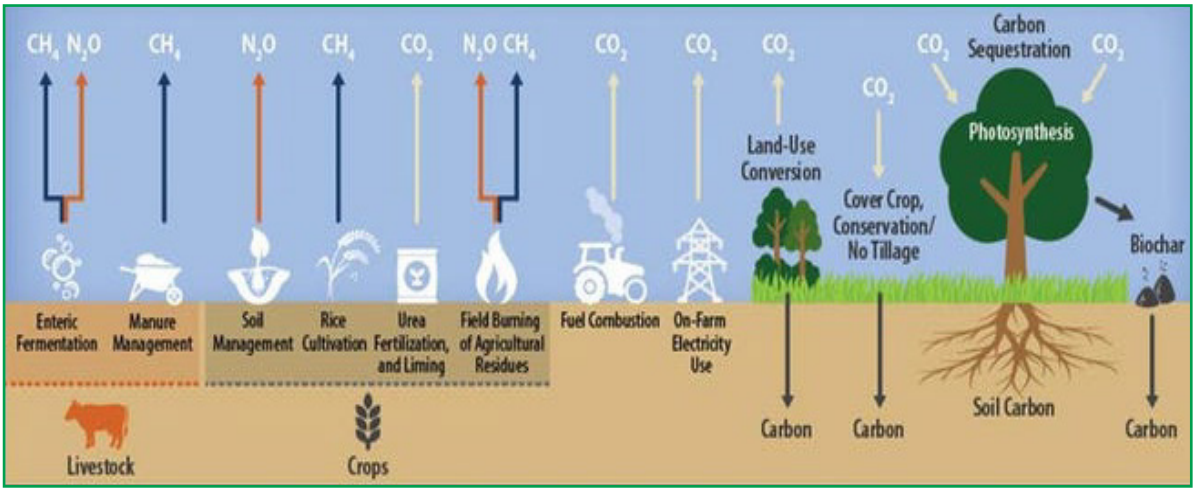
Figure 3.3b: Trend of GHG Emissions from IPPU Sector, 2000 – 2015



3.4. Inventory of GHG Emissions from AFOLU Sector

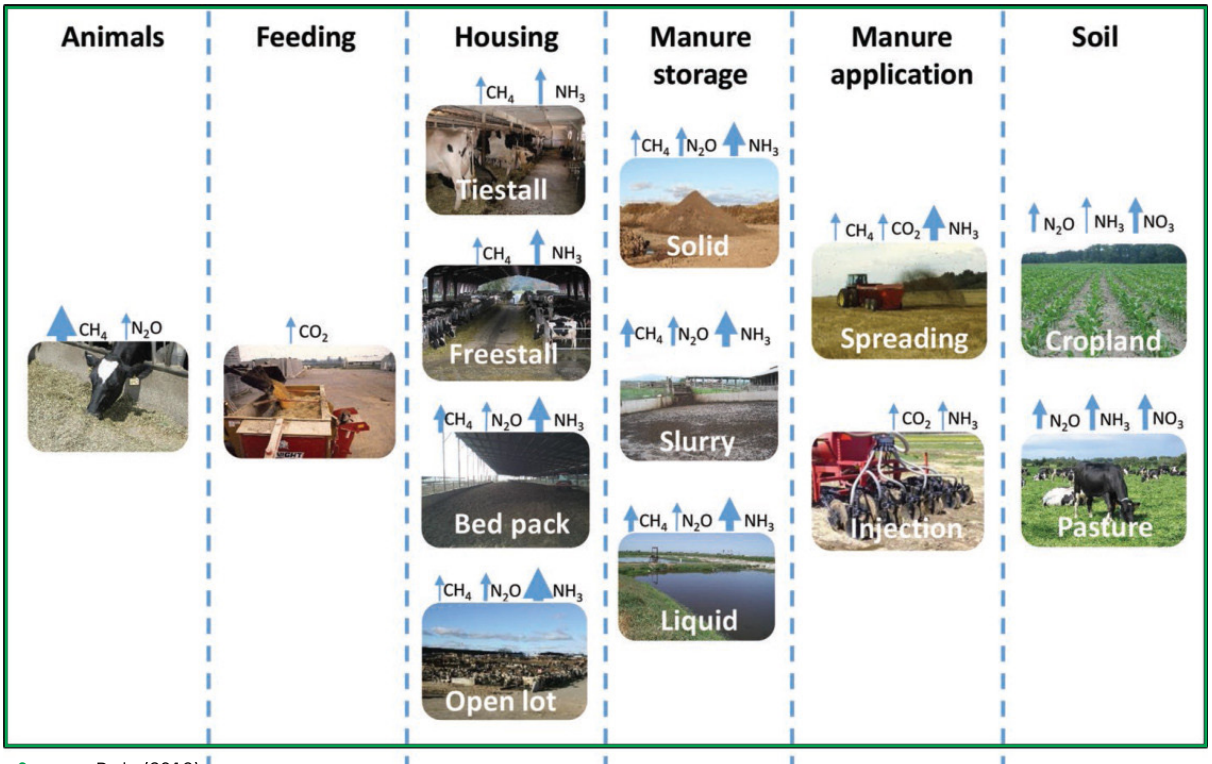
This section presents the emissions and removals of GHGs from the AFOLU sector constituted by Agriculture, Forestry, and Other Land Use. The GHG emissions from Agriculture and Land Use and Land Use Change and Forestry (LULUCF) have been combined into a single sector called AFOLU. According to the IPCC 2006 guidelines, AFOLU sector is made up of three categories: 3A-Livestock; 3B-Land; and 3C-Aggregate Sources and Non-CO_2 Emissions on Land. AFOLU activities lead to both sources of CO_2 and sinks of CO_2, and to non-CO_2 emissions primarily from agriculture (e.g. from livestock, rice cultivation, manure storage and agricultural soils, and biomass burning) (Smith et al. 2014). See **Figures 3.4a** and **3.4b**.

Figure 3.4a: Agricultural activities releasing CO_2, CH_4, and N_2O, and activities storing carbon in plants and soil



Source: Wisfarmer (2021)

Figure 3.4b: Important direct and indirect GHG sources and relative amounts (differently sized arrows) emitted from dairy farms



Source: Rotz (2018)

Table 3.4a shows a summary inventory of GHG emissions from the AFOLU Sector (excl. FOLU) for the period 2000 to 2015. **Figure 3.4c** reveals a fluctuating trend over the years, with the highest estimate recorded in 2002 at 2,385.87 Gg CO_2-eq and the lowest recorded in 2015 at 1,403.77 Gg CO_2-eq. As aforementioned, livestock is a major emitter of greenhouse gases (GHG) in the AFOLU sector (excl. FOLU) via enteric fermentation. In 2002, enteric fermentation contributed the highest percentage (96.4%) to the total emissions from the AFOLU sector (excl. FOLU) and the remaining 3.6 percent was from manure management. In 2015, enteric fermentation was still dominating by 95.3 percent while manure management contributed only 4.7 percent of the total emissions from AFOLU (excl. FOLU). Enteric fermentation continued to be the leading source of GHG emissions throughout the 2000-2015 inventory years.

Table 3.4a: Agriculture Sector Emissions by category (Gg CO2-eq): 2000 - 2015

GHG Categories	GHG Sub-categories	2000	2001	2002	2003	2004	2005	2006	2007
3.A - Livestock	3.A.1-Enteric Fermentation	1,643.96	1,941.83	2,299.92	1,604.72	1,694.15	1,665.86	1,637.56	1,439.03
	3.A.2-Manure Management	63.15	75.04	85.95	64.52	66.45	65.35	64.24	56.1
TOTAL		**1,707.11**	**2,016.87**	**2,385.87**	**1,669.24**	**1,760.61**	**1,731.21**	**1,701.80**	**1,495.13**
3.A.1-Enteric Fermentation **(%)** contribution		96.3	96.28	96.4	96.13	96.23	96.23	96.23	96.25
3.A.2-Manure Management **(%)** contribution		3.7	3.72	3.6	3.87	3.77	3.77	3.77	3.75

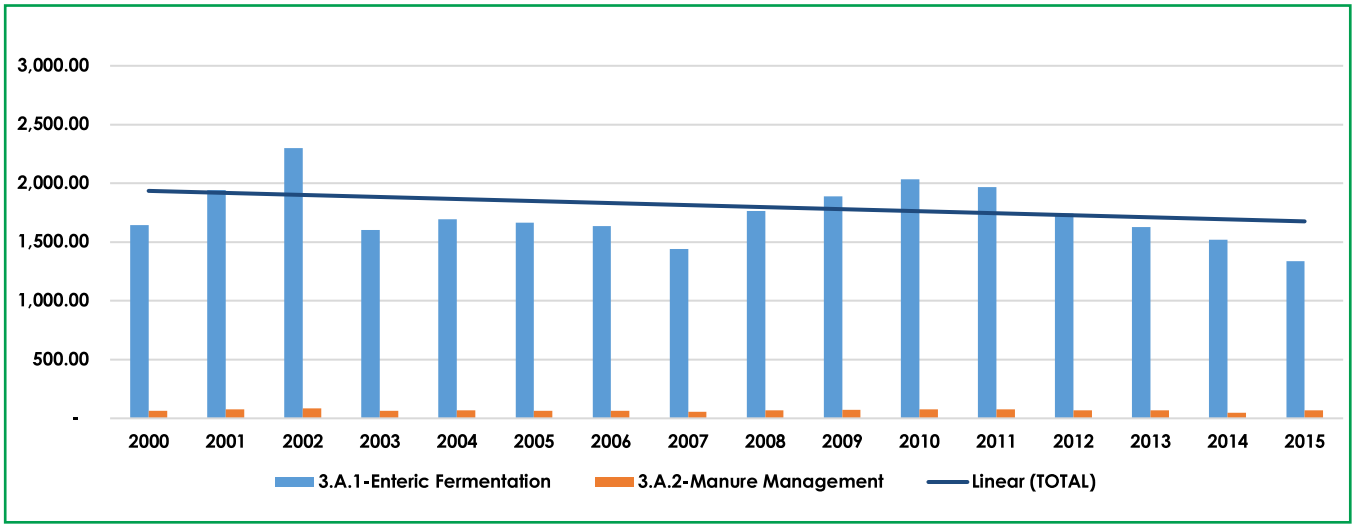
Source: Department of Meteorological Services

Table 3.4a Cont'd: Agriculture Sector Emissions by category (Gg CO2-eq): 2000 - 2015

GHG Categories	GHG Sub-categories	2008	2009	2010	2011	2012	2013	2014	2015
3.A - Livestock	3.A.1-Enteric Fermentation	1,765.94	1,889.65	2,035.35	1,969.18	1,742.47	1,625.82	1,519.82	1,337.31
	3.A.2-Manure Management	68.41	72.68	76.75	74.58	66.47	66.46	47.18	66.46
TOTAL		**1,834.35**	**1,962.33**	**2,112.10**	**2,043.76**	**1,808.94**	**1,692.28**	**1,567.00**	**1,403.77**
3.A.1-Enteric Fermentation **(%)** contribution		96.27	96.3	96.37	96.35	96.33	96.07	96.99	95.27
3.A.2-Manure Management **(%)** contribution		3.73	3.7	3.63	3.65	3.67	3.93	3.01	4.73

Source: Department of Meteorological Services

Figure 3.4c: Summary Inventory of GHGs Emissions from AFOLU SECTOR (exl. FOLU), 2000-2015



[2] **Aggregate Sources and Non-CO2 Emissions:** emission sources from liming, rice cultivation, direct and indirect N_2O from managed soils, biomass burning, urea application, and indirect N_2O from manure management (IPCC, 2006).

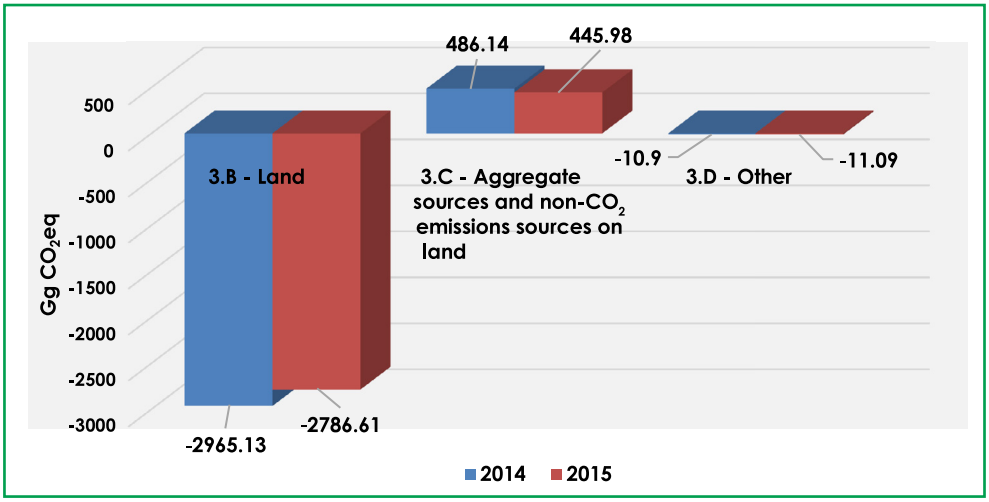
Table 3.4b represents the net emissions from Forest and Other Land use (FOLU) category for the years 2014 and 2015. For the net emissions, the trend is dominated by forest land as the major sink. It appears to have been a minimal conversion of forest land to other land uses, such as settlements or croplands. The total removals of GHGs from the land category reduced by 6.02 percent in 2015 (-2, 786.61 Gg net CO_2-eq) from (-2, 965.13 Gg net CO_2-eq) in 2014. The major emitter of GHGs from the land category was grassland with a contribution of 1, 3196.1 CO_2-eq in 2014 which increased by 7 percent to 1, 5198.92 CO_2-eq in 2015. **Table 3.4b** further shows that the Aggregate sources and non-CO_2 emissions sources on land accounted for approximately 486.14 Gg CO_2-eq emissions in 2014 and in the year 2015, approximately 445.98 Gg CO_2-eq emissions, a decrease of 8.3 percent.

