Contact Details
Tel office: +264 61 379 500
Fax office: +264 61 22 5371
E-mail: nabdesk@nab.com.na
Website: www.nab.com.na

Physical address:
Agricultural Boards' Building
30 David Hosea Meroro Road
Windhoek
Namibia

Postal address:
PO Box 5096
Ausspannplatz
Windhoek
Namibia

NAMIBIAN AGRONOMIC BOARD

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AGRONOMY AND HORTICULTURE DEVELOPMENT DIVISION

RESEARCH AND DEVELOPMENT SUBDIVISION

RESEARCH REPORT

AN ANALYSIS OF THE IMPACTS OF CLIMATE CHANGE ON THE NAMIBIAN CROP INDUSTRY

MARCH 2024

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EXECUTIVE SUMMARY

Climate change is a global challenge, and it has a damaging impact on food production. Namibia has been experiencing persistent drought conditions for over 7 years, affecting about 750,000 people, as evidenced by high levels of food insecurity (IFRC, 2022). The country also recorded major flood destruction in seven regions (Zambezi, Kavango East, Kavango West, Oshana, Oshikoto, Ohangwena & Omusati) in 2009 (Government of the Republic of Namibia, 2010). These disasters are happening due to climate change, and they have the potential to substantially reduce future crop yields in Namibia, thereby affecting food security and livelihood.

This study used a survey approach to zoom into the Namibian crop industry, specifically the agronomic crops of white maize, wheat, and pearl millet, and investigated how these specific crop farmers have been affected by climate change in Namibia, and thereafter suggested possible strategies to lessen the impacts. Approximately 102 farmers from 5 production zones (North Central 34, Kavango 35, Zambezi 13, Central 7, and Karst 13) responded to the questionnaires administered to them.

The study found that an average of 23 pearl millet farmers, 10 white maize farmers, and 3 wheat farmers have lost approximately 1 hectare of their production during the 10 years under review (2012/13 to 2021/22). Overall, climate change has significantly impacted the production of key grain crops under review in Namibia. Maize production decreased from 36,694 tons in 2013/2014 to 28,887 tons in 2019/2020, a year marked by extreme drought, leading to a surge in imports (171,031 tons). Similarly, wheat production was severely affected in 2019/2020, recording its lowest output (4,466 tons) due to low water levels in the Hardap Dam, which is crucial for irrigation. Pearl millet production also decreased, with the worst drought being experienced in 2015/2016, leading to an extremely low harvest of just 111 tons.

Drought and high-temperature variability emerged as the major causes of crop failure across all crops under review, with wheat mostly affected in terms of the shortage of irrigation water since it is a winter crop cultivated under irrigation. Farmers have tried to adopt a few adaptation techniques, such as crop rotation, intercropping, reduced tillage, etc., to deal with the climate change impacts; however, there is a significant knowledge gap among farmers on climate change.

The study recommends several strategies such as: Promoting a climate-smart irrigation system and extending subsidies to promote irrigated crop production; invest in more water infrastructures; boost awareness and upscale Conservation Agriculture (CA); invest in improved/certified seed provision; extend the seeds and fertiliser subsidy scheme to surplus and commercial farmers; introduce crop insurance schemes for farmers; awareness and training, and Research and Development for climate-

smart agriculture technology and innovation, etc, to help deal with the impacts of climate change in crop production.

1. INTRODUCTION AND BACKGROUND

Crop production is vital to the entire human population, including the Namibian population. Crop production impacts society in many ways, including the critical need to support livelihoods through food and jobs; providing raw materials for other products; and building strong economies through trade. A major global success of the last half of the twentieth century was the increase in crop production (Maryville University, 2022). According to Fageria et al. (2006), about 1.2 billion people in the world live in a state of absolute poverty, of which 800 million people live under uncertain food security, and 160 million preschool children suffer from malnutrition. In addition, the land available for crop production is decreasing steadily due to urban growth, land degradation, and climate change. Natural and human-induced abiotic and biotic stresses have become major constraints for global food production (Fageria et al., 2006). Under these situations, ensuring sustainable crop production is crucial to meet Namibia's food demand.

Crop production is vulnerable to climate variability, and climate change is associated with temperature increases, increases in carbon dioxide (CO_2), and changing patterns of rainfall that may lead to a considerable decline in crop production. Also, extreme weather events such as droughts, extreme heat waves, and heavy rainfall leading to floods have increased in the past decades (Raza et al., 2019). Enhancing crop production to meet rising demands owing to the increasing population, against the background of the threats of climate change, is a challenging task. According to the Food and Agriculture Organisation (FAO, 2015), negative impacts of climate change are more commonly found than positive ones. Observations of the effects of climate trends on crop production indicate that climate change has already negatively affected wheat and maize yields in many regions, as well as globally. It can disrupt food availability, reduce access to food, and affect food quality. For example, projected increases in temperatures, changes in precipitation patterns, changes in extreme weather events, and reductions in water availability may all result in reduced agricultural productivity (United States Environmental Protection Agency (EPA), 2022).

According to Petersen (2022), after almost seven years of drought, the government of Namibia foresees more severe droughts, floods, and changes to the farming seasons. These changes will cause more frequent and longer droughts, more heatwaves, more frequent and severe wildfires, and even increased flooding, as rain patterns change due to climate change or global warming. Namibia has been experiencing years of devastating periods of drought during recent years, which was also declared as a national state of emergency during the 2013/14, 2015/16, and 2019/20 marketing years (International Federation of Red Cross and Red Crescent Societies (IFRC), 2022). During these periods, Namibia recorded the lowest local production of cereal grains (white maize, pearl millet, and wheat), which are part of the main staple food in the country (NAB, 2022).

Therefore, this study aimed to investigate the effects of climate change on Namibia's crop industry, specifically the agronomic crops (white maize, wheat, and pearl millet), from the grain producer's perspective. Through a survey approach, agronomy producers from 5 main production zones where the grains of white maize, wheat, and pearl millet are mainly produced were targeted for this study to collect the primary data on the perceptions of the farmers. Secondary data, such as rainfall, temperature, and production data, were also used in the compilation of the final report. The findings were then summarised, and various recommendations to minimise the adverse impacts of climate change on the crop industry are presented in this report.

2. PROBLEM STATEMENT

Climate change is a global challenge, and it has detrimental impacts on food production. Namibia has been experiencing persistent drought conditions for over 7 years, affecting an estimated number of about 750,000 people with high levels of food insecurity (IFRC, 2022). The country also recorded major flood destruction in 7 regions (Zambezi, Kavango East, Kavango West, Oshana, Oshikoto, Ohangwena, and Omusati) in 2009 due to floods (Government of the Republic of Namibia, 2010). These disasters, happening as a result of climate change, have the potential to substantially reduce future crop yields in Namibia, therefore affecting food security and livelihoods. There is an urgent need to formulate, adopt, and implement strategies to mitigate the impacts of climate change-induced yield losses. This study, therefore, zoomed in on the crop industry sector, specifically the agronomic crops of white maize, wheat, and pearl millet, and investigated how these specific crop farmers have been affected by climate change in Namibia, and further suggested possible strategies to lessen the impacts.

3. RESEARCH OBJECTIVES

The development of adaptation strategies that are responsive to the changing climate patterns provides useful information for all other stakeholders, such as farmers, researchers, financial institutions, academia, etc., in mitigating the negative effects of climate change.

The specific objectives of this research are:

- ✓ To determine the impacts of climate change on several key crops, namely white maize, wheat, and pearl millet, in Namibia, in terms of productivity trends under different climatic conditions over the years;
- ✓ To assess the remedial actions that are currently in place to mitigate the impacts of climate change on crop production; and

- ✓ To suggest recommendations on what should be done to lessen the effects of climate change on the crop industry in Namibia.

4. METHODOLOGY

4.1. Study design

The study used both qualitative and quantitative methods to collect primary and secondary data. Primary data were collected through a survey design approach whereby face-to-face interviews were administered using a structured questionnaire, with both closed and open-ended questions. Where necessary, the telephone interview approach was also used to collect the primary data or to ask follow-up questions with the respondents with missing key data. A review of secondary sources of information (literature) was also done, whereby time-series data such as rainfall and temperature trends, production data, etc., were collected to complement the primary data obtained from the field survey.

4.2. Study area

The study was conducted in Namibia, whereby various farmers or respondents were sampled from 5 agronomy production zones in the country, namely, Zambezi, Kavango, North Central, Karst, and Central, respectively. Figure 1 shows the study area with selected production zones.

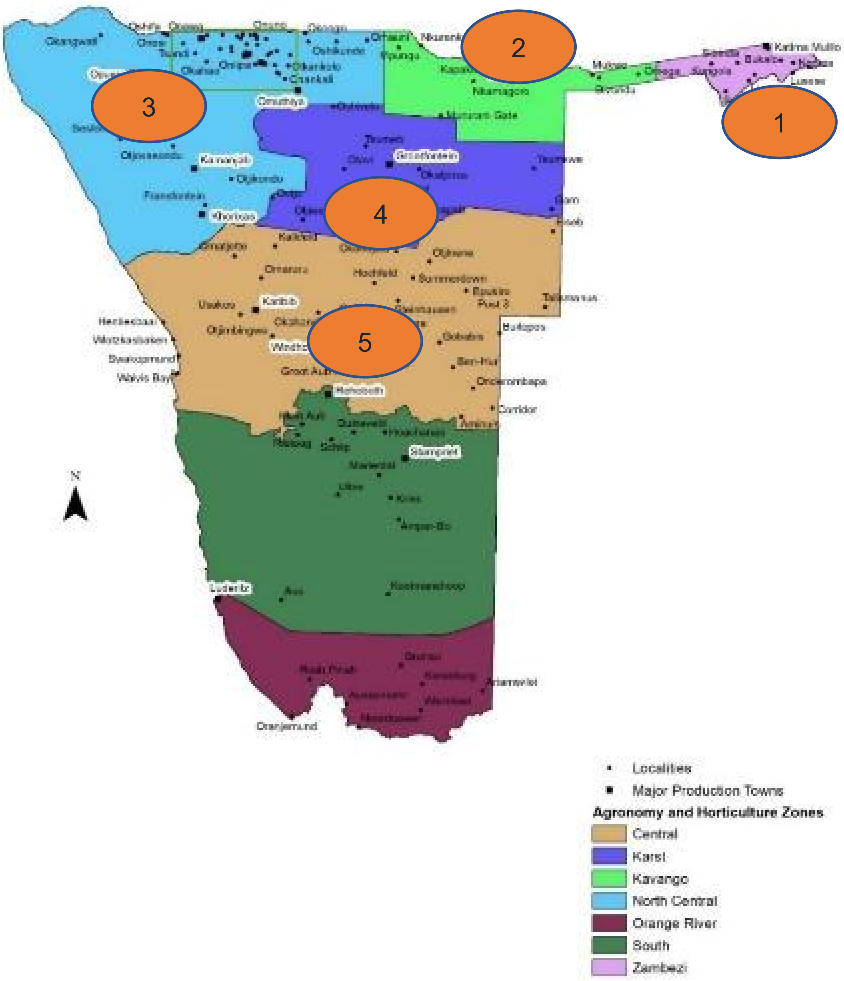


Figure 1: Study area map

4.3. Population and sampling strategy

The study employed a probability sampling method whereby a stratified sampling technique, complemented by a snowballing sampling technique, was used to identify different respondents from within the 5 production zones.

As presented in Table 1 below, the producers/farmers population comprised 12 registered wheat farmers, 190 maize farmers, and 245 pearl millet farmers, adding up to a total of 447 farmers as the population size for this study. The study, therefore, sampled and targeted a total of 119 farmers, representing 26% of the population, as shown in Table 1.

Table 1: Sampling plan for each agronomic crop

Crop type	Population (Registered producers)	Targeted sample (Registered producers)
Wheat	12	6
White maize	190	51
Pearl millet	245	62
TOTAL	**447**	**119**

The sample size above was distributed over the targeted production zones (strata) as indicated in Table 2.

Table 2: Sampling plan for each targeted production/trading zone versus each of the agronomic crops

Production Zone	Wheat	White Maize	Pearl millet	Total
Zambezi	-	7	-	**7**
Kavango	2	3	25	**30**
North Central	-	3	37	**40**
Karst	2	20	-	**22**
Central	1	15	-	**16**
South	1	3	-	**4**
TOTAL	**6**	**51**	**62**	**119**

4.4. Data collection instruments and analysis

Primary data from this study were collected using structured questionnaires, whereby oral interviews were conducted with the sampled farmers or producers. The collected data were analysed using descriptive statistics and thematic analysis (Microsoft Excel and Microsoft Word applications and SPSS) and with the aid of an online data analysis tool called QuestionPro.

5. NAMIBIA CLIMATIC CONDITIONS AND PRODUCTION ANALYSIS

5.1 Namibia rainfall, temperature, and humidity trends

Namibia's rainfall, temperature (maximum and minimum), and humidity analysis form an important section of this report to understand the patterns over the last 10 years. This section further illustrates how climate change has impacted Namibia's rainfall pattern, temperature, and humidity, which in turn have impacted the growth and development of crops, ultimately affecting crop yields. Figure 2 toFigure 4 indicate the average rainfall, temperature, and humidity trend analysis over 10 years from 2014 to 2023 (Ministry of Works and Transport, 2023).

Figure 2 illustrates the average rainfall in Namibia over 10 years from 2014 to 2023, ranging from 26.4mm in 2014 to 37mm in 2023. The rainfall recorded the lowest peak in 2019 with an average rainfall of 12.3mm, while its highest peak was recorded in 2023. Due to extremely low rainfall in 2019, drought was declared a national emergency by the Government of the Republic of Namibia (Government Gazette No. 6900). The same emergency declaration was also made in 2013 and 2015 (Office of the Prime Minister, 2014; Government Gazette No. 6056). This significant variability trend and extreme rainfall patterns suggest an increasing unpredictability in rainfall, which is a clear symbol of climate change.

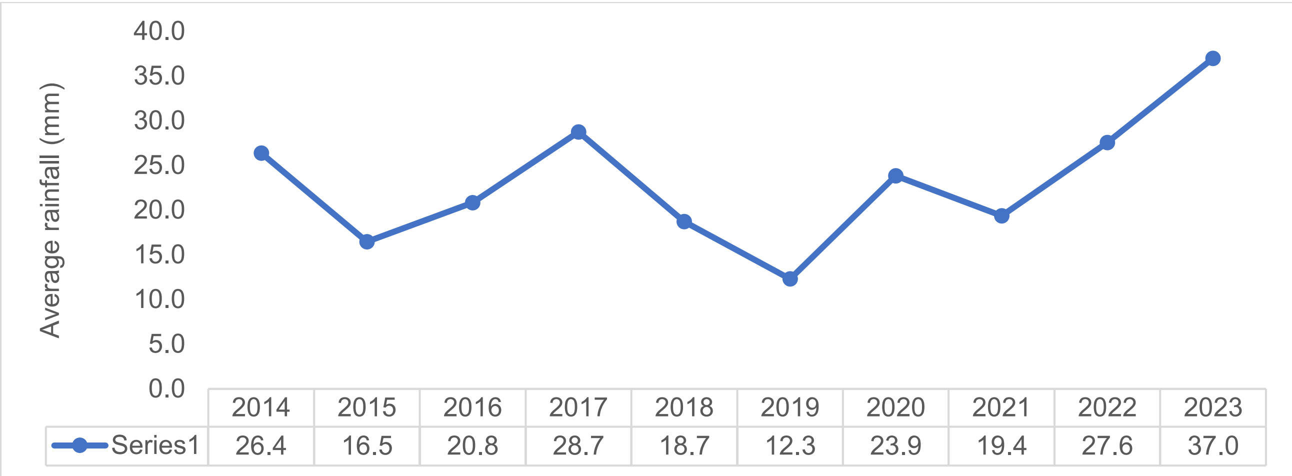


Figure 2: Namibia's 10-year average rainfall trend (2014 – 2023)

Figure 3 depicts Namibia's 10-year average temperature trend from 2014 to 2023. Namibia's average maximum temperature ranged between 29.7 °C and 31.1 °C. A consistent increase in temperature can also be observed, with the majority of the years recording above 30 °C. For the minimum temperature, Namibia's record was as low as 13.8 °C in 2014, and the rest of the months averaged above 14 °C respectively (Figure 3). This also indicates a reduced cooler season throughout the years under review, as the temperatures remain shifting towards the hot side. Overall, Namibia's temperature data, as presented in Figure 3, indicates a warming trend, especially in terms of minimum temperatures, alongside fluctuating maximum temperatures, ultimately underscoring the impacts of climate change in the country.