Table 3.4b: Net Emissions from Land, and Aggregate sources and non-CO_2 emissions sources on land subcategories: 2014 & 2015 (CO_2-eq)

	Year	
GHG Categories	**2014**	**2015**
Unit	**Net Gg CO_2eq**	**Net Gg CO_2eq**
3.B - Land	**-2965.13**	**-2786.61**
3.B.1 - Forest land	-16196.29	-18019.6
3.B.2 - Cropland	0.03	0.03
3.B.3 - Grassland	13196.1	15198.92
3.B.4 - Wetlands	33.62	33.62
3.B.5 - Settlements	1.31	0.33
3.B.6 - Other Land	0.1	0.1
3.C - Aggregate sources and non-CO_2 emissions sources on land	**486.14**	**445.98**
3.D - Other	**-10.9**	**-11.09**

Source: Department of Meteorological Services

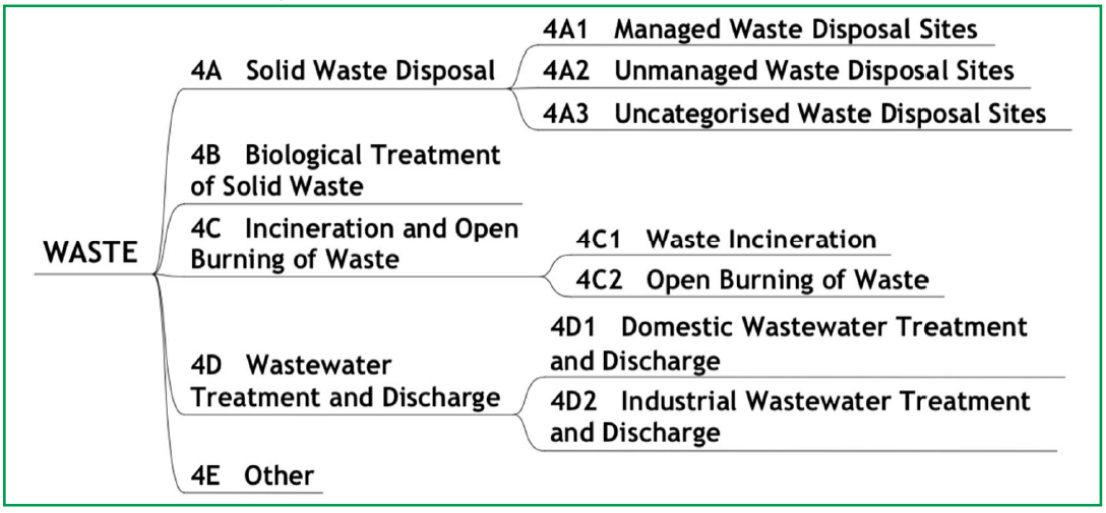
Figure 3.4d: Net Emissions from Land, and Aggregate sources and non-CO_2 emissions sources on land subcategories: 2014 & 2015 (CO_2-eq)



3.5. Inventory of GHG Emissions from Waste Sector

This section presents emissions of GHGs from the waste sector, the main categories being Solid Waste Disposal and Waste water Treatment and Discharge. Waste is a small contributor to global GHG emissions contributing <5% of total global emissions, the largest source being landfill methane (CH_4), followed by wastewater CH_4 and nitrous oxide (N_2O); in addition, minor emissions of carbon dioxide (CO_2) result from incineration of waste containing fossil carbon (C) (plastics; synthetic textiles) (Bogner et al. 2007). The waste sector contributes up to 1% of Botswana's total emissions (GoB, 2019). **Figure 3.5a** shows the structure of categories within the Waste Sector and coding of their IPCC categories.

Figure 3.5a: Structure of Waste Sector



Source: IPCC (2006)

Table 3.5 and **Figure 3.5b** illustrate the summary inventory of GHG emissions from the Waste sector for the period 2000 to 2015. It is evident from the table that there was an upward trend of total GHG emissions from the waste sector which indicates a general increase in the emissions by categories in this sector. The trend is dominated by emissions from the Solid waste disposal category which contributed annual average of about 77.5 percent towards the total sector emissions. The highest emissions from the solid waste disposal category were recorded in the year 2015 with 584.07 Gg CO_2-eq. The domestic waste water treatment and discharge category also followed an upward trend, with the highest emissions estimated at 101.85 Gg CO_2-eq in 2015 and the lowest at 60.04 Gg CO_2-eq recorded in 2000.

Table 3.5: Time series Waste Sector emissions by categories (Gg CO_2-eq): 2000–2015

GHG Categories	GHG Sub- categories	2000	2001	2002	2003	2004	2005	2006	2007
4.A-Solid Waste Disposal	4.A-Solid Waste Disposal	138.88	158.5	175.84	191.9	215.74	244.24	275.13	305
4.D -Wastewater Treatment and Discharge	4.D.1- Domestic Wastewater Treatment and Discharge	60.04	82.61	78.63	79.76	80.7	81.45	82.03	82.83
TOTAL		**198.92**	**241.1**	**254.48**	**271.66**	**296.44**	**325.7**	**357.16**	**387.83**
4.A-Solid Waste Disposal **(%)**		69.82	65.74	69.10	70.64	72.78	74.99	77.03	78.64
4.D- Domestic Wastewater Treatment and Discharge **(%)**		30.18	34.26	30.90	29.36	27.22	25.01	22.97	21.36

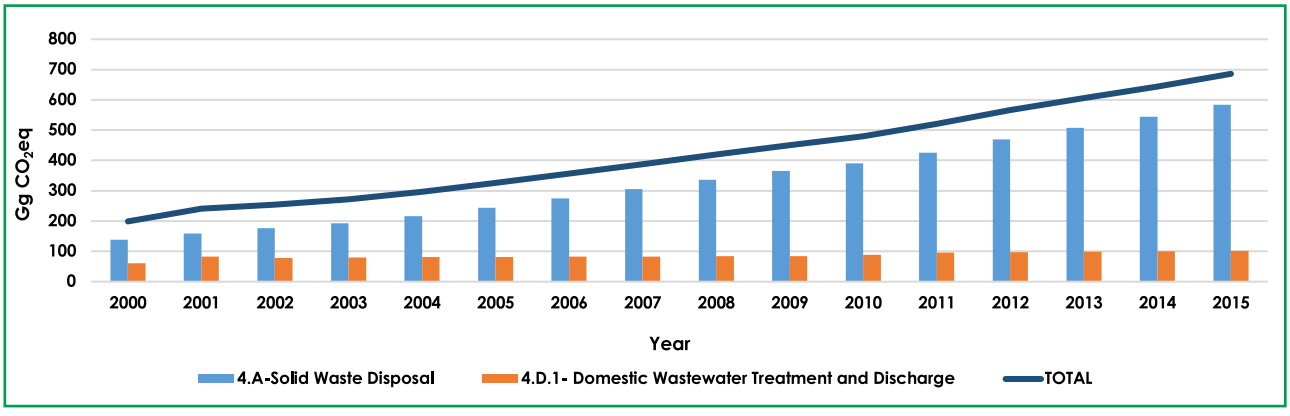
Source: Department of Meteorological Services

Table 3.5 Cont'd: Time series Waste Sector emissions by categories (Gg CO_2-eq): 2000–2015

GHG Categories	GHG Sub- categories	2008	2009	2010	2011	2012	2013	2014	2015
4.A-Solid Waste Disposal	4.A-Solid Waste Disposal	336.48	366.12	391.16	425.29	469.5	507.38	543.99	584.07
4.D -Wastewater Treatment and Discharge	4.D.1- Domestic Wastewater Treatment and Discharge	83.76	84.8	88.07	95.48	97.5	98.97	100.43	101.85
TOTAL		**420.24**	**450.92**	**479.23**	**520.78**	**566.99**	**606.35**	**644.42**	**685.92**
4.A-Solid Waste Disposal **(%)**		80.07	81.19	81.62	81.66	82.81	83.68	84.42	85.15
4.D- Domestic Wastewater Treatment and Discharge **(%)**		19.93	18.81	18.38	18.33	17.20	16.32	15.58	14.85

Source: Department of Meteorological Services

Figure 3.5b: Time series Waste Sector emissions by categories (Gg CO_2-eq): 2000–2015



4.0. NATURAL DISASTERS

The information on natural hazards causing disasters is provided in this chapter. It centres on trends of incidences of floods, storms and heavy rains, and their impact on people's livelihoods and the environment they depend on.

4.1. Floods and Storms

Floods are the most recurrent type of natural disaster and occur when an overflow of water submerges land that is usually dry. Floods are often caused by heavy rainfall, a storm surge from a tropical cyclone among others. Floods are among the hazards that cause widespread destruction to human lives, properties and the environment every year and occur at different places with varied scales across the globe (Glago, 2021). Floods are categorised as natural hazards and they only become disasters when they destroy human settlements, or when they displace, cause injuries or death. In Botswana the most common floods are both river floods from seasonal precipitation and flash floods caused by seasonal storms.

Presented in this sub-section are floods, heavy rains, and storm occurrences by location and year, as well as the number of households and individuals affected, and assistance given.

4.1.1. Floods

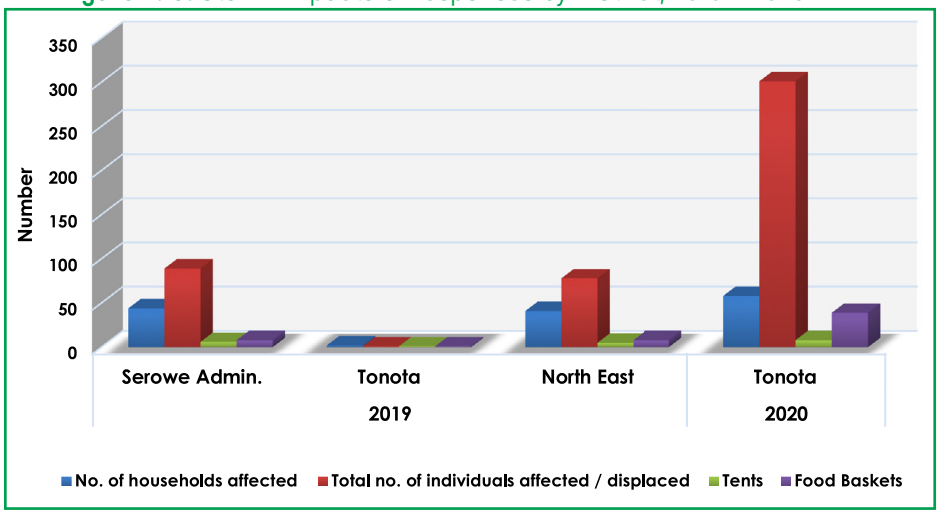
Table 4.1a shows the total floods incidences and impacts by district in Botswana for the period 2019 – 2020. During the same period floods affected 145 households with 469 individuals affected/displaced. The impact resulted in a total of 20 tents and 56 food baskets issued to the victims as a form of relief.

Table 4.1a: Floods Incidences & Impacts by District, 2019 – 2020

Incident	Year	District	Villages	Impact/Damages		Assistance given	
				No. of households affected	Total no. of individuals affected / displaced	Tents	Food Baskets
Floods	**2019**	**Serowe Admin.**	Setshe, Kgosing, Mausu, Moeletsi	44	89	6	8
		Tonota	Shashemooke, Jamataka	2	1	1	1
		North East	Zwenshambe, Gungwe, Kalakamati	41	78	5	8
	2020	**Tonota**	Tonota, Makobo, Foley	58	301	8	39
			Total	**145**	**469**	**20**	**56**

Source: National Disaster Management Office

Figure 4.1a: Storm Impacts & Responses by District, 2019 – 2020



4.1.2. Storms Incidences (Hailstorm & Storm)

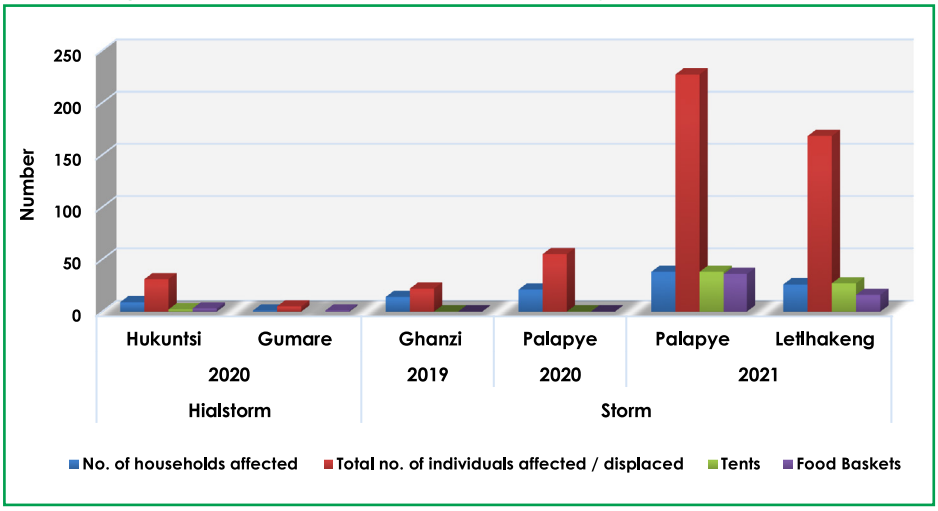
The most current storm incidences were recorded in the year 2021 as depicted in **Table 4.1b** and **Figure 4.1b**. The storm incidences reported in 2021 took place at Tamasane and Lesenepole villages in Palapye Sub District affecting 38 households with 227 individuals. Consequently, a total of 38 tents and 36 food baskets were issued to the affected households. On the other hand, Sorilatholo, Salajwe, Motokwe, Khudumelapye, Botlhapatlou villages in Letlhakeng district recorded a total of 26 households with 168 individuals affected by storm in 2021. **Table 4.1b** also depicts that hailstorm incidences were only reported in 2020 at Lehututu village in Hukuntsi district and Gumare village.

Table 4.1b: Storm Incidences, Impacts & Responses by District, 2019 – 2021

Incident	Year	District	Villages	Impact/Damages		Assistance given	
				No. of households affected	Total no. of individuals affected / displaced	Tents	Food Baskets
Hailstorm	2020	Hukuntsi	Lehututu	9	31	2	3
		Gumare	Gumare	1	5	0	1
Storm	2019	Ghanzi	New Xade	14	22	0	0
	2020	Palapye	Tamasane, Lesenepole	21	55	0	0
	2021	Palapye	Tamasane, Lesenepole	38	227	38	36
		Letlhakeng	Sorilatholo, Salajwe, Motokwe, Khudumelapye, Botlhapatlou	26	168	27	16
Total				109	508	67	56

Source: National Disaster Management Office

Figure 4.1b: Storm Impacts & Responses by District, 2016 – 2021



4.1.3. Heavy Rains

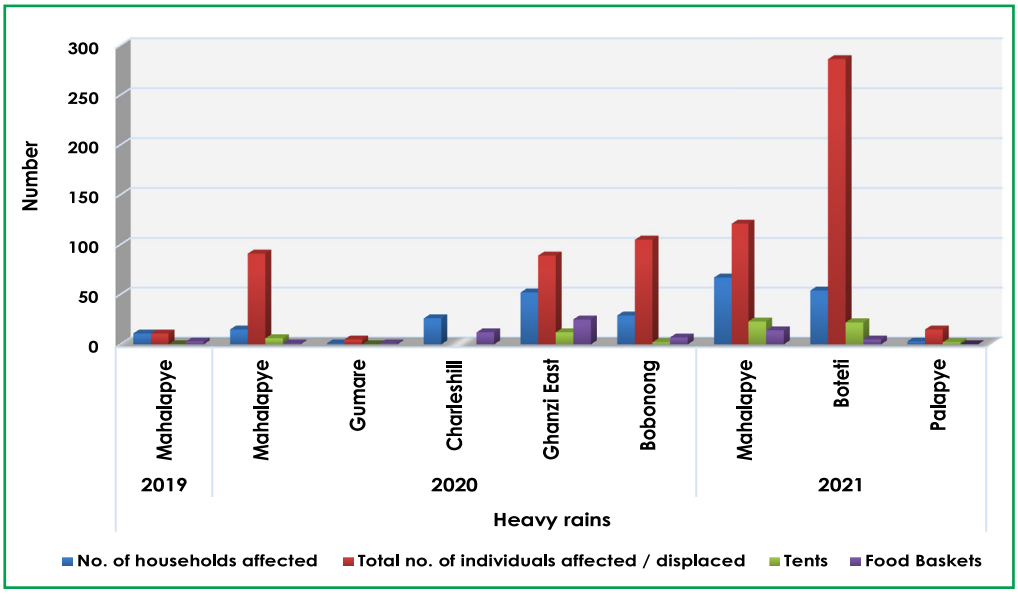
From a total of 258 households affected by heavy rains during the period 2019 to 2021, the highest number of households affected (67) were recorded in the Mahalapye District in 2021. During the same period Boteti district recorded the highest number (286) of individuals affected / displaced by heavy rains in 2021, followed by Mahalapye district (121) in the same year. About 40 percent (286) of the total number (723) of individuals affected / displaced by heavy rains during the review period was from the Boteti district **(Table 4.1c and Figure 4.1c)**.

Table 4.1c: Heavy Rains Incidences & Impacts by District, 2019 – 2021

Incident	Year	District	Villages	Impact/Damages		Assistance given	
				No. of households affected	Total no. of individuals affected / displaced	Tents	Food Baskets
Heavy rains	**2019**	**Mahalapye**	Borotsi, Chadibe, Sefhare	11	11	0	3
	2020	**Mahalapye**	Seleka, Shakwe	15	91	6	1
		Gumare	Bothathogo	1	5	0	1
		Charleshill	Ncojane	26			12
		Ghanzi East	Kgaphamadi, Khurakhura, Kabakae	52	89	12	25
		Bobonong	Mmadinare, Tsetsebjwe, Meremetsi, Mosetlha, Gobojango	29	105	2	7
	2021	**Mahalapye**	Moralane, Mosolotshane, Pallaroad, Shoshong, Shakwe, Kalamare	67	121	23	14
		Boteti	Rakops, Letlhakane	54	286	22	5
		Palapye	Mogapinyana	3	15	2	0
		Total		**258**	**723**	**67**	**68**

Source: National Disaster Management Office

Figure 4.1c: Heavy Rains Incidences & Impacts by District, 2019 – 2021



5.0. AGRICULTURAL PRODUCTION

This section presents trends in agricultural production with particular reference to production and yield of grains and perennial crops. Agricultural production has always involved the exploitation of resources such as soil, water, and energy. Increasing production to feed a growing world population while at the same time conserving resources for future generations has led to a search for 'sustainable' agricultural methods (Edwards & Duffy, 2014). Agricultural production relies on a host of water-related ecosystem services, ranging from water supply (quantity), to purification (quality), and flood protection (Brauman et al. 2007). Agricultural production has been challenged by many factors including high temperature, low rainfall, diseases, weeds, and insect pests resulting in loss of crop yield (Rani et al. 2020).

In Botswana the top three cereals that are produced are sorghum, maize and millet. Crop production in Botswana continues to experience limits on its growth posed by recurring drought, limited skills, inadequate market access and marketing facilities, as well as inadequate use of improved technology. About 70% of rural household derive their livelihoods from agriculture, through subsistence farming which is rain fed based (GoB, 2012). Hence there is need to document trends in agricultural production in order to monitor the challenging situation of food insecurity the country is faced with.

5.1. National Crop Yield Estimates (Grains)

Table 5.1 displays the yield per hectare harvested by crop in 2012 – 2019 for the traditional sector. The crops under discussion include sorghum, maize, millet and beans/pulses. Millet had the highest yield per hectare harvested during the period 2012 to 2019, followed by sorghum, maize and beans/pulses in that order.

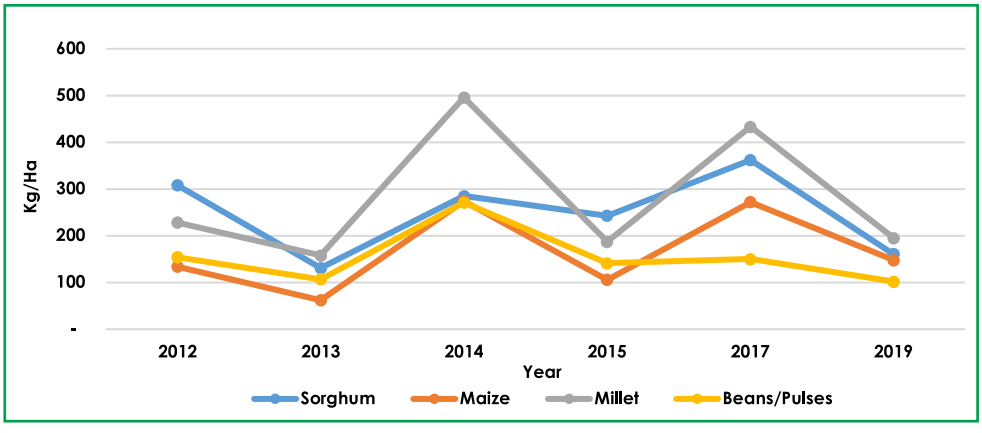
In 2014, millet recorded the highest annual yield of 496 Kg/Ha harvested which declined to 195 Kg/Ha in 2019. As for sorghum, the highest annual yield per hectare harvested was recorded in 2017 with 362 Kg/ha. Maize experienced the lowest annual yield per hectare during the review period with 62 Kg/Ha harvested in 2013. In general, all the annual yields per hectare per crop saw a fluctuating trend during the review period with a decline towards the current years **(Table 5.1 and Figure 5.1)**.

Table 5.1: Yield per Hectare Harvested (Kg/Ha) by Crop, 2012 - 2019

Crop	2012	2013	2014	2015	2017	2019
Sorghum	308	131	285	243	362	161
Maize	134	62	274	106	272	148
Millet	228	158	496	187	433	195
Beans/Pulses	154	107	271	141	150	102

Source: Agricultural Statistics Unit, Statistics Botswana

Figure 5.1: Yield per Hectare Harvested (Kg/Ha) by Crop, 2012 - 2019



5.2. National Grain Production

Table 5.2 shows the production in Metric Tonne (MT) by cereal crop (sorghum, maize, millet) and beans/pulses in 2012 – 2019 for the traditional sector. In 2019, grain production fell to 2,709 metric tonnes down by 88.36 percent from 23,283 metric tonnes of grains produced in Botswana in 2017. Maize had the highest cereal production during the 2012 – 2019 period, with 54,960 metric tonnes produced followed by sorghum (34,898 metric tonnes) and beans/pulses (14,201 metric tonnes). Together, these three crops accounted for nearly 93 percent of the national grain production **(Figure 5.2b)**. The highest annual grain production was recorded in 2014 with 53,084 MT and maize constituted about 54 percent (28,550 MT) of the total production for that year.

Generally, all the annual yields per crop observed a fluctuating trend during the review period with a decline towards 2019 **(Table 5.2 and Figure 5.2a)**.

Table 5.2: Grain Production (MT), 2012 - 2019

Crop	2012	2013	2014	2015	2017	2019	Total
Sorghum	7,461	4,401	14,310	1,927	5,973	826	**34,898**
Maize	7,450	2,689	28,550	1,417	13,867	987	**54,960**
Millet	1,582	1,263	3,398	513	1,100	313	**8,169**
Beans/Pulses	1,915	1,738	6,826	796	2,343	583	**14,201**
Total	**18,408**	**10,091**	**53,084**	**4,653**	**23,283**	**2,709**	**112,228**

Source: Agricultural Statistics Unit, Statistics Botswana

Figure 5.2a: Grain Production (MT), 2012 - 2019

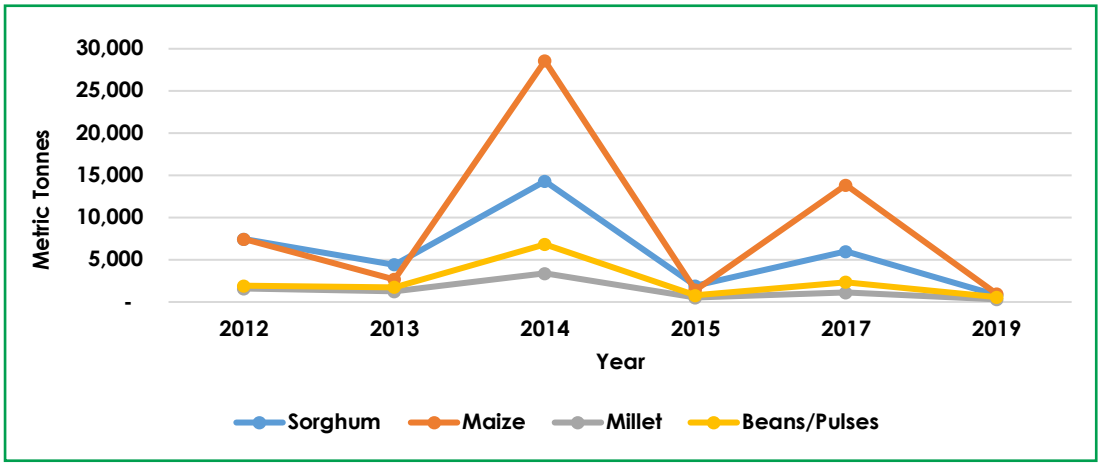
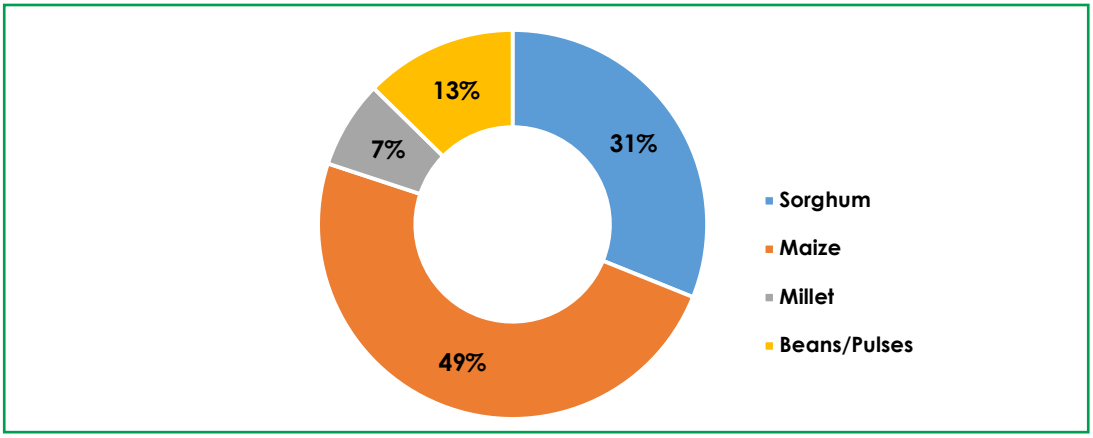


Figure 5.2b: Percent Contribution of Cereal Crops & Pulses to total production, 2012 - 2019



5.3. National Perennial Crop Production

Perennial crops are plants, used in agriculture that can be harvested multiple times before replanting and they are beneficial in a variety of ways, producing food and fuel, and providing agronomic, environmental, and cultural benefits (Tregeagle, 2017). There are many types of perennial crops ranging from fruit trees to perennial grasses (e.g. sugar cane) and plants used for decoration, like roses and other flowering shrubs. The focus here is on fruit production.