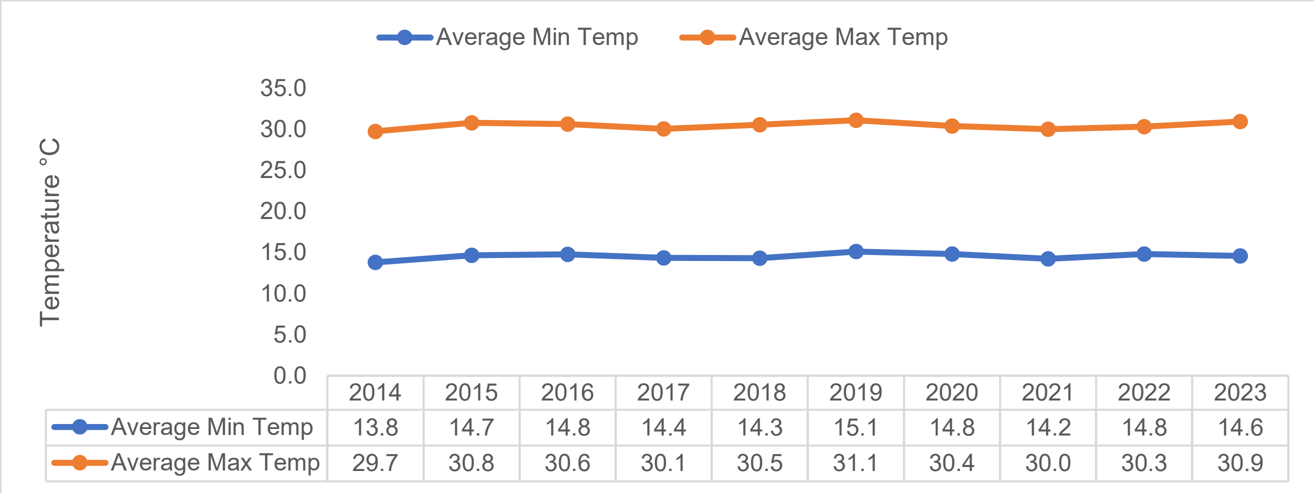


Figure 3: Namibia’s 10-year average temperature trend (2014 – 2023)

Figure 4 shows Namibia’s 10-year average humidity (%) from 2014 to 2023. Humidity levels were also recorded to average 50% but never above 60%. It was recorded as low as 47.3% in 2019, which is the same year that the highest temperature was recorded in Namibia (Figure 4). Namibia’s humidity levels have shown a fluctuating trend, reflecting the influence of climate variability and change. Variability in humidity affects evaporation rates, soil moisture, and crop production, and resultantly impacting Namibia's agricultural sector.

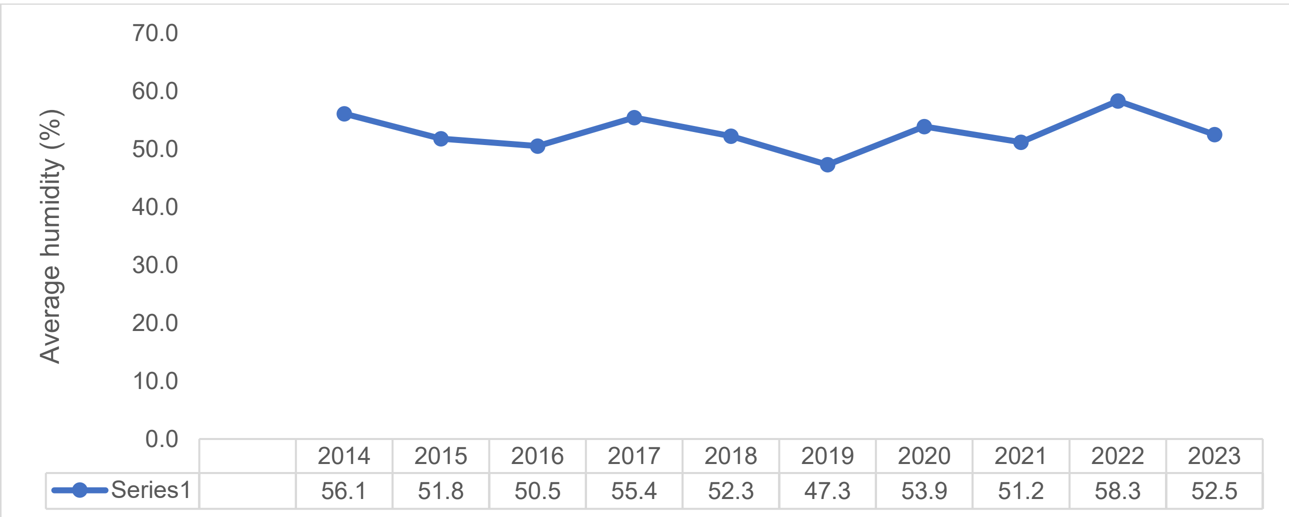
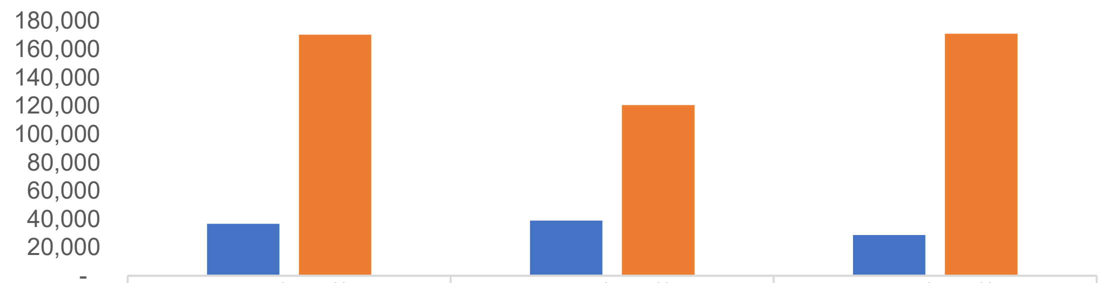


Figure 4: Namibia’s 10-year average humidity (%) (2014 – 2023)

5.2 Agronomy Production Trends in Namibia

To further understand the production trends of white maize, wheat, and pearl millet in Namibia, an analysis of local production versus imports was done.

Figure 5 illustrates how local production of maize decreased from 36,694 tons in 2023/2014 to 28,887 tons in 2019/2020. During both seasons, drought was declared a national emergency due to critically low rainfall that negatively impacted maize production. The graph also indicates high imports, especially during 2019/2020 when it surged to 171,031 tons, highlighting a dependence on imports due to severe drought caused by climate change.

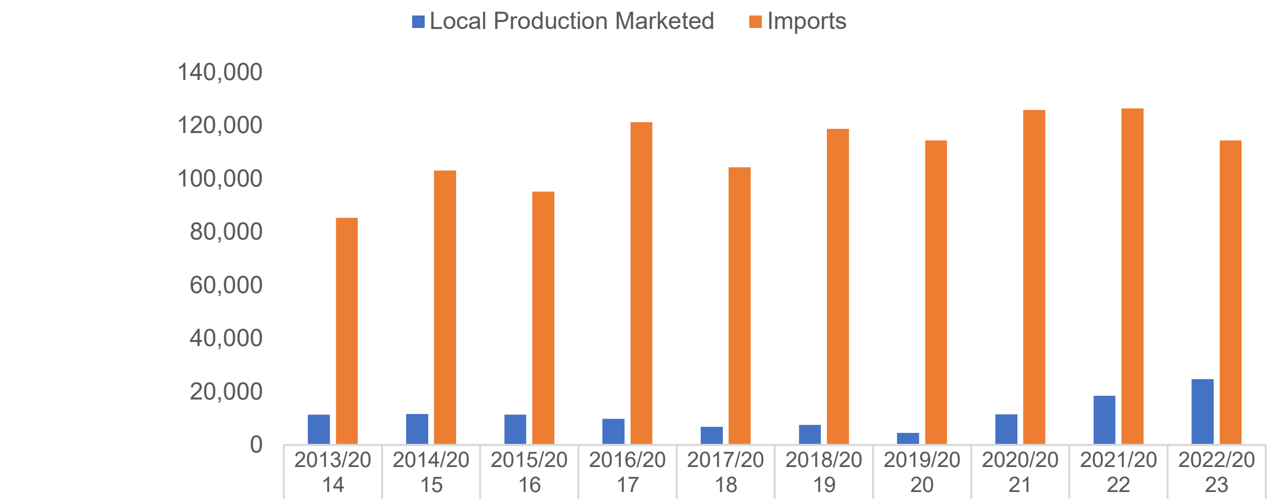


	2013/2014**	2015/2016**	2019/2020**
Local Production Marketed	36,694	38,900	28,887
Imports	170,234	120,650	171,031

Figure 5: White maize local production and import trends during the drought years

Figure 6: Undeveloped maize cobs due to water stress caused by drought (Photo: NAB, 2023)

As shown in Figure 7, the lowest local production volumes of wheat marketed were recorded in the 2019/2020 season (4,466 tons), which also coincided with the year that Namibia experienced the most drastic drought period. Climate change has affected the availability of water for irrigation, and hence, wheat local production has also fluctuated. This is particularly so as our biggest wheat-producing area is the Hardap area, which depends on water from the Hardap dam to grow wheat. The dam has run dry several times in recent years, which is due to the effects of climate change.



	2013/2014	2014/2015	2015/2016	2016/2017	2017/2018	2018/2019	2019/2020	2020/2021	2021/2022	2022/2023
Local Production Marketed	11,312	11,600	11,411	9,822	6,863	7,508	4,466	11,498	18,498	24,696
Imports	85,257	103,035	95,190	121,261	104,244	118,698	114,363	125,838	126,441	114,370

Figure 7: Wheat local production and import trends

In recent years, the Hardap dam has experienced critically low water levels, whereby the authority (NAMWATER) has been forced to suspend irrigation water supply to local farmers due to the severe depletion of its reservoir, thus impacting crop yields for the surrounding farmers who rely on the dam.

Figure 8: Left: Hardap Dam standing critically low at 11% (Photo: Steven Klukowski, 2024); Right: Hardap Dam at 70% capacity (Photo: Dirk Heinrich, 2017)

For pearl millet, Namibia experienced its worst drought season during 2015/2016 with a poor harvest as low as 111 tons (Figure 9). This continued drought resulted in high imports to meet the local demand.

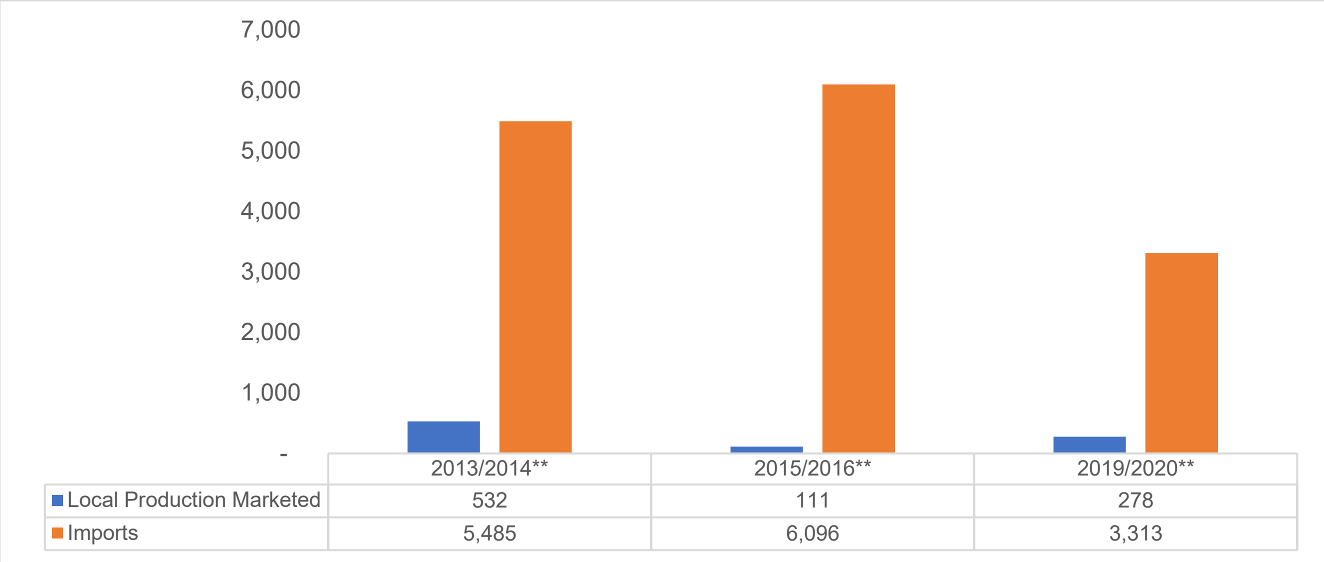


Figure 9: Pearl millet local production and import trends

Figure 10: Pearl millet field crop hard hit by drought (Photo: NAB, 2023)

6 RESULTS AND DISCUSSIONS

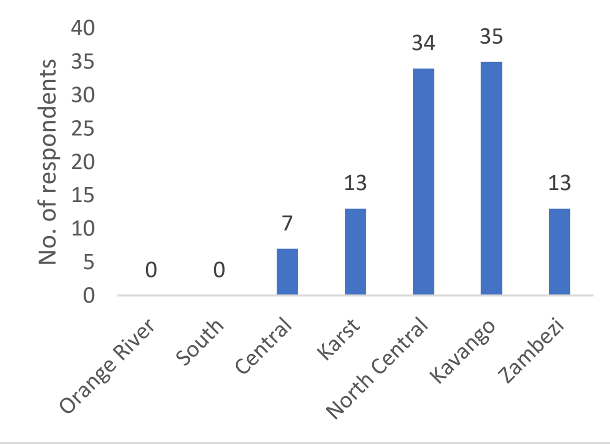
6.1. Demographic characteristics

Although the study was targeted to interview 119 farmers as indicated in subsection 4.3 above, due to other resource constraints and the unavailability of some of the targeted farmers, the study only ended up interviewing 102 respondents, and thus the study's sample size represented 86% of the targeted sample. The descriptive analysis in terms of production zone, gender, and age is hereby presented in Tables 3 to 5.

As illustrated in Table 3, the majority of the respondent farmers in this study were from the Kavango production zone, with 34%, followed by the North Central production zone with 33%. Zambezi and Karst production zones had an equal number of respondents (13% each), whilst Central had 7% of respondent farmers.

Table 3: Production zones of respondents

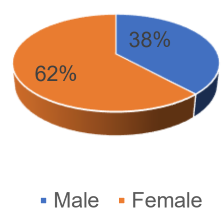
Production zone	**No. of Respondents**	**Percent (%)**
North Central	34	33
Kavango	35	34
Zambezi	13	13
Central	7	7
Karst	13	13
South	0	0
Orange River	0	0
Total	102	100



The majority of the respondents were female, represented by 62% of the interviewed farmers, whilst male respondents accounted for 38% (Table 4).

Table 4: Gender of respondents

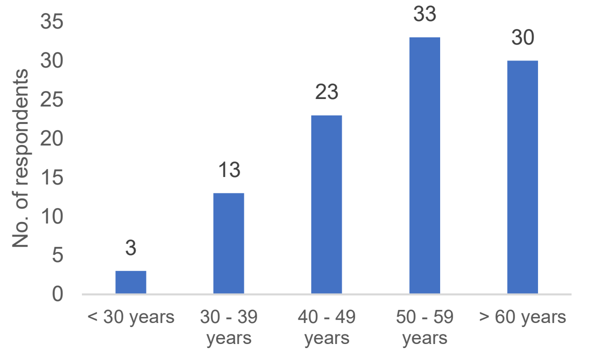
Gender	**No. of Respondents**	**Percent (%)**
Male	39	38
Female	63	62
Total	102	100



In terms of age category, the majority of the respondents were aged between 50 and 59 years old, followed by those aged 60 years and older. Those aged less than 30 years accounted for 3% of the interviewed respondents accordingly (Table 5).

Table 5: Age category of respondents

Age	No. of Respondents	Percent (%)
<30	3	3
30 - 39	13	13
40 - 49	23	23
50 - 59	33	32
60+	30	29
Total	102	100



6.2. Farmers' general knowledge about climate change

As indicated in Table 6, 89% of farmers interviewed in this study were aware and had a general understanding of climate change. About 90% of the farmers also indicated that they follow weather updates consistently and observe changes in weather patterns. A total of 97% of the farmers interviewed also revealed that their crop production levels had been affected by these changing weather patterns, hence acknowledging the impacts of climate change.

Table 6: Perceived knowledge and impact of climate change

Knowledge	Yes	No	Don't know
Do you have a general understanding/ knowledge of climate change?	91 (89%)	11 (11%)	
Do you follow weather updates consistently, and have you observed trends in weather pattern changes?	90 (88%)	11 (11%)	1 (1%)
Do you feel that the pattern of weather is generally changing?	90 (88%)	4 (4%)	8 (8%)
Do you think that your crop production is being affected by climate change?	97 (95%)	5 (5%)	

Table 7 indicates that 95% of farmers noted that there has been an increase in temperature levels, while 87% indicated that they have noted a decrease in rainfall in their area. In terms of rainfall patterns, the majority of the farmers indicated that the rainfall now starts late (as late as December or January) and stops too early, hence the rainy season has become too short and very dry. Some farmers, accounting for 42%, also indicated a decrease in flood incidences, possibly due to the reduced rainfall. At least 81% of the farmers interviewed reported an increase in drought occurrences, with only 11% indicating that they have noticed a decrease in drought.