Table 5.3 shows fruit production in tonnes/crop (oranges, mango, pawpaw, strawberry, grapes, naartjies, peaches and guava) during the 2012/13 – 2018/19 cropping seasons, as well as area planted (Ha). It is evident from **Table 5.3** that oranges followed by mango and pawpaw yielded the highest harvests during the review period with total fruit production of 21,779.14 tonnes, 832.75 tonnes and 322.63 tonnes respectively. The total annual perennial crop production saw a fluctuating trend during the 2012/3 – 2018/19 cropping seasons with the highest production recorded in 2015/16 with 5,112.84 tonnes.

On the other hand, **Table 5.3** reveals that changes in area planted with perennial crops (fruit trees) had no significant effect on production during that period. For example, in 2015/16 cropping year about 71.96 hectare of area planted produced 5,112.84 tonnes of fruits while in 2017/18 cropping season about 210.84 hectare of area planted produced 4,037.06 tonnes of fruits. The highest area planted was recorded in 2013/14 cropping season from which 3,383.96 tonnes of fruits were produced.

Table 5.3: Fruit Production (Tonnes), 2012/3 – 2018/19

Fruit Production	2012/13		2013/14		2014/15		2015/16		2016/17		2017/18		2018/19	
	Area (ha) planted	Actual tons/ crop	Area (ha) planted	Actual tons/ crop	Area (ha) planted	Actual tons/ crop	Area (ha) planted	Actual tons/ crop	Area (ha) planted	Actual tons/ crop	Area (ha) planted	Actual tons/ crop	Area (ha) planted	Actual tons/ crop
Oranges	51.61	3,495.57	313.05	3,343.56	24.05	3,334.21	53.62	5,026.28	11.04	260.43	206.63	3,914.15	18.07	2,404.93
Mango	3.00	535.06	27.31	35.79	0.08	44.12	14.66	74.91	1.00	4.74	4.08	108.83	3.71	29.30
Pawpaw	0.10	304.17	0.10	0.53	0.12	0.05	0.75	0.21	-	1.20	-	8.42	0.02	8.05
Strawberry	-	0.05	0.38	4.08	0.56	2.35	1.00	10.00	2.00	2.02	0.13	5.16	0.91	4.17
Grapes	0.03	1.04	2.50	-	0.03	3.90	0.22	1.05	3.00	3.10	-	0.50	-	4.70
Naartjies	0.04	10.00	0.40	-	0.03	-	1.13	-	-	-	-	-	-	-
Peaches	0.13	1.80	6.01	-	0.03	-	0.58	-	-	-	-	-	0.04	0.27
Guava	0.10	-	1.25	-	-	-	0.00	0.39	-	-	-	-	-	-
Total	**55.01**	**4,347.69**	**351.00**	**3,383.96**	**24.88**	**3,384.63**	**71.96**	**5,112.84**	**17.04**	**271.49**	**210.84**	**4,037.06**	**22.75**	**2,451.42**

Dash (-) means data not available
Source: Department of Crop Production, Ministry of Agriculture

6.0. WATER

6.1. Dam levels

Climate change affects human well-being through various factors, which include fresh water availability. Rainfall recharges water reservoirs while temperatures determine the rate of evaporation from the reservoirs. Abstraction is the process of withdrawing water for treatment and use for human well-being.

Botswana has nine dams from which surface water is sourced, namely Gaborone, Nnywane, Bokaa, Letsibogo, Shashe, Ntimbale, Thune, Lotsane and Dikgathong dams. Botswana also imports water from Molatedi dam in the Republic of South Africa.

Table 6.1: Dam Capacities (Mm^3)

Dam	Capacity (Mm^3)
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: Water Utilities Cooperation
Note: Molatedi dam is in South Africa and provides imported water to Botswana

Table 6.1 shows the dam capacities. Dikgathong dam is the country's largest dam by capacity at 400 million cubic metres (Mm^3) while Nnywane is the smallest at 2.3 million cubic meters. Dam levels depend on rainfall in the catchment areas, as well as inflows and outflows of water into and out of the dams. Evaporation rates are also a determinant in the dam levels.

Table 6.2 shows the mid-month dam levels for the period 2016 to 2021. **Figure 6.1** shows the annual average dam levels. Gaborone dam recorded the lowest point at 1.7 percent in January and February 2016, after the effects of the 2015 drought. The highest annual average dam level was recorded at Dikgathong dam followed by Ntimbale dam in 2017. Nationally, the dams held the highest annual average levels in 2017, followed by 2021 and 2018.

Table 6.2: Mid-month dam levels (Percent)

Year:	Date	Gaborone	Nnywane	Bokaa	Letsibogo	Shashe	Ntimbale	Thune	Lotsane	Dikgathong	Molatedi	Monthly Average
2016	Jan 18th	1.7	100.0	51.7	35.6	83.8	82.7	36.5	46.5	70.4	7.3	51.6
	Feb 15th	1.7	93.3	49.4	36.5	80.7	91.0	37.0	44.4	70.0	7.0	51.1
	Mar 17th	9.0	102.6	73.5	68.7	100.8	101.6	37.3	98.0	88.0	8.9	68.8
	Apr 20th	18.8	94.6	99.0	75.9	98.1	97.8	39.9	96.9	97.9	39.3	75.8
	May 19th	18.6	88.2	91.5	72.9	95.4	95.4	37.0	93.2	95.9	36.0	72.4
	Jun 6th	17.2	80.1	88.5	71.1	93.7	93.8	37.0	91.0	94.5	35.0	70.2
	Jul 21st	16.1	77.3	82.5	67.9	89.4	90.6	36.2	87.8	92.1	33.7	67.4
	Aug 8th	15.5	74.1	80.0	66.0	87.2	88.0	-	-	91.0	-	71.7
	Sep 12th	14.4	68.0	75.7	63.3	83.6	88.5	-	-	-	29.7	60.5
	Oct 10th	13.2	61.5	71.4	60.6	80.5	87.0	-	-	-	-	62.4
	Nov 18th	13.7	54.0	71.8	57.3	77.8	79.8	29.9	91.5	84.2	24.7	58.5
	Dec 8th	14.6	74.5	99.8	56.3	76.3	78.7	29.9	92.6	83.2	24.9	63.1
	Annual Average	12.9	80.7	77.9	61.0	87.3	89.6	35.6	82.4	86.7	24.7	64.4
2017	Jan 16th	22.2	100.0	100.0	67.9	100.8	100.9	47.2	100.9	101.8	30.4	77.2
	Feb 13th	35.8	100.0	100.8	100.0	100.0	103.6	72.4	100.9	104.0	37.6	85.5
	Mar 15th	99.6	99.7	100.0	100.0	100.4	100.2	87.4	100.8	101.8	65.9	95.6
	Apr 12th	97.0	91.9	95.8	97.2	97.7	99.0	85.4	96.4	99.3	64.4	92.4
	May 15th	94.7	91.9	90.8	95.0	94.3	92.7	80.9	94.2	96.9	61.9	89.3
	Jun 15th	91.6	91.9	85.1	92.4	91.1	95.5	80.5	89.1	95.1	59.0	87.1
	Jul 19th	89.6	91.2	80.5	89.6	87.2	91.8	78.4	88.8	93.2	57.2	84.8
	Aug 15th	87.7	89.4	75.4	88.0	84.5	90.6	76.0	86.1	91.8	54.9	82.4
	Sep 15th	85.7	86.5	70.0	85.4	81.5	85.1	74.8	82.9	89.7	52.5	79.4
	Oct 16th	83.7	79.0	64.9	83.8	79.3	82.9	72.9	81.3	88.2	49.7	76.6
	Nov 15th	80.7	73.9	58.4	80.8	76.8	80.2	72.1	77.5	86.1	46.4	73.3
	Dec 11th	79.4	72.3	55.8	85.1	74.8	80.0	67.8	74.8	84.9	44.1	71.9
	Annual Average	79.0	89.0	81.5	88.8	89.0	91.9	74.7	89.5	94.4	52.0	83.0
2018	Jan 15th	76.0	67.3	51.6	81.7	72.4	77.4	66.2	67.4	82.3	39.5	68.2
	Feb 15th	75.8	81.0	67.5	81.2	70.2	82.6	63.7	63.9	80.4	39.4	70.6
	Mar 14th	74.0	80.4	64.3	96.9	99.8	99.9	70.4	72.1	100.8	38.2	79.7
	Apr 15th	81.5	100.6	87.7	96.3	100.0	100.0	69.9	71.7	100.5	39.8	84.8
	May 17th	79.5	97.5	84.8	93.5	97.5	97.1	67.7	62.4	98.8	39.8	81.9
	Jun 15th	91.6	91.9	85.1	92.4	91.1	95.5	80.5	89.1	95.1	59.0	87.1
	Jul 19th	75.3	90.5	74.1	86.3	91.5	91.2	65.1	62.0	94.0	37.1	76.7
	Aug 15th	73.5	87.7	70.5	86.2	88.7	89.1	63.5	61.3	92.6	34.3	74.7
	Sep 15th	70.8	83.1	65.9	84.8	85.5	85.8	61.9	57.8	90.6	31.5	71.8
	Oct 16th	68.5	78.7	59.9	81.7	82.5	83.5	59.7	55.2	88.5	28.7	68.7
	Nov 15th	65.8	73.7	55.1	78.4	79.5	79.9	57.5	49.3	85.6	26.0	65.1
	Dec 11th	62.8	68.4	49.7	74.4	77.2	78.2	56.5	49.1	84.6	22.5	62.3
	Annual Average	74.6	83.4	68.0	86.2	86.3	88.4	65.2	63.4	91.2	36.3	74.3

Table 6.2 Cont'd: Mid-month dam levels (Percent)

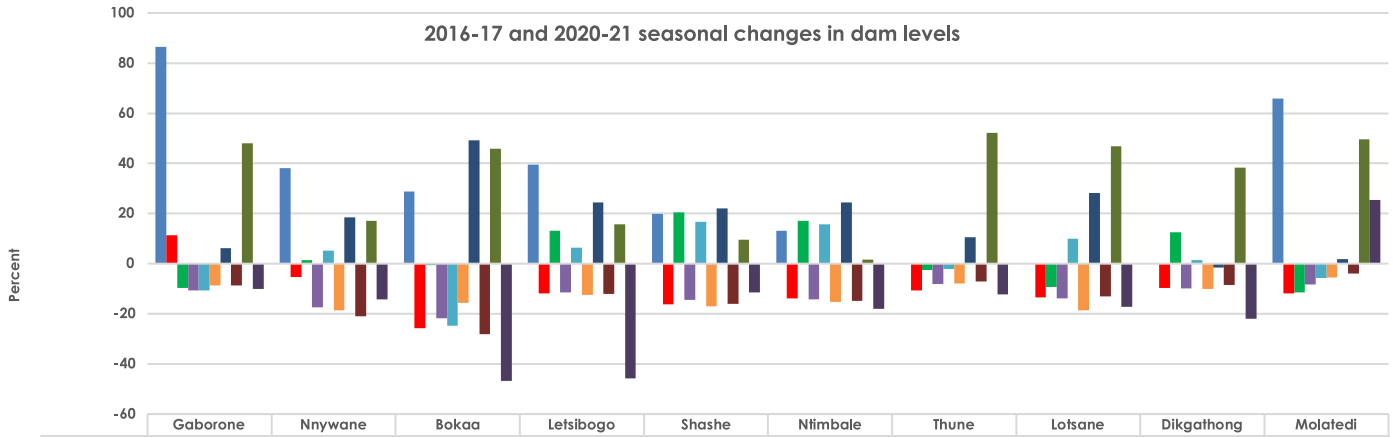
Year	Date	Gaborone	Nnywane	Bokaa	Letsibogo	Shashe	Ntimbale	Thune	Lotsane	Dikgathong	Molatedi	Monthly Average
2019	Jan 16th	60.6	87.9	44.0	78.5	83.2	100.0	58.3	68.7	85.8	25.0	69.2
	Feb 13th	58.0	84.0	36.8	80.2	97.3	100.0	57.4	66.1	86.3	23.0	68.9
	Mar 15th	57.9	83.8	35.1	88.0	99.1	99.1	57.5	65.2	90.0	23.0	69.9
	Apr 12th	69.6	100.9	66.8	85.4	96.2	95.6	57.6	62.4	87.3	23.5	74.5
	May 15th	68.7	99.0	64.8	82.0	92.8	92.2	55.5	58.1	85.1	22.8	72.1
	Jun 14th	66.9	95.1	61.3	79.9	90.4	89.6	54.0	56.1	83.2	21.4	69.8
	Jul 17th	64.9	91.9	58.4	77.2	87.2	87.3	52.9	53.9	81.4	20.6	67.6
	Aug 15th	63.4	87.2	55.1	75.6	82.3	84.6	51.8	51.7	79.4	19.1	65.0
	Sep 16th	61.0	82.2	51.2	73.0	79.2	80.3	49.7	43.7	77.3	18.0	61.6
	Oct 15th	58.8	76.8	45.6	71.2	77.1	75.7	48.1	42.8	75.0	15.6	58.7
	Nov 15th	59.0	75.0	62.7	69.7	74.5	72.9	46.1	41.4	73.0	14.6	58.9
	Dec 16th	62.8	100.6	100.0	82.0	76.2	83.9	46.8	55.2	72.7	17.4	69.8
	Annual Average	62.6	88.7	56.8	78.6	86.3	88.4	53.0	55.4	81.4	20.3	67.2
2020	Jan 15th	62.6	100.0	100.0	79.3	73.1	81.7	46.7	60.4	70.1	17.7	69.2
	Feb 14th	67.7	98.6	99.4	93.5	92.4	96.2	60.3	72.2	70.9	19.5	77.1
	Mar 16th	65.0	95.2	94.9	95.6	99.1	100.1	58.6	70.9	73.5	17.4	77.0
	Apr 12th	63.2	93.0	86.1	92.3	95.6	96.2	55.9	66.1	71.5	16.1	73.6
	May 15th	62.1	88.4	87.3	89.6	92.2	93.1	54.6	62.6	69.5	15.6	71.5
	Jun 15th	59.8	81.8	78.9	86.6	88.5	86.7	52.5	58.2	67.5	14.7	67.5
	Jul 15th	58.3	78.8	72.7	84.8	85.5	86.1	51.3	57.6	65.9	13.8	65.5
	Aug 14th	51.1	75.9	67.3	82.0	82.1	83.9	50.1	56.1	64.3	13.0	62.6
	Sep 15th	54.6	72.1	57.9	80.2	79.5	81.3	48.8	53.0	63.0	12.2	60.3
	Oct 15th	52.5	82.0	52.5	83.2	89.6	96.9	47.5	51.7	62.2	11.9	63.0
	Nov 16th	52.0	88.6	71.1	80.5	85.9	91.7	46.0	48.7	60.6	13.9	63.9
	Dec 14th	52.0	101.5	70.5	79.0	96.4	101.6	46.3	48.2	61.4	14.1	67.1
	Annual Average	58.4	88.0	78.2	85.6	88.3	91.3	51.6	58.8	66.7	15.0	68.2
2021	Jan 15th	54.5	101.0	69.2	98.8	100.0	100.9	69.1	54.8	70.2	13.6	73.2
	Feb 15th	65.3	101.3	100.0	102.2	100.2	100.0	102.1	102.6	102.5	61.7	97.5
	Mar 15th	64.1	99.0	98.4	98.8	99.2	98.6	99.7	98.6	100.6	61.5	95.5
	Apr 15th	63.1	99.0	94.2	96.9	96.6	98.4	95.8	94.8	97.9	58.0	93.0
	May 14th	59.3	96.5	89.2	93.6	93.7	95.6	93.2	90.7	95.9	56.4	90.1
	Jun 15th	56.6	92.9	85.1	89.9	89.8	93.6	90.7	86.7	93.6	53.3	86.9
	Jul 14th	55.1	85.3	82.7	88.0	86.6	90.1	88.8	84.0	91.8	51.6	80.4
	Aug 16th	52.7	84.6	79.2	86.3	83.4	86.2	86.8	80.7	89.7	49.5	77.9
	Sep 15th	51.1	84.8	47.5	51.1	85.1	80.3	83.5	77.5	76.0	83.4	75.7
	Oct 15th	48.8	81.7	44.0	48.8	83.0	77.7	81.2	73.1	71.1	84.4	73.1
	Nov 16th	47.0	79.3	41.1	47.0	80.7	74.9	74.8	69.3	65.7	81.1	69.8
	Dec 14th	46.5	98.0	39.4	46.5	80.4	86.6	81.5	72.4	66.5	99.7	75.8
	Annual Average	55.3	92.0	72.5	79.0	89.9	90.2	87.3	82.1	85.1	62.9	82.4