Table 7: Farmers' perceptions of the severity of climate conditions

Weather conditions	Perceived direction *(%)*			
	Increasing	**decreasing**	**No change**	**I don't know**
Temperature	94%	2%	2%	2%
Rainfall	6%	87%	4%	2%
Flood	21%	42%	20%	17%
Drought	81%	11%	3%	5%

6.3. Farmers' production information about climate change

In terms of land size, the majority of the farmers interviewed, representing 36.3%, owned land of a size between 1.1 and 5 hectares, followed by those who owned more than 10 hectares of land, represented by 30.4%. Overall, only 11.8% of the interviewed farmers owned less than 1 hectare of land (Table 8).

Table 8: Total size of land

Land size	No. of farmers	%
<1 ha	12	11.8
1,1 - 5 ha	37	36.3
5,1 - 10 ha	22	21.6
10+ ha	31	30.4
Total	102	100.0

Q: What is the total size of your land?

As indicated in Table 9, the majority of farmers interviewed in this study, accounting for 50% of the respondents, had more than 15 years' experience in growing agronomy crops (either white maize, pearl millet, or wheat). This, therefore, indicates that the majority of the farmers consulted may have experienced some climate variabilities throughout their production years. At least 17.6% had less than 5 years of experience in growing various agronomy crops.

Table 9: Years of farming experience

Years of farming	No. of farmers	%
<5 years	18	17.6
5 - 10 years	17	16.7
10 - 15 years	16	15.7
15+ years	51	50.0
Total	102	100.0

Q: How long have you been producing the selected crop/s above?

Figure 11 above indicates that pearl millet is the majority crop cultivated by the farmers engaged in this study, representing 48%. Pearl millet is followed by white maize, accounting for 42% whilst wheat and other crops (i.e., sorghum) accounted for 9% and 1% of farmers interviewed, respectively.

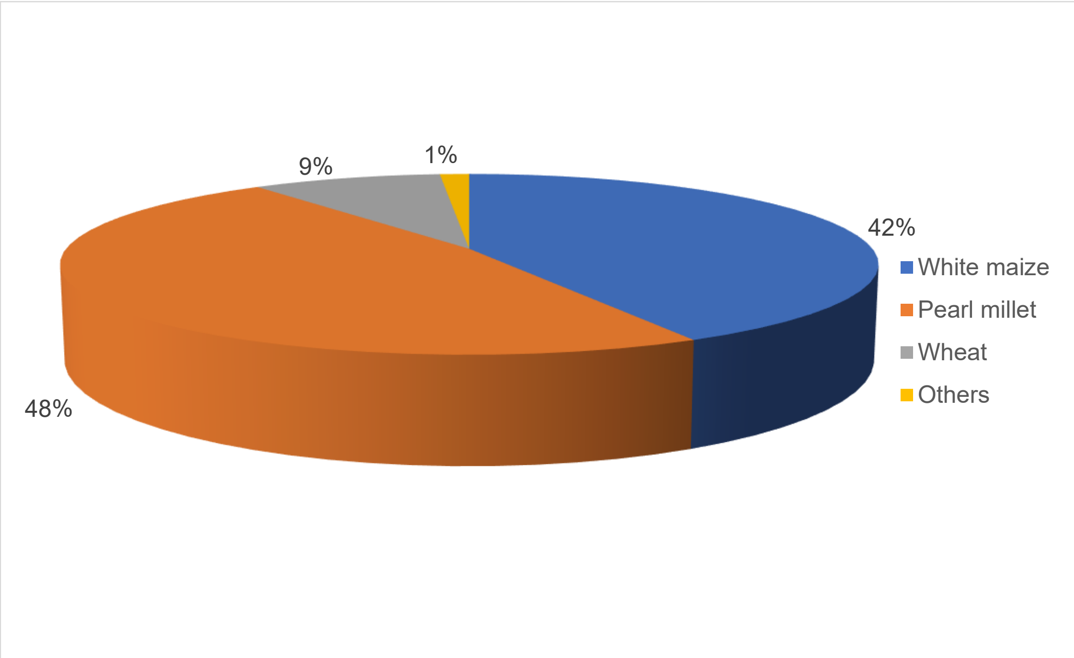


Figure 11: Type of agronomy crop cultivated

Interviewed farmers were also asked to indicate how much of their crop was lost or damaged during production due to climate change during the past 10 years, indicated as the period between 2012/13 and 2021/22. This was to help determine the impacts of climate change in terms of how many farmers faced damage or loss of their agronomic crops due to climate change, in terms of hectares lost/damaged.

As indicated in Figure 12, the majority (23) of **pearl millet** farmers indicated that they lost 1 hectare or less of their production during the 10 years under review (2012/13 to 2021/22), followed by those who lost between 1 and 5 hectares. A majority (10 farmers) of **white maize** farmers indicated having lost 1 hectares or less of production during the same period, followed by 8 farmers who lost between 1 and 5 hectares of production. For **wheat**, which is mostly cultivated under irrigated conditions as it is a winter crop, the majority (3) of the farmers indicated a crop loss of less than 1 hectare, followed by an average of 2 farmers who lost more than 10 hectares of production during the same period.

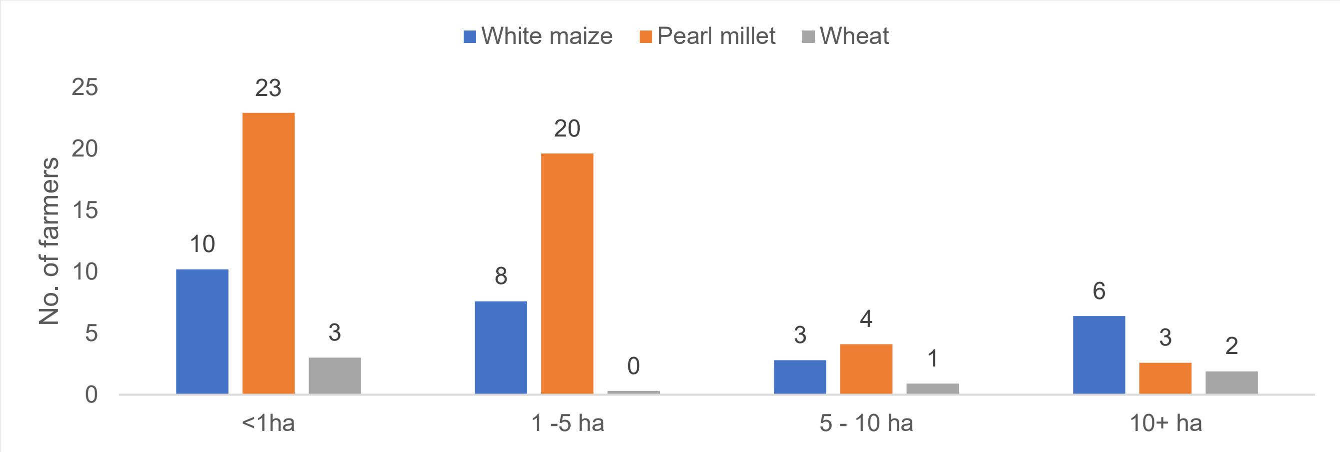


Figure 12: Area of crop damaged/lost in hectares

The subsequent figures (Figure 13, Figure 14 & Figure 15) indicate the most prominent climate change conditions that contributed to the crop damage or loss experienced by farmers as indicated in Figure 12 above.

Of the farmers who indicated crop damage or loss of white maize during the 10 years from 2012/13 to 2021/22, ranging from different land sizes, the majority stated drought as the main cause of the crop damage. Flood and frost were stated to be the least common causes of crop damage for white maize farmers.