Source: Water Utilities Corporation

6.1.1. Seasonal changes in dam levels

Figure 6.2 shows the wet and dry season changes in the dam levels for the period 2016 to 2021. The highest gains were recorded for Gaborone dam during the 2016/17 wet season, when Gaborone dam was recovering from the effects of a drought, followed by Molatedi (in South Africa) and Thune dams. The highest losses were recorded for Bokaa dam followed by Letsibogo dam during the 2021 dry season and Bokaa dam in 2020 during the dry season.

Figure 6.2. Seasonal changes in dam levels 2016/17 to 2020/21 (percent)



	Gaborone	Nnywane	Bokaa	Letsibogo	Shashe	Ntimbale	Thune	Lotsane	Dikgathong	Molatedi
2016/17 wet	86.4	38.2	28.7	39.4	19.9	13.2				65.9
2017 dry	11.3	-5.4	-25.8	-11.8	-16.2	-13.9	-10.6	-13.5	-9.6	-11.9
2017/18 wet	-9.7	1.4	-0.6	13.1	20.5	17	-2.5	-9.2	12.6	-11.5
2018 dry	-10.7	-17.5	-21.8	-11.5	-14.5	-14.2	-8	-13.9	-9.9	-8.3
2018/19 wet	-10.6	5.1	-24.8	6.3	16.6	15.6	-2.2	10	1.5	-5.7
2019 dry	-8.6	-18.7	-15.6	-12.4	-17	-15.3	-7.9	-18.7	-10	-5.5
2019/20 wet	6.2	18.4	49.3	24.4	22	24.4	10.5	28.1	-1.5	1.8
2020 dry	-8.6	-20.9	-28.2	-12.1	-16.1	-14.9	-7.1	-13.1	-8.5	-3.9
2020/21 wet	48.1	17	45.9	15.6	9.6	1.7	52.2	46.9	38.4	49.6
2021 dry	-10	-14.2	-46.7	-45.8	-11.5	-18.1	-12.3	-17.3	-21.9	25.4

6.2. Abstraction

6.2.1. Abstraction For own use

Table 6.3 shows the water abstracted for own use. The agriculture sector is the largest user of water abstracted for own use, with more water used for livestock than for irrigation. Mines also extract water for own use, with the main mining activity, diamond mining extracting the most. Water extracted for own use was highest in 2017/18 and lowest in 2016/17.

Table 6.3: Abstraction for own use 2016/17 – 2018/19 (m^3)

	Agriculture		Mining and Quarrying						Manufacturing				Electricity	Water service providers	sewerage	Construction	Trade	Hotel & restaurants	Transport	Finance and business	Social & personal services	Government	Int. Organisations	Total
	Livestock	Irrigation	Diamond	Copper/nickel	Coal	Soda ash	Gold	Other mining	Meat & meat products	Textiles	Leather & leather products	Other manufacturing												
2016/17	42,217.00	26,759.20	20,324.30	110.8	23.2	561.5	-	-	-	-	-	-	212.5	58.3	-	-	-	-	-	-	-	-	-	**90,266.70**
2017/18	41,588.00	37,975.90	23,189.40	35.9	12.4	522.4	-	-	-	-	-	-	-	50.4	-	-	-	-	-	-	-	-	-	**103,374.50**
2018/19	40,001.40	34,589.60	25,332.90	-	0.4	480.9	-	-	-	-	-	-	333.8	62.8	-	-	-	-	-	-	-	-	-	**100,801.90**

Source: Department of Water and Sanitation

6.2.2: Abstraction For distribution

Table 6.4 shows the water abstracted for distribution. Water service providers withdrew and distributed the most, followed by the diamond and the coal mining industries, and the electricity generating sector. The mines and electricity sectors distribute the water to mining towns and their residential communities. The amount of water abstracted for distribution has declined over the period.

Table 6.4: Abstraction for distribution 2016/17 – 2018/19 (m^3)

	Agriculture		Mining and Quarrying						Manufacturing				Electricity	Water service providers	sewerage	Construction	Trade	Hotel & restaurants	Transport	Finance and business	Social & personal services	Government	Int. Organisations	Total
	Livestock	Irrigation	Diamond	Copper/nickel	Coal	Soda ash	Gold	Other mining	Meat & meat products	Textiles	Leather & leather products	Other manufacturing												
2016/17	-	-	2,203.59	-	-	-	-	-	-	-	-	-	-	100,502.01	-	-	-	-	-	-	-	-	-	**102,705.60**
2017/18	-	-	1,983.46	-	1,133.49		-	-	-	-	-	-	356.08	97,087.57	-	-	-	-	-	-	-	-	-	**100,560.60**
2018/19	-	-	1,983.46	-	-	-	-	-	-	-	-	-	92.60	99,094.13	-	-	-	-	-	-	-	-	-	**101,170.19**

Source: Department of Water and Sanitation

Table 6.5 shows the total abstraction for the period 2016/17 to 2018/19 by industry. The water service providers abstracted the highest volumes of water for the three (3) years. The abstraction was highest in 2016/17.

Table 6.5: Total abstraction 2016/17 – 2018/19 (m^3)

	Agriculture		Mining and Quarrying						Manufacturing			
	Livestock	Irrigation	Diamond	Copper/nickel	Coal	Soda ash	Gold	Other mining	Meat & meat products	Textiles	Leather & leather products	Other manufacturing
2016/17	42,216.96	26,759.22	22,527.86	110.79	23.23	561.46	-	-	-	-	-	-
2017/18	41,588.04	37,975.86	25,172.83	35.93	1,145.89	522.44	-	-	-	-	-	-
2018/19	40,001.41	34,589.64	27,316.39	-	0.45	480.89	-	-	-	-	-	-

Source: Department of Water and Sanitation

Table 6.5 Cont'd: Total abstraction 2016/17 – 2018/19 (m^3)

	Electricity	Water service providers	sewerage	Construction	Trade	Hotel & restaurants	Transport	Finance and business	Social & personal services	Government	Total
2016/17	212.46	100,560.32	-	-	-	-	-	-	-	-	**192,972.30**
2017/18	356.08	97,138.02	-	-	-	-	-	-	-	-	**203,935.09**
2018/19	426.38	99,156.92	-	-	-	-	-	-	-	-	**201,972.07**

Source: Department of Water and Sanitation

6.2.3. Ground water abstraction

Table 6.6 shows ground water abstraction. The agriculture sector abstracted the highest volumes of ground water for the period, with livestock farming abstracting the most groundwater, followed by irrigation. Water services providers follow the agriculture sector, followed by the mining sector, with diamond mining abstracting the most within the sector. **Figure 6.3** shows the total groundwater abstracted for the period 2016/17 to 2018/19. Reduction in ground water abstraction by water service providers had a big effect on the overall reduction in groundwater abstraction.

Figure 6.3: Total ground water abstracted 2016/17 to 2018/19 ('000 m^3)

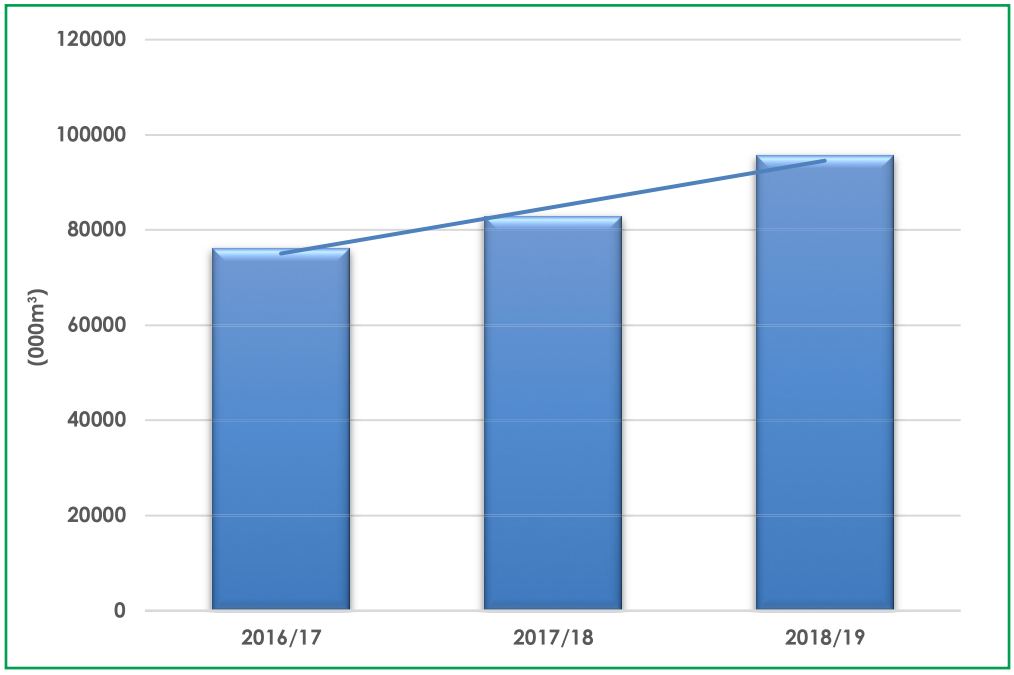


Table 6.6: Ground Water Abstraction 2016/17 – 2018/19 ('000m^3)

	Agriculture		Mining and Quarrying						Manufacturing			
	Livestock	Irrigation	Diamond	Copper/nickel	Coal	Soda ash	Gold	Other mining	Meat & meat products	Textiles	Leather & leather products	Other manufacturing
2016/17	31662.7	17393.5	18689.5	74.7	23.2	561.5	0.0	-	-	-	-	-
2017/18	31,191.0	24,684.3	22,451.3	35.9	1,145.9	522.4	-	-	-	-	-	-
2018/19	30,001.1	22,483.3	25,135.1	-	0.4	480.9	-	-	-	-	-	-

Source: Department of Water and Sanitation

Table 6.6 Cont'd: Ground Water Abstraction 2016/17 – 2018/19 ('000m^3)

	Electricity	Water service providers	Construction	Trade	Hotel & restaurants	Transport	Finance and business	Social & personal services	Government	Int. Organisations	Total agr & ind	households	Total
2016/17	212.5	48268.9	-	-	-	-	-	-	-	-	**-**	-	**116886.5**
2017/18	356.1	40,798.0	-	-	-	-	-	-	-	-	**121,184.9**	-	**121,184.9**
2018/19	426.4	27,860.3	-	-	-	-	-	-	-	-	**106,387.4**	-	**106,387.4**

Source: Department of Water and Sanitation

6.3.4. Surface water abstraction

Table 6.7 shows the amounts of surface water abstracted for the years 2016/17 to 2018/19. Water service providers sector had the highest surface water abstraction followed by the agriculture sector. Irrigation withdrew more surface water than livestock in the agriculture sector. **Figure 6.4** shows the total surface water abstraction for the period 2016/17 to 2018/19. Total surface water abstraction increased during the period.