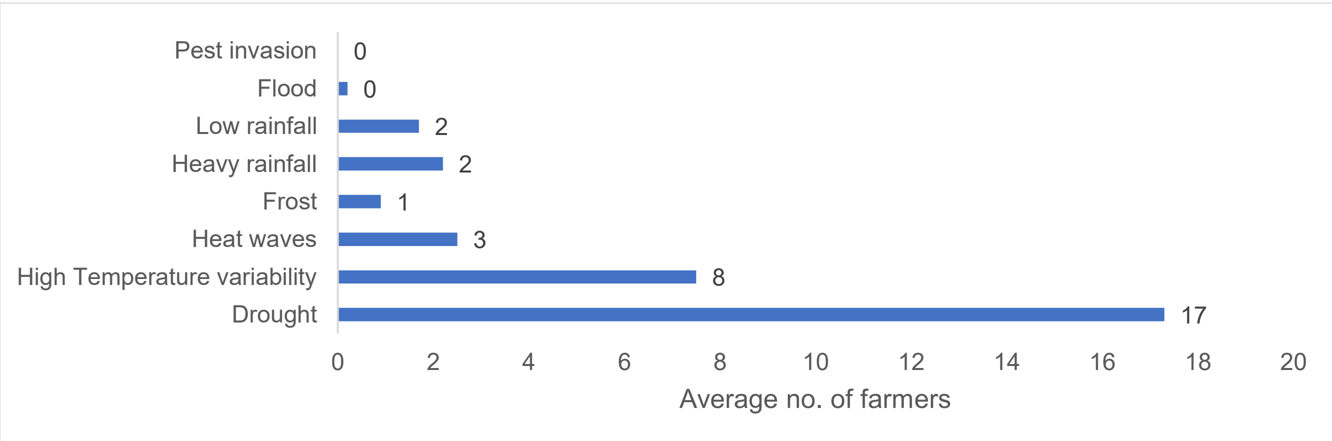


Figure 13: Climatic cause of the crop damage/loss – White maize

As depicted in Figure 14, drought and high-temperature variabilities were stated to be the main climatic causes of the crop damage in pearl millet production, having been experienced by an average of 34 and 15 farmers, respectively. Other “least” climatic conditions that cause crop damage to pearl millet are flood, low rainfall, and heavy rainfall.

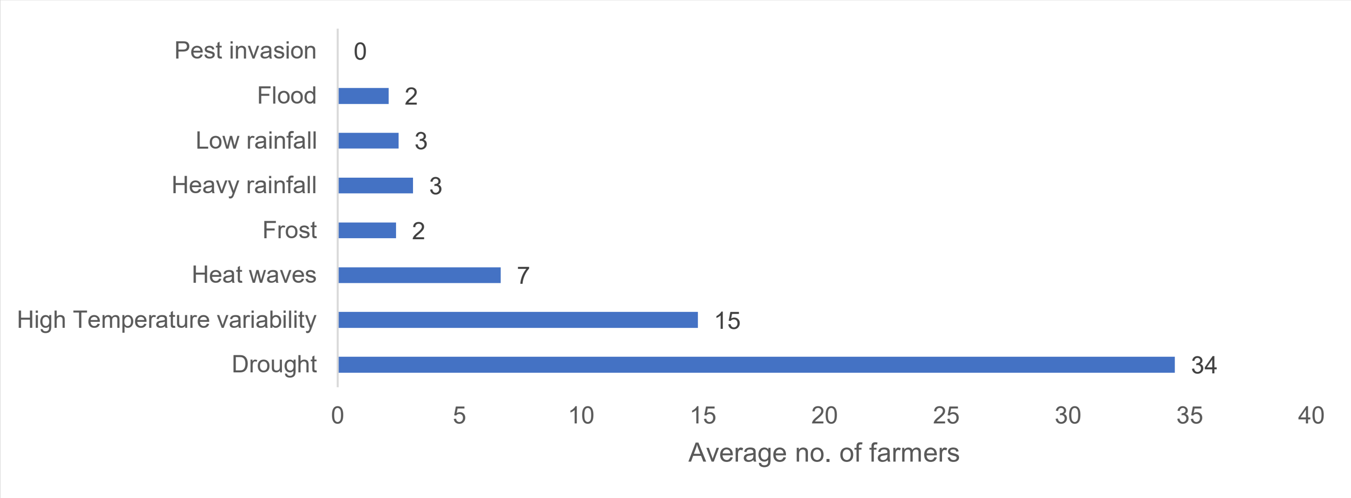


Figure 14: Climatic cause of the crop damage/loss – Pearl millet

For wheat production, which is commonly cultivated under irrigation conditions, drought and high-temperature variability were stated as the most common causes of the experienced crop damage/loss (Figure 15). This can be attributed to the fact that drought leads to reduced availability of irrigation water needed for wheat cultivation. High temperatures and heat waves are also some unfavourable conditions that can impact wheat production, as this is a winter crop.

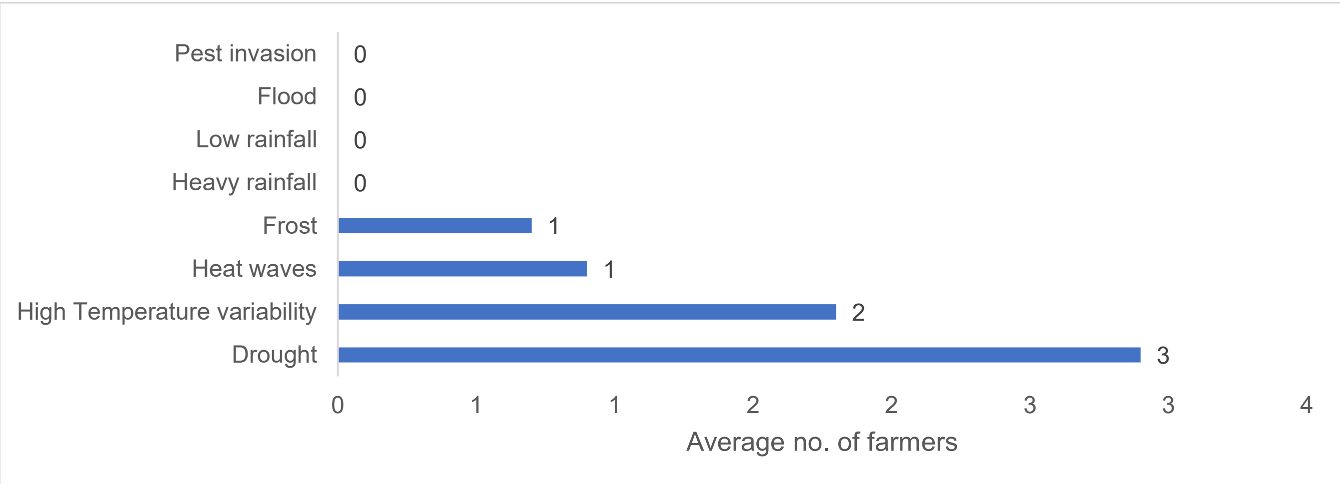


Figure 15: Climatic cause of the crop damage/loss - Wheat

Table 10 indicates the perceived yield by the interviewed farmers under good climatic conditions. A total of 50% of interviewed farmers indicated harvesting 1 – 5 tons/ha of white maize under good climatic conditions. Additionally, 67% of the interviewed farmers indicated that they harvest 5 – 10 tons/ha of wheat, whilst 75% indicated that they harvest 1 – 5 tons/ha of pearl millet under good conditions, respectively.

Table 10: Yield under good climatic conditions

Crop type	***Yield***			
	< 1 ton/ha	**1 - 5 tons/ha**	**5 - 10 tons/ha**	**> 10 tons/ha**
White maize	4%	50%	30%	16%
Wheat	0%	22%	67%	11%
Pearl millet	7%	75%	15%	3%
Q: What is your average yield under good climatic conditions (above-average rainfall)?				

The number of farmers harvesting less than 1 ton/ha of white maize and pearl millet seems to increase to 15% for white maize and 67% for pearl millet when the climatic conditions are harsh. It is, however, worth noting that the number of farmers harvesting 5 – 10 tons/ha of wheat seems to be stable because this is an irrigated crop, and it only slightly decreased due to the reduced availability of water for irrigation and some extreme temperature variability (Table 11).

Table 11: Yield under harsh climatic conditions

Crop type	***Yield***			
	< 1 ton/ha	**1 - 5 tons/ha**	**5 - 10 tons/ha**	**> 10 tons/ha**
White maize	15%	73%	10%	2%
Wheat	0%	44%	56%	0%
Pearl millet	67%	28%	5%	0%
Q: What is your average yield under harsh conditions (low rainfall)				

In terms of perceptions of the overall yield of white maize, wheat, and pearl millet, 43% of white maize farmers observed a decrease in yield, 46% observed a yield increase, and 38% felt like there was no change in white maize yield. For wheat, only 3% of farmers reported having observed a yield decrease, 15% observed a yield increase, and 23% reported no change in wheat yield. A total of 54% of pearl millet farmers observed a yield decrease, 38% observed an increase in yield, and 38% felt that there was no change in the yield of pearl millet (Figure 16).