Table 6.7: Surface water 2016/17 – 2018/19 ('000m^3)

	Agriculture		Mining and Quarrying						Manufacturing			
	Livestock	Irrigation	Diamond	Copper/nickel	Coal	Soda ash	Gold	Other mining	Meat & meat products	Textiles	Leather & leather products	Other manufacturing
2016/17	10,554.2	9,365.7	3,838.4	36.0	0.0	0.0	0.0	-	-	-	-	-
2017/18	10,397.0	13,291.6	2,721.5	-	-	-	-	-	-	-	-	-
2018/19	10,000.4	12,106.4	2,181.3	-	-	-	-	-	-	-	-	-

Source: Department of Water and Sanitation

Table 6.7 Cont'd: Surface water 2016/17 – 2018/19 ('000m^3)

	Electricity	Water service providers	sewerage	Construction	Trade	Hotel & restaurants	Transport	Finance and business	Social & personal services	Government	Int. Organisations	Total agr & ind	households	Total
2016/17	-	52,291.4	-	-	-	-	-	-	-	-	-	**76,085.8**	-	**76,085.8**
2017/18	-	56,340.1	-	-	-	-	-	-	-	-	-	**82,750.1**	-	**82,750.1**
2018/19	-	71,296.6	-	-	-	-	-	-	-	-	-	**95,584.6**	-	**95,584.6**

Source: Department of Water and Sanitation

Figure 6.4: Total Surface Water Abstraction 2016/17 to 2018/19 ('000m³)

6.2.5. Total abstraction

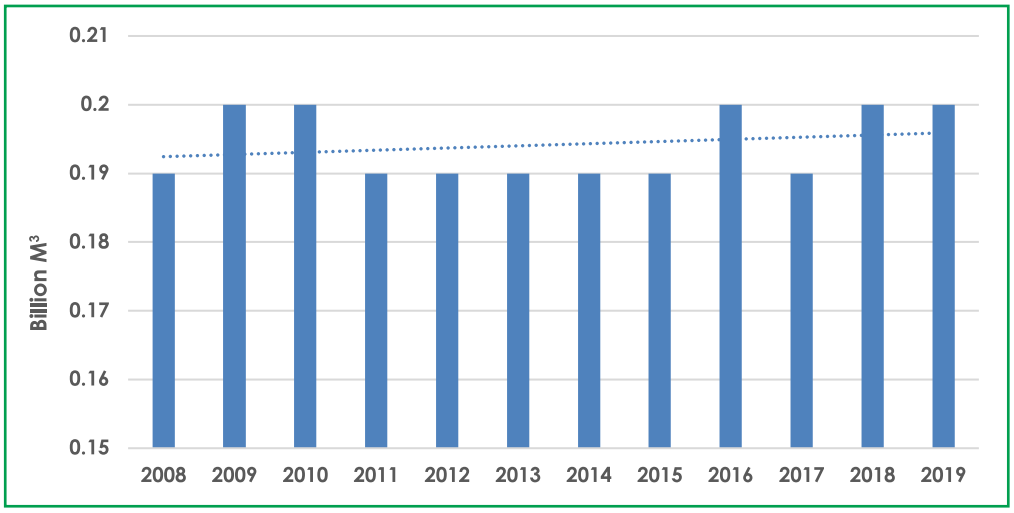
Table 6.8 and **Figure 6.4** show the total annual freshwater withdrawals for the country. The general trend is an increase in the water withdrawn from water sources.

Table 6.8: Total Annual Freshwater Withdrawals (billion cubic meter)

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total Annual Freshwater Withdrawals	0.19	0.20	0.20	0.19	0.19	0.19	0.19	0.19	0.20	0.19	0.20	0.20

Source: SADC Statistics

Figure 6.5: Total annual freshwater withdrawals (billion cubic meter)



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ANNEX

Annex 1: Average monthly minimum temperatures 2014 to 2021(Degrees Celsius)

February		2014	2015	2016	2017	2018	2019	2020	2021
Pandamatenga	February	17.7	14.2	17.9	18.1	16.6	14.3	17.5	16.4
Sowa	February	19.1	17.1	16.8	17.8	16.6	15.1	16.9	2.8
Ghanzi	February	17.2	15.1	15.0	17.1	16.0	16.0	16.3	14.7
Mahalapye	February	16.7	14.1	17.4	17.4	15.9	15.6	13.6	14.4
Tshane	February	18.4	16.0	16.3	16.4	12.6	15.5	18.5	14.8
Werda	February	17.7	12.2	17.5	15.5	10.7	12.5	16.3	12.0
Goodhope	February	16.7	14.3	16.1	16.2	14.5	15.8	13.7	14.4
Tsabong	February	18.8	13.2	16.5	16.2	11.2	14.0	17.8	-4.1
average	February	17.8	14.5	16.7	16.8	14.3	14.9	16.3	10.7
March		**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Pandamatenga	March	16.9	7.3	17.3	14.1	16.8	16.6	16.2	13.7
Sowa	March	16.8	15.5	16.0	12.6	15.2	17.0	2.0	13.2
Ghanzi	March	16.5	15.4	14.4	12.1	16.4	16.7	13.9	14.0
Baines Drift	March	18.6	14.9	12.6	12.6	15.8	17.5	14.3	12.5
Mahalapye	March	16.1	14.0	12.8	12.4	15.1	17.7	13.3	12.7
Tshane	March	16.6	16.1	13.1	12.5	13.0	14.9	14.8	13.7
Werda	March	16.3	11.0	12.0	7.9	8.5	10.7	9.5	9.8
Goodhope	March	15.4	14.5	12.9	12.7	11.5	15.3	12.9	10.8
Tsabong	March	16.5	13.2	10.7	9.4	9.5	12.8	11.7	10.5
average	March	16.6	13.5	13.5	11.8	13.5	15.5	12.1	12.3
April		**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Pandamatenga	April	15.7	11.3	11.6	10.3	10.3	14.4	10.8	10.9
Sowa	April	16.1	13.1	12.7	11.1	11.0	12.2	12.8	8.2
Ghanzi	April	15.5	11.6	10.5	9.7	10.2	10.6	9.1	7.8
Baines Drift	April	12.4	12.4	10.1	10.1	10.4	11.8	11.4	8.2
Mahalapye	April	14.9	11.9	10.6	8.7	10.7	10.8	9.2	8.3
Lephephe	April	15.8	12.2	10.6	7.7	9.2	10.3	6.5	-8.6
Tshane	April	15.7	11.6	12.0	10.0	10.0	9.8	5.2	8.2
Werda	April	15.1	7.7	9.5	6.8	7.4	9.4	4.0	5.7
Goodhope	April	14.0	8.1	12.0	8.9	9.6	11.6	7.4	8.0
Tsabong	April	15.3	6.4	9.5	7.0	8.9	7.8	5.4	7.2
average	April	15.1	10.6	10.9	9.0	9.8	10.9	8.2	6.4
May		**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Pandamatenga	May	14.9	6.6	7.2	8.8	9.2	9.9	7.9	6.2
Sowa	May	15.2	6.2	6.2	7.2	7.4	6.3	3.9	6.1
Ghanzi	May	15.2	3.8	2.7	3.1	4.3	5.2	-0.4	4.2
Mahalapye	May	14.3	8.3	5.9	5.4	7.6	6.9	1.5	4.7
Lephephe	May	15.3	6.5	3.2	3.9	5.1	5.3	-0.7	-9.6
Tshane	May	15.5	4.7	4.3	1.6	2.7	6.8	-2.5	3.8
Werda	May	14.9	0.8	1.7	0.0	-1.5	5.4	-5.9	-0.1
Goodhope	May	13.9	6.3	5.7	2.7	3.6	6.6	-1.0	1.7
Tsabong	May	15.3	2.5	4.3	0.0	-0.7	4.3	-2.5	0.5
average	May	14.9	5.1	4.6	3.6	4.2	6.3	0.0	1.9

Annex 1 Cont'd: Average monthly minimum temperatures 2014 to 2021(Degrees Celsius)

June		2014	2015	2016	2017	2018	2019	2020	2021
Pandamatenga	June	8.1	4.9	6.3	5.1	4.0	6.3	4.5	6.0
Sowa	June	5.4	1.9	5.2	5.1	3.9	6.6	1.7	4.4
Ghanzi	June	1.7	-1.4	1.8	0.0	1.8	0.8	-2.9	0.8
Mahalapye	June	3.0	0.3	3.6	2.2	4.6	3.8	-1.1	4.1
Lephephe	June	-1.0	-1.0	2.0	-1.7	2.0	1.1	-3.8	-8.6
Tshane	June	0.7	-2.4	0.7	-3.8	-0.7	1.7	-4.9	-1.1
Werda	June	-2.5	-3.3	-3.8	-1.4	-2.2	-2.9	-5.5	-4.2
Goodhope	June	-1.4	-0.7	3.5	-0.9	2.1	2.6	-2.6	1.1
Tsabong	June	-3.1	-3.0	-0.5	-4.4	-2.0	-4.6	-5.7	-0.9
average	June	1.2	-0.5	2.1	0.0	1.5	1.7	-2.3	0.2
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Pandamatenga	July	4.0	5.9	4.7	6.0	4.9	5.2	4.8	4.4
Sowa	July	4.2	-0.5	2.0	3.9	3.8	4.0	1.6	3.4
Ghanzi	July	-0.7	-2.6	-2.5	2.2	-1.7	-0.5	-1.6	-2.9
Mahalapye	July	-1.8	0.3	-0.1	3.7	2.6	1.7	0.4	0.4
Lephephe	July	-4.0	-0.4	-1.1	2.6	0.3	-0.3	-2.1	-5.2
Tshane	July	-2.0	-2.4	-5.2	-2.5	-1.3	-1.9	-2.1	-5.6
Werda	July	-8.3	-4.9	-8.0	-3.2	-6.8	-3.6	-6.0	-9.7
Goodhope	July	-4.7	0.4	-1.2	0.1	-4.5	-0.1	-3.0	-5.5
Tsabong	July	-7.6	-2.6	-3.9	-2.4	-5.9	-2.6	-4.7	-7.7
average	July	-2.3	-0.8	-1.7	1.2	-1.0	0.2	-1.4	-3.2
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Pandamatenga	August	7.6	4.7	7.9	8.7	9	8.4	7.8	6.8
Sowa	August	4.8	2	4.6	2.1	9.5	7	6.4	4
Ghanzi	August	0.3	0.3	0.1	-0.3	-0.6	4.3	-1.3	-2.1
Mahalapye	August	1.8	1	3.1	4.6	6.1	7.2	3.9	2.4
Tshane	August	-1.3	-2.4	-1.2	1.7	-0.5	5.2	-2.3	-0.5
Werda	August	-4.3	-2.9	-5.2	-3.7	-6.4	1.9	-6	-6.5
Goodhope	August	0.4	-0.2	1.8	-0.3	1.2	6.9	-2	-1.7
Tsabong	August	-1.8	-4.3	-2.5	-0.6	-5.7	1	-3.6	-3.9
average	August	0.9	-0.2	1.1	1.5	1.6	5.2	0.4	-0.2
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Pandamatenga	September	8.1	8.2	10.9	11.1	6.5	7.9	12.2	12.7
Sowa	September	6.8	10.1	10.2	10.9	7.1	6.3	8.5	10.1
Ghanzi	September	4.3	5.4	6.4	9.2	1.5	1.6	4.0	8.6
Mahalapye	September	4.9	7.7	8.1	8.5	3.9	5.1	8.7	7.3
Lephephe	September	3.5	6.9	7.3	4.8	1.8	4.3	7.3	15.6
Tshane	September	5.5	5.1	4.5	7.2	-1.5	1.3	4.1	7.1
Werda	September	1.1	1.8	2.6	0.5	-2.8	-1.9	-0.1	2.6
Goodhope	September	6.2	5.5	6.5	4.6	1.8	2.4	4.5	6.6
Tsabong	September	0.8	4.4	6.2	3.2	-2.3	-0.1	-0.4	0.0
average	September	4.6	6.1	7.0	6.7	1.8	3.0	5.4	7.8

Annex 1 Cont'd: Average monthly minimum temperatures 2014 to 2021(Degrees Celsius)

		2014	2015	2016	2017	2018	2019	2020	2021
Shakawe	October	9.1	12.7	11.7	10.5	8.9	7.6	12.9	18.3
Pandamatenga	October	12.9	15.8	14.8	14.5	12.3	13.1	16.5	14.5
Sowa	October	12.2	16.7	13.6	13.2	11.8	13.6	-5.5	12.4
Ghanzi	October	7.8	9.6	9.4	6.9	9.6	7.1	11.5	6.8
Mahalapye	October	10.0	15.0	13.0	10.7	10.3	12.4	13.1	10.1
Lephephe	October	7.6	11.8	8.9	8.6	9.5	11.4	11.2	8.0
Tshane	October	6.3	9.5	5.9	8.1	7.9	6.1	2.0	7.3
Werda	October	1.3	6.9	0.2	5.6	6.4	4.7	3.7	3.5
Goodhope	October	7.2	10.1	8.7	7.0	7.4	7.6	11.0	7.1
Tsabong	October	4.8	7.4	3.4	5.8	7.1	4.8	4.0	-4.4
average	October	7.9	11.6	9.0	9.1	9.1	8.8	8.0	8.4
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Shakawe	November	14.4	14.8	16.4	8.4	12.3	16.2	10.2	10.6
Pandamatenga	November	16.1	13.7	17.0	14.2	17.4	18.8	15.9	17.7
Sowa	November	13.7	15.5	16.5	10.4	14.4	19.3	3.4	7.8
Ghanzi	November	12.5	9.1	17.5	7.0	8.2	16.7	16.2	12.7
Mahalapye	November	9.6	12.8	16.3	11.9	12.6	17.5	14.5	14.7
Lephephe	November	10.7	12.0	15.9	8.7	11.4	16.7	15.4	14.5
Tshane	November	11.3	8.1	15.9	5.2	9.2	14.2	13.6	11.0
Werda	November	6.7	6.1	12.4	6.6	5.9	10.7	11.0	7.4
Goodhope	November	11.7	9.1	14.6	6.6	9.1	14.0	13.3	11.1
Tsabong	November	8.8	6.7	12.1	6.5	7.3	12.5	-6.7	9.8
average	November	11.6	10.8	15.5	8.6	10.8	15.7	10.7	11.7
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Pandamatenga	December	18.0	19.2	18.0	17.3	14.7	18.6	19.2	17.8
Sowa	December	15.6	18.8	17.7	15.3	16.3	17.2	18.5	15.4
Ghanzi	December	14.5	14.4	16.6	14.0	15.6	17.0	16.9	14.9
Baines Drift	December	19.0	17.9	12.6	12.6	15.4	17.4	16.9	17.8
Mahalapye	December	14.6	19.8	16.6	13.7	15.6	15.0	15.6	-8.0
Lephephe	December	16.2	18.6	17.4	14.3	16.2	16.1	16.0	14.2
Tshane	December	17.2	14.2	17.1	14.4	15.7	-8.5	14.8	14.0
Werda	December	16.9	11.5	16.6	9.6	14.7	11.6	11.3	12.6
Goodhope	December	15.2	15.9	15.6	12.8	14.4	13.5	-9.1	12.7
Tsabong	December	17.7	13.2	16.1	15.1	13.6	13.7	-8.1	12.8
average	December	16.5	16.4	16.4	13.9	15.2	13.2	11.2	12.4
Averages		**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
February		17.8	14.5	16.7	16.8	14.3	14.9	16.3	10.7
March		16.6	13.5	13.5	11.8	13.5	15.5	12.1	12.3
April		15.1	10.6	10.9	9.0	9.8	10.9	8.2	6.4
May		14.9	5.1	4.6	3.6	4.2	6.3	0.0	1.9
June		1.2	-0.5	2.1	0.0	1.5	1.7	-2.3	0.2
July		-2.3	-0.8	-1.7	1.2	-1.0	0.2	-1.4	-3.2
August		0.9	-0.2	1.1	1.5	1.6	5.2	0.4	-0.2
September		4.6	6.1	7.0	6.7	1.8	3.0	5.4	7.8
October		7.9	11.6	9.0	9.1	9.1	8.8	8.0	8.4
November		11.6	10.8	15.5	8.6	10.8	15.7	10.7	11.7
December		16.5	16.4	16.4	13.9	15.2	13.2	11.2	12.4

Annex 2: Average monthly maximum temperatures 2014 to 2021 (Degrees Celsius)

		2014	2015	2016	2017	2018	2019	2020	2021
Pandamatenga	February	30.5	35.7	36.3	32.9	29.2	35.2	33.3	30.0
Sowa	February	30.3	38.2	39.9	32.8	34.0	36.4	37.2	33.1
Ghanzi	February	30.0	39.3	40.0	32.1	36.3	38.6	35.9	32.1
Mahalapye	February	30.4	36.8	39.9	33.5	34.9	38.2	35.3	33.5
Tshane	February	29.9	38.3	38.6	33.0	34.9	37.7	36.2	34.7
Werda	February	30.7	38.9	40.2	33.3	36.9	38.6	36.6	36.0
Goodhope	February	27.8	35.7	36.9	30.7	32.3	36.5	33.0	33.7
Tsabong	February	30.7	39.2	39.9	35.0	37.4	38.8	40.6	37.1
Average	February	30.0	37.8	39.0	32.9	34.5	37.5	36.0	33.8
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Pandamatenga	March	29.8	35.2	33.1	31.3	31.8	36.5	32.3	33.4
Sowa	March	29.8	37.0	34.4	31.9	33.8	38.0	35.0	34.5
Ghanzi	March	30.0	36.0	34.5	32.3	33.0	39.9	34.2	32.8
Baines Drift	March	36.8	36.4	34.6	34.6	35.9	37.0	39.6	36.5
Mahalapye	March	30.4	36.4	32.7	33.0	35.2	39.5	35.7	34.3
Tshane	March	30.0	36.8	35.4	33.6	36.0	38.5	35.1	34.9
Werda	March	30.4	37.6	36.5	34.5	37.0	39.4	35.2	36.4
Goodhope	March	27.2	34.5	33.2	31.3	32.9	37.2	32.1	32.5
Tsabong	March	30.5	37.8	36.7	36.2	37.3	39.4	36.3	36.0
Average	March	30.5	36.4	34.6	33.2	34.8	38.4	35.1	34.6
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Pandamatenga	April	29.1	30.2	33.8	31.5	31.9	34.4	33.9	32.2
Sowa	April	30.2	31.0	33.6	31.7	31.8	35.1	36.2	34.0
Ghanzi	April	28.6	29.9	34.1	31.9	31.8	34.2	32.6	32.2
Baines Drift	April	34.5	35.2	35.1	35.1	33.6	34.9	37.6	34.9
Mahalapye	April	28.0	32.7	33.3	33.6	31.4	34.2	34.2	32.5
Lephephe	April	28.2	31.7	33.7	33.1	31.8	33.4	34.3	34.3
Tshane	April	28.2	30.0	33.8	33.3	32.1	34.2	32.2	32.4
Werda	April	27.8	31.4	33.7	34.9	32.5	34.0	32.4	33.7
Goodhope	April	26.3	29.4	31.4	31.7	28.6	29.5	31.1	30.6
Tsabong	April	28.5	32.0	34.5	36.9	32.9	34.5	33.7	34.5
Average	April	28.9	31.4	33.7	33.4	31.8	33.8	33.8	33.1
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Pandamatenga	May	27.7	31.4	32.0	30.9	31.1	31.2	31.8	31.0
Sowa	May	28.8	32.3	31.4	30.7	31.2	33.3	32.3	30.8
Ghanzi	May	27.5	30.2	31.4	29.4	29.3	32.3	30.9	28.5
Mahalapye	May	27.0	32.4	28.9	29.5	29.6	30.2	28.4	29.2
Lephephe	May	27.4	32.1	29.3	29.7	29.8	31.5	29.6	29.8
Tshane	May	28.6	30.9	29.0	28.6	29.5	31.2	29.9	27.9
Werda	May	28.6	32.0	29.5	29.2	29.4	30.9	29.8	28.7
Goodhope	May	26.7	29.9	26.3	25.8	26.4	26.7	26.6	26.5
Tsabong	May	29.7	31.8	29.6	30.0	29.4	32.0	30.6	29.7
Average	May	28.0	31.4	29.7	29.3	29.5	31.0	30.0	29.1

Annex 2 Cont'd: Average monthly maximum temperatures 2014 to 2021 (Degrees Celsius)

		2014	2015	2016	2017	2018	2019	2020	2021
Pandamatenga	June	28.4	30.1	29.2	28.8	29.7	30.0	27.5	28.5
Sowa	June	28.4	29.5	29.5	29.4	29.9	30.8	29.5	29.4
Ghanzi	June	28.0	28.4	29.6	27.6	29.8	29.4	27.3	28.0
Mahalapye	June	27.6	27.3	27.8	28.4	28.7	28.5	26.0	29.4
Lephephe	June	27.1	28.0	28.4	28.4	28.7	29.2	26.7	29.9
Tshane	June	26.5	27.8	28.7	27.3	28.5	27.9	27.3	28.7
Werda	June	27.4	27.7	28.6	28.0	28.3	28.0	27.3	29.9
Goodhope	June	25.3	23.8	24.4	25.6	25.2	24.9	25.9	27.1
Tsabong	June	28.1	27.3	26.9	30.3	27.9	28.2	27.9	30.9
Average	June	27.4	27.8	28.1	28.2	28.5	28.5	27.3	29.1
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Pandamatenga	July	29.0	31.7	30.2	29.0	29.1	29.2	28.3	30.0
Sowa	July	28.6	30.5	32.2	28.8	29.6	30.1	27.7	30.6
Ghanzi	July	28.0	29.1	29.3	28.6	29.5	29.5	27.2	28.3
Mahalapye	July	27.4	29.0	27.8	28.0	28.1	27.6	26.7	28.3
Lephephe	July	27.5	29.0	29.2	27.9	29.1	28.6	28.0	29.2
Tshane	July	27.9	28.4	28.0	28.7	28.7	28.0	27.4	28.1
Werda	July	28.2	28.4	27.1	29.2	30.0	28.5	27.3	28.4
Goodhope	July	25.5	24.5	24.6	25.8	27.3	26.1	24.7	26.2
Tsabong	July	29.2	28.2	26.0	37.2	30.0	27.8	27.4	28.6
Average	July	27.9	28.8	28.3	29.2	29.0	28.4	27.2	28.6
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Pandamatenga	August	32.6	33.3	33.6	33.6	33.5	34.1	34.6	32.9
Sowa	August	33.3	34.7	33.4	33.7	35.1	34.9	35.0	33.6
Ghanzi	August	31.8	34.4	32.7	33.1	32.4	34.9	33.0	33.5
Mahalapye	August	32.3	33.1	32.5	31.2	33.5	33.9	32.5	33.2
Tshane	August	30.3	33.4	31.8	33.3	32.4	31.8	31.7	31.6
Werda	August	30.5	34.2	31.1	32.8	32.4	32.9	32.9	32.5
Goodhope	August	27.9	31.1	28.1	30.2	29.5	30.5	29.9	29.4
Tsabong	August	30.5	33.8	31.7	32.6	32.4	33.0	32.6	31.5
Average	August	31.2	33.5	31.9	32.6	32.7	33.3	32.8	32.3
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Pandamatenga	September	36.2	36.7	36.3	37.4	36.2	36.2	37.7	37.1
Sowa	September	37.6	37.9	37.3	37.7	38.5	36.7	37.8	38.0
Ghanzi	September	36.0	36.7	36.6	37.2	37.3	35.0	37.0	36.1
Mahalapye	September	36.4	36.5	37.0	36.4	39.4	34.6	36.3	37.3
Lephephe	September	36.3	37.4	36.5	37.0	38.4	35.1	36.8	36.7
Tshane	September	35.4	36.7	35.5	36.4	36.7	35.3	35.7	35.6
Werda	September	36.3	37.7	36.0	36.4	37.2	36.1	36.5	37.3
Goodhope	September	33.4	34.4	33.4	34.2	35.4	33.4	33.9	34.1
Tsabong	September	36.4	36.9	36.2	37.6	36.2	37.3	36.1	37.1
Average	September	36.0	36.8	36.1	36.7	37.3	35.5	36.4	36.6

Annex 2 Cont'd: Average monthly maximum temperatures 2014 to 2021 (Degrees Celsius)

		2014	2015	2016	2017	2018	2019	2020	2021
Shakawe	October	39.7	39.2	41.5	40.6	39.5	41.0	40.1	39.0
Pandamatenga	October	38.0	38.5	39.7	39.7	38.6	40.2	38.0	39.2
Sowa	October	39.1	39.5	41.3	40.2	39.1	42.1	39.3	39.4
Ghanzi	October	37.6	38.3	41.6	37.5	38.2	39.2	39.2	37.0
Mahalapye	October	37.6	38.9	40.3	37.6	37.5	39.9	38.1	39.0
Lephephe	October	37.7	38.8	40.2	37.7	37.4	39.9	38.6	38.3
Tshane	October	37.3	38.6	41.0	35.5	37.0	38.4	38.8	37.1
Werda	October	38.2	39.9	41.1	36.1	37.9	38.7	39.9	38.4
Goodhope	October	34.9	36.8	38.1	34.4	35.4	37.3	37.0	34.5
Tsabong	October	38.1	39.3	44.2	36.4	38.3	38.2	40.7	37.6
Average	October	37.8	38.8	40.9	37.6	37.9	39.5	39.0	38.0
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Shakawe	November	37.2	41.5	41.1	38.7	39.8	39.6	39.4	39.5
Pandamatenga	November	37.6	39.9	39.1	38.0	38.3	37.9	39.1	38.4
Sowa	November	38.9	41.6	40.6	39.6	39.7	39.4	40.1	40.3
Ghanzi	November	37.3	41.0	40.4	37.0	40.1	39.8	39.7	38.9
Mahalapye	November	35.4	41.2	37.5	38.6	38.3	39.4	38.3	38.4
Lephephe	November	36.7	41.4	38.1	38.2	38.9	38.9	37.9	38.6
Tshane	November	37.2	39.7	40.8	36.8	39.1	38.5	38.1	38.7
Werda	November	37.9	41.0	41.0	38.8	40.2	39.4	38.5	40.6
Goodhope	November	33.6	38.6	36.2	35.7	37.1	35.9	36.9	37.9
Tsabong	November	37.7	38.8	44.0	38.8	40.7	39.7	38.2	40.4
Average	November	37.0	40.5	39.9	38.0	39.2	38.9	38.6	39.2
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Pandamatenga	December	36.3	37.2	37.2	34.9	37.1	38.3	31.7	37.9
Sowa	December	38.6	40.4	39.2	36.5	38.6	40.7	35.7	39.0
Ghanzi	December	35.4	39.2	40.1	37.0	38.9	37.1	36.5	36.9
Baines Drift	December	39.2	40.0	38.5	38.5	39.8	40.9	37.2	38.1
Mahalapye	December	38.5	39.9	38.6	37.8	39.3	39.0	35.6	37.3
Lephephe	December	38.0	38.9	40.0	37.3	39.4	39.0	34.1	36.0
Tshane	December	36.6	39.3	39.6	37.3	41.0	38.0	37.8	36.6
Werda	December	37.6	41.9	41.5	37.7	42.0	39.7	38.5	37.0
Goodhope	December	35.1	38.6	36.9	35.0	39.1	35.4	35.5	32.9
Tsabong	December	38.2	41.8	41.3	38.5	41.7	39.4	37.4	38.6
Average	December	37.4	39.7	39.3	37.1	39.7	38.8	36.0	37.0
Averages		**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
February		30.0	37.8	39.0	32.9	34.5	37.5	36.0	33.8
March		30.5	36.4	34.6	33.2	34.8	38.4	35.1	34.6
April		28.9	31.4	33.7	33.4	31.8	33.8	33.8	33.1
May		28.0	31.4	29.7	29.3	29.5	31.0	30.0	29.1
June		27.4	27.8	28.1	28.2	28.5	28.5	27.3	29.1
July		27.9	28.8	28.3	29.2	29.0	28.4	27.2	28.6
August		31.2	33.5	31.9	32.6	32.7	33.3	32.8	32.3
September		36.0	36.8	36.1	36.7	37.3	35.5	36.4	36.6
October		37.8	38.8	40.9	37.6	37.9	39.5	39.0	38.0
November		37.0	40.5	39.9	38.0	39.2	38.9	38.6	39.2
December		32.0	35.6	35.3	33.6	34.5	35.1	34.6	34.7