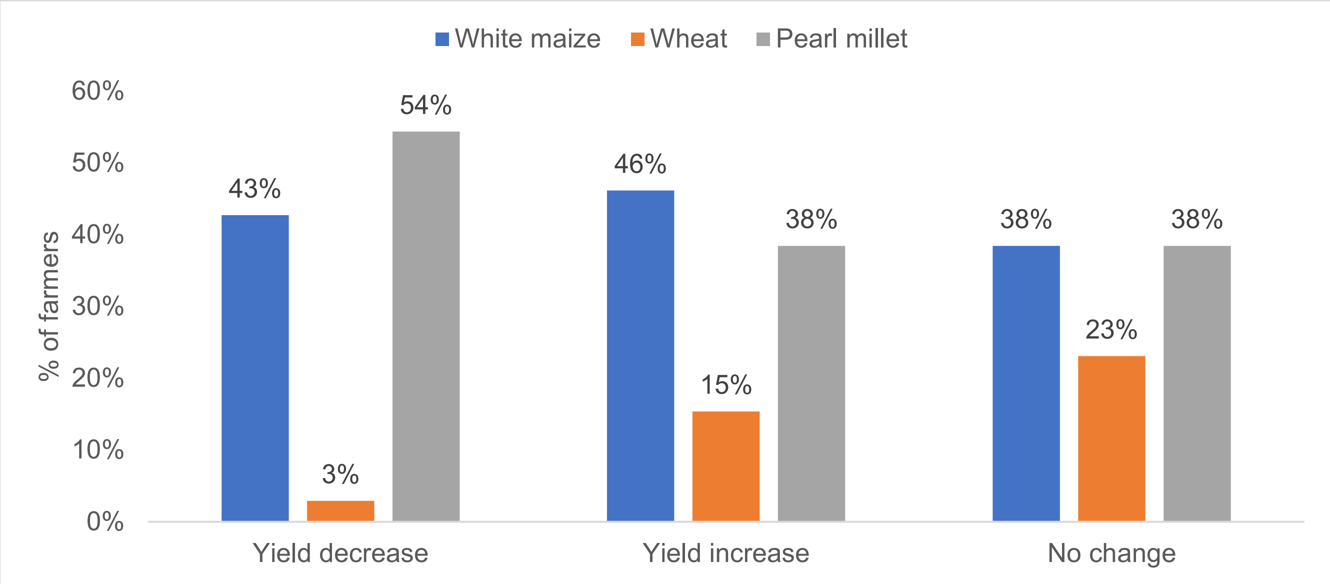


Figure 16: Perceived impact of climate change on yield

Overall, pearl millet seems to be more affected by climate change in terms of yield, as the majority of farmers reported a decrease in yield. For white maize and wheat, more farmers reported having observed either an increased yield or no change in yield. This is because most farmers have resorted to increasing their irrigation acreage to supplement the limited rain and, therefore, cope with the long dry spells brought about by climate change. Other adopted coping mechanisms are also noted in the subsequent sub-sections below.

Table 12 shows that 78% of the interviewed farmers feel that climate change has disrupted the availability of natural agriculture-required resources for crop production. Over 90% of farmers also indicated that climate change has now caused eco-anxiety in their crop production environment. These findings agree with Shoko (2023), who stated that the psychosocial impacts of climate change have a bearing on the sustainable development of emerging rural communities, as some farmers may experience heightened negative feelings, thoughts, and emotions towards their farming endeavours.

Table 12: Farmers' perceptions of environmental disruption and eco-anxiety

Question	**Yes**	**No**
Has climate change disrupted the availability of natural agriculture-required resources (i.e. arable land, organic matter, manure) for crop production?	79 (78%)	22 (22%)
Is climate change causing eco-anxiety (a fear of environmental damage or ecological disaster) in your crop production environment?	93 (91%)	9 (9%)

6.4. Combating measures/ adaptation strategies

To reduce vulnerability to the impacts of climate change, farmers must adopt some measures to cope and reduce vulnerability, and in this case, crop damage or loss, especially of staple crops such as white maize, pearl millet, and wheat, which were under review in this study.

As shown in Figure 17, 53% of farmers adopted crop rotation as a strategy to help cope with the impacts of climate change. Many others are also implementing coping mechanisms such as intercropping (45%), reduced tillage practices (41%), planting of drought-resistant and early maturing varieties (39%), and practising conservation agriculture (33%). A few other farmers mentioned other measures, such as reducing plant population when planting, switching to drip irrigation to minimise water usage, and switching to solar energy as a power source.

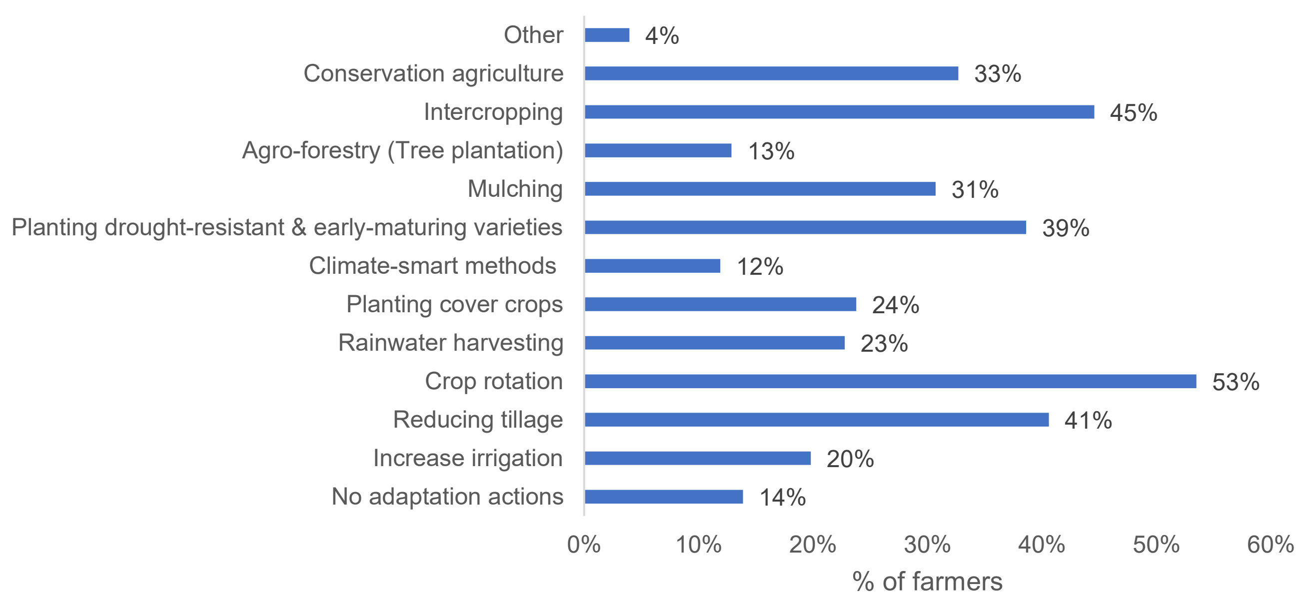


Figure 17: Farmers' adaptation strategies/measures for climate change

New strategies, unfortunately, sometimes come at an additional cost to a farmer, or some other limiting factors may limit farmers from fully participating or adopting some available climate change strategies. Figure 18 indicates that 65% of the farmers faced a challenge of a lack of funds, whilst 56% faced a challenge of high cost of inputs such as fertilisers and improved seeds. As a result of using some of the coping measures to deal with climate change impacts, other farmers faced challenges of high cost of farm labour (45%), inadequate knowledge about how to cope with climate change effects (37%), non-availability of farming inputs (37%), poor potential for irrigation (31%) and many other challenges as shown in Figure 18.