Annex 3: Monthly total rainfall 2014 to 2021 (mm)

		2014	2015	2016	2017	2018	2019	2020	2021
Pandamatenga	February	14.0	166.0	175.0	184.0	322.2	229.6	113.0	17.2
Sowa	February	14.2	7.6	74.4	312.8	194.4	0.8	4.0	1.2
Ghanzi	February	137.2	58.6	23.2	159.0	43.2	36.0	95.0	395.0
Mahalapye	February	7.8	18.0	207.4	160.6	96.8	44.6	28.4	188.4
Lephephe	February	0.8	16.8	141.6	225.2	81.6	13.0	57.8	125.4
Tshane	February	132.2	32.0	6.8	142.6	30.0	79.6	24.8	0.0
Werda	February	140.4	50.6	25.2	246.6	68.2	67.4	20.4	151.0
Goodhope	February	117.2	1.0	0.4	287.2	60.2	35.2	31.4	131.2
Tsabong	February	36.4	29.0	15.0	85.0	74.2	31.6	62.6	148.0
Total	**February**	**600.2**	**379.6**	**669.0**	**1803.0**	**970.8**	**537.8**	**437.4**	**1157.4**
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Pandamatenga	March	88.6	47.2	126.8	48.2	166.6	0.2	72.0	0.6
Sowa	March	105.8	109.4	261.2	40.6	74.2	0.4	0.8	1.8
Ghanzi	March	95.4	103.6	69.4	26.4	110.8	3.8	56.2	52.8
Baines Drift	March	40.8	87.8	31.8	31.8	7.6	0.0	6.0	8.8
Mahalapye	March	120.8	43.8	81.0	23.4	61.8	14.4	12.8	31.6
Lephephe	March	62.2	54.0	75.0	3.8	65.4	11.6	23.6	0.2
Tshane	March	30.6	63.0	124.4	6.6	59.2	1.4	0.0	0.0
Werda	March	40.2	32.2	101.6	0.0	78.2	5.4	35.2	96.0
Goodhope	March	30.6	52.6	51.4	25.4	114.0	29.4	64.8	62.4
Tsabong	March	51.8	26.6	41.0	41.2	40.4	4.2	45.0	72.2
Total	**March**	**666.8**	**620.2**	**963.6**	**247.4**	**778.2**	**70.8**	**316.4**	**326.4**
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Pandamatenga	April	14.0	77.8	5.2	27.6	13.8	66.6	17.6	0.0
Sowa	April	37.8	54.8	15.0	69.2	9.2	0.0	0.0	0.6
Ghanzi	April	25.6	147.2	27.0	61.8	36.0	30.4	42.6	0.0
Baines Drift	April	13.8	2.2	17.4	17.4	1.8	35.6	16.8	2.6
Mahalapye	April	9.8	2.6	9.0	12.8	0.4	111.0	28.8	15.6
Lephephe	April	6.0	24.4	6.2	13.8	7.0	63.6	31.4	0.2
Tshane	April	0.4	43.8	14.2	50.2	26.6	37.8	0.0	0.0
Werda	April	4.0	27.4	46.2	51.4	46.0	76.6	46.2	18.8
Goodhope	April	9.8	20.2	0.2	59.4	50.0	126.6	66.0	35.0
Tsabong	April	4.6	11.2	157.4	44.4	133.6	49.6	14.8	31.2
Total	**April**	**125.8**	**411.6**	**297.8**	**408.0**	**324.4**	**597.8**	**264.2**	**104.0**
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Pandamatenga	May	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sowa	May	1.6	0.2	0.0	0.0	5.2	0.0	0.0	0.2
Ghanzi	May	7.2	0.0	0.0	0.4	2.2	0.0	0.0	0.0
Baines Drift	May	0.0	5.0	0.0	0.0	10.4	0.0	0.0	0.2
Mahalapye	May	0.0	0.0	2.4	0.2	9.8	0.0	0.0	0.2
Lephephe	May	1.2	0.0	0.0	0.0	2.0	0.0	0.0	0.0
Tshane	May	26.0	0.0	9.8	0.0	0.2	4.6	0.0	0.0
Werda	May	6.6	0.0	3.8	0.0	1.2	6.0	0.0	0.0
Goodhope	May	0.0	0.0	0.0	0.8	7.0	7.6	0.0	0.0
Tsabong	May	19.2	0.4	10.2	0.2	3.8	1.0	0.0	1.0
Total	**May**	**61.8**	**5.6**	**26.2**	**1.6**	**41.8**	**19.2**	**0.0**	**1.6**

Annex 3 Comt'd: Monthly total rainfall 2014 to 2021 (mm)

		2014	2015	2016	2017	2018	2019	2020	2021
Pandamatenga	June	0.0	0.8	0.0	0.0	0.0	0.0	0.2	0.0
Sowa	June	1.0	0.0	0.4	0.0	0.0	0.6	0.2	0.2
Ghanzi	June	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Baines Drift	June	0.0	1.2	0.0	0.0		0.0	0.2	0.6
Mahalapye	June	0.0	0.0	13.0	0.4	0.0	0.0	0.0	0.0
Lephephe	June	0.0	3.0	16.8	0.0	0.0	0.0	0.0	0.0
Tshane	June	1.6	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Werda	June	0.0	4.4	7.8	0.0	0.0	0.0	0.0	4.0
Goodhope	June	0.0	6.4	0.0	0.0	0.0	0.0	1.2	6.0
Tsabong	June	0.2	3.4	1.2	0.2	0.0	0.0	0.0	7.0
Total	**June**	**2.8**	**19.4**	**39.4**	**0.6**	**0.0**	**0.6**	**1.8**	**17.8**
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Pandamatenga	July	0.0	0.0	0.6	0.0	1.2	0.0	0.0	0.0
Sowa	July	0.0	0.0	0.0	0.6	6.8	0.0	0.0	0.2
Ghanzi	July	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0
Baines Drift	July	0.2	1.0	0.0	0.0	0.2	0.0	0.0	0.0
Mahalapye	July	0.0	0.0	0.0	4.8	1.0	0.0	0.2	0.0
Lephephe	July	0.0	6.0	0.0	0.0	5.4	0.0	0.0	0.0
Tshane	July	3.6	0.4	0.0	0.0	2.6	0.0	0.0	0.0
Werda	July	0.0	0.2	0.0	0.0	15.8	0.4	0.0	0.0
Goodhope	July	0.0	2.0	0.0	0.4	1.8	0.0	0.0	0.0
Tsabong	July	0.0	4.0	0.2	0.0	2.0	0.0	0.2	0.0
Total	**July**	**3.8**	**13.6**	**0.8**	**5.8**	**40.8**	**0.4**	**0.4**	**0.2**
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Pandamatenga	August	0.2	0.2	0.2	0.0	0.8	0.0	0.2	0.0
Sowa	August	0.0	0.2	0.0	5.2	0.2	0.0	0.0	0.2
Ghanzi	August	0.0	0.0	0.0	0.0	2.0	0.0	1.2	0.0
Baines Drift	August	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.0
Mahalapye	August	0.0	0.0	0.0	0.6	0.6	0.0	0.0	0.0
Tshane	August	0.2	0.0	0.0	0.2	0.2	0.0	0.0	0.0
Werda	August	0.0	0.0	0.2	0.2	0.2	0.0	0.0	3.0
Goodhope	August	12.8	0.0	0.0	0.0	0.2	0.2	0.2	9.0
Tsabong	August	2.2	1.0	0.0	0.4	0.4	0.0	0.0	1.2
Total	August	15.4	1.4	0.4	6.6	4.6	0.2	4.4	13.4
Total	**April**	**125.8**	**411.6**	**297.8**	**408.0**	**324.4**	**597.8**	**264.2**	**104.0**
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Pandamatenga	September	0.0	0.0	0.0	0.0	1.2	0.0	0.6	0.0
Sowa	September	0.0	18.4	0.0	6.6	0.8	0.0	0.0	0.0
Ghanzi	September	0.0	0.0	0.0	11.0	0.2	0.0	1.2	0.0
Baines Drift	September	38.4	0.0	0.0	0.0	4.4	0.0	13.6	0.0
Mahalapye	September	0.4	22.0	6.0	0.0	0.0	0.0	6.6	1.6
Lephephe	September	2.8	17.8	0.2	0.0	0.0	0.4	7.2	0.0
Tshane	September	0.0	7.0	0.2	0.4	0.0	0.0	0.0	0.0
Werda	September	0.2	7.8	0.4	17.0	0.6	0.0	28.2	23.8
Goodhope	September	0.0	27.4	0.0	2.8	0.6	0.0	1.2	15.4
Tsabong	September	1.4	17.0	0.6	1.4	1.2	0.0	6.6	0.0
Total	**September**	**43.2**	**117.4**	**7.4**	**39.2**	**9.0**	**0.4**	**65.2**	**40.8**

Annex 3 Comt'd: Monthly total rainfall 2014 to 2021 (mm)

		2014	2015	2016	2017	2018	2019	2020	2021
Shakawe	October	1.4	1.6	0.0	0.2	7.4	0.8	0.0	11.0
Pandamatenga	October	2.0	4.2	4.6	10.6	0.4	5.0	5.4	0.0
Sowa	October	11.6	0.6	2.8	25.2	0.0	0.2	0.2	0.0
Ghanzi	October	2.0	1.0	0.4	58.2	30.2	0.0	0.0	0.2
Baines Drift	October	4.4	14.4	110.2	110.2	2.2	4.2	63.6	18.6
Mahalapye	October	19.0	9.2	27.8	38.0	0.4	0.0	55.4	29.4
Lephephe	October	19.0	4.8	22.2	31.6	13.8	0.0	101.8	10.4
Tshane	October	4.8	33.0	0.0	80.8	35.6	0.0	0.0	0.0
Werda	October	0.8	4.2	18.4	23.4	1.0	1.4	41.2	43.2
Goodhope	October	1.8	2.8	5.2	37.0	11.0	2.8	40.0	79.2
Tsabong	October	1.8	5.6	3.4	11.6	1.2	0.4	0.2	50.4
Total	**October**	**68.6**	**81.4**	**195.0**	**426.8**	**103.2**	**14.8**	**307.8**	**242.4**
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Shakawe	November	78.6	17.6	35.0	14.2	11.2	16.2	0.2	35.2
Pandamatenga	November	70.2	37.8	33.2	74.0	67.6	75.8	20.4	0.2
Sowa	November	28.0	31.2	87.4	45.2	5.0	0.0	1.2	0.2
Ghanzi	November	74.0	12.4	34.0	20.8	3.2	73.0	121.8	4.2
Baines Drift	November	32.6	71.8	57.4	57.4	26.6	52.0	55.8	41.4
Mahalapye	November	29.0	31.2	58.8	66.6	48.6	80.4	169.8	78.6
Lephephe	November	62.6	24.0	98.8	49.4	2.0	52.8	3.0	128.2
Tshane	November	33.0	0.4	77.2	3.4	2.2	3.8	0.0	0.0
Werda	November	41.4	18.4	20.8	3.2	6.6	25.6	85.4	14.6
Goodhope	November	44.2	39.0	78.2	30.0	15.6	87.8	113.2	81.2
Tsabong	November	76.6	0.0	7.2	0.2	4.6	12.6	94.2	5.6
Total	**November**	**570.2**	**283.8**	**588.0**	**364.4**	**193.2**	**480.0**	**665.0**	**389.4**
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Pandamatenga	December	201.6	77.2	114.6	96.6	24.4	44.4	8.0	3.6
Sowa	December	150.8	50.8	209.0	105.8	0.4	0.6	1.8	0.6
Ghanzi	December	105.8	61.4	79.2	44.8	72.6	55.6	112.2	0.6
Baines Drift	December	43.4	210.0	24.2	24.2	71.4	48.2	217.6	152.6
Mahalapye	December	132.4	49.2	86.8	28.6	162.4	128.4	148.6	87.2
Lephephe	December	38.6	48.2	90.6	94.0	92.2	127.4	0.0	87.4
Tshane	December	60.2	20.4	21.2	95.4	7.2	87.0	0.0	0.0
Werda	December	73.0	11.0	74.6	102.6	28.8	20.0	23.8	170.6
Goodhope	December	123.8	6.0	99.2	53.2	86.8	112.4	33.6	56.8
Tsabong	December	16.8	2.4	29.6	51.0	7.0	77.0	111.6	111.4
Total	**December**	**946.4**	**536.6**	**829.0**	**696.2**	**553.2**	**701.0**	**657.2**	**670.8**
Totals		**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
February		600.2	379.6	669.0	1803.0	970.8	537.8	437.4	1157.4
March		666.8	620.2	963.6	247.4	778.2	70.8	316.4	326.4
April		125.8	411.6	297.8	408.0	324.4	597.8	264.2	104.0
May		61.8	5.6	26.2	1.6	41.8	19.2	0.0	1.6
June		2.8	19.4	39.4	0.6	0.0	0.6	1.8	17.8
July		3.8	13.6	0.8	5.8	40.8	0.4	0.4	0.2
August		15.4	1.4	0.4	6.6	4.6	0.2	4.4	13.4
September		43.2	117.4	7.4	39.2	9.0	0.4	65.2	40.8
October		68.6	81.4	195.0	426.8	103.2	14.8	307.8	242.4
November		570.2	283.8	588.0	364.4	193.2	480.0	665.0	389.4
December		946.4	536.6	829.0	696.2	553.2	701.0	657.2	670.8

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