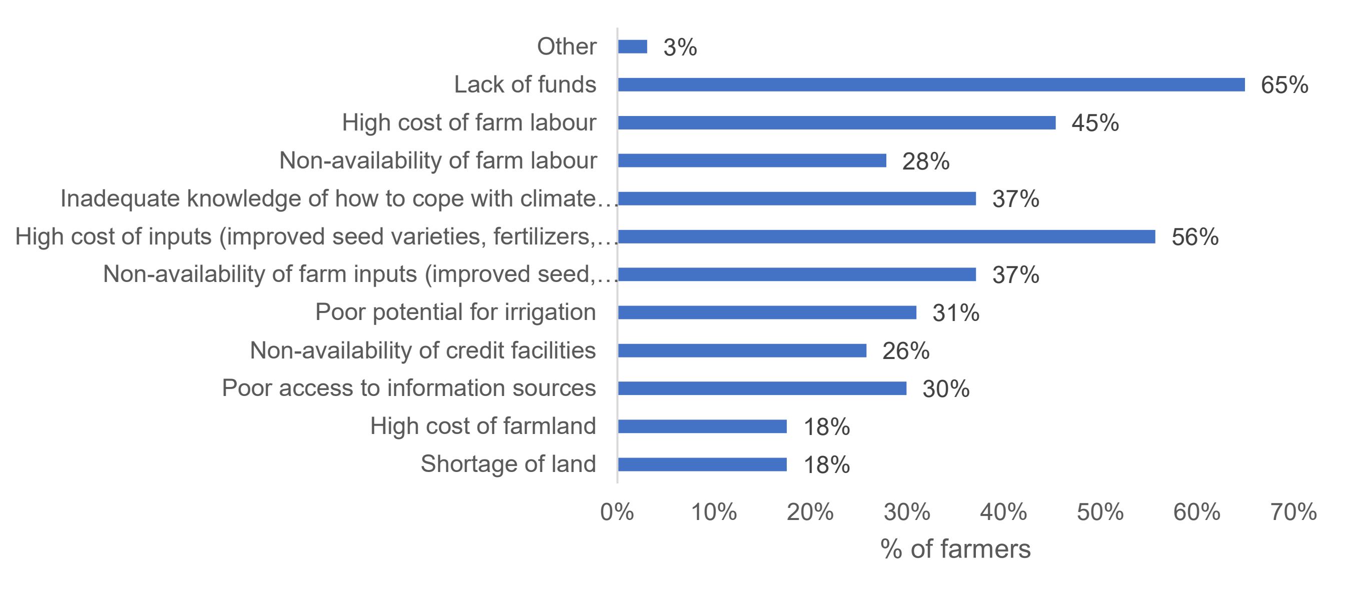


Figure 18: Farmers' constraints to adopting climate change strategies/measures

Figure 19 shows that 76% of the farmers interviewed in this study felt that deforestation is the main contributor to climate change, and that it is accelerating its impacts. A total of 52% of the farmers also indicated livestock farming (overgrazing) as one of the agricultural practices that is accelerating the impacts of climate change. At least 4% of the farmers gave other reasons, such as an increase in human population and soil erosion (which is caused by deforestation), as other factors that are accelerating the impacts of climate change in Namibia.

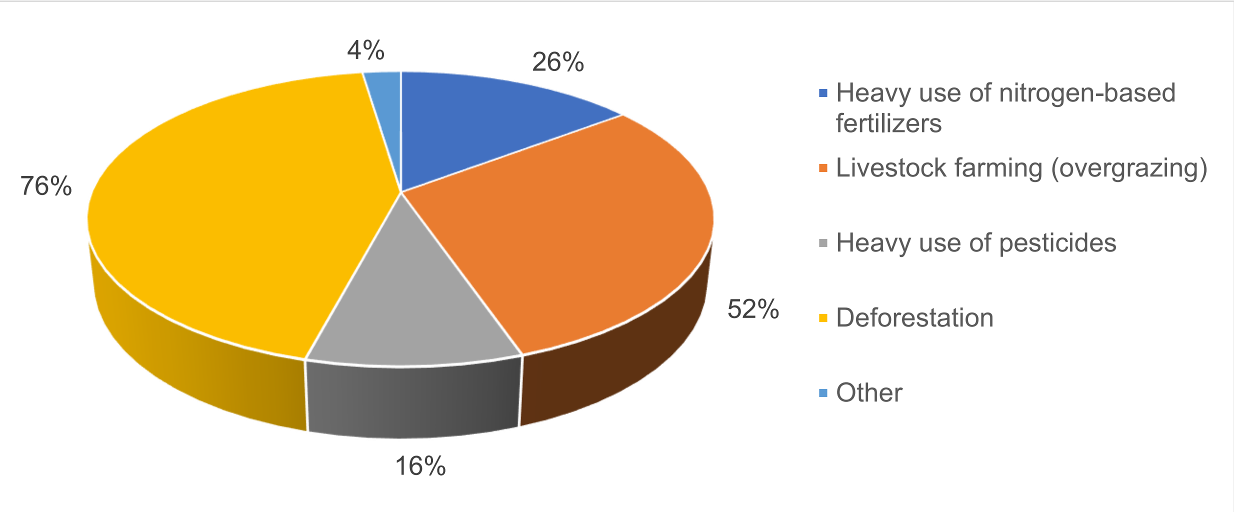


Figure 19: Farmers' perceptions on the agricultural practices that are accelerating climate change impacts

As illustrated in Figure 20, at least 70% of the farmers indicated that they are struggling to cope with the impacts of climate change due to one or more reasons stated in Figure 18. Hence, 100% of the farmers consulted in this study agreed that there is a need for enhanced training and awareness sessions on climate change to be conducted for farmers and the whole communities in Namibia.

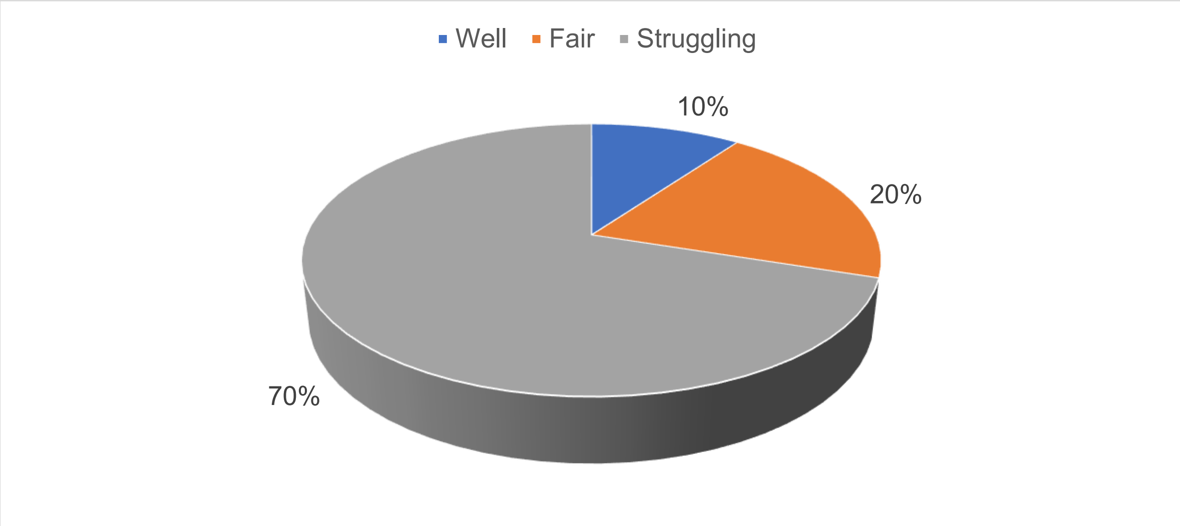


Figure 20: Farmers' adaptation level to climate change impacts

6.5. Major constraints/consequences of climate change in Namibia

Farmers were also asked to rank several consequences of climate change as experienced in order of how common they occur in Namibia. The presented consequences could be ranked from 1 = the most common consequence and the last, 9 = being the least common consequence of climate change as experienced by the farmers. The frequency rankings of the different consequences of climate change by the surveyed farmers are presented in Table 13.

Table 13: Farmers' perceptions of the most or least common consequence of climate change

Ranked Frequencies/ Consequences	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	***Mean***	***Rank order***
Veld fires	7	14	12	7	6	3	4	5	-	3.71	3
Drought	69	14	2	2	-		1	1	-	1.47	1
High-temperature variability	16	42	14	1	6	3	3	-	-	2.53	2
Heat waves	3	8	22	17	3	6	2	4	-	3.85	4
Frost	-	3	7	12	5	4	5	11	-	5.26	9
Heavy rainfall	-	1	11	8	11	3	2	1	-	4.38	6
Low rainfall	2	2	4	5	2	4	3	-	-	4.23	5
Floods	1	2	7	12	5	6	6	2	-	4.71	7
Pest invasion	-	8	4	9	11	6	6	6	1	4.98	8
Other	1	-	-	-	1	-	-	-	-	3	10

A decision or conclusion is made based on the mean scores of each consequence, whereby the lowest mean is ranked number 1 or the most common, and the highest mean is ranked number 9 or the least common consequence of climate change experienced by farmers.

Figure 21 further illustrates the mean scores of each consequence as perceived by the farmers. The majority of the respondents ranked drought (1.47 mean score) as the most common consequence of climate change or the most occurring event as a result of climate change. Drought is followed by high-temperature variability, which scored a mean of 2.53, and thirdly, veld fires, which scored a mean of 3.71. Other phenomena such as frost, pest invasion, and flood are perceived to be the least common occurring as a result of climate change.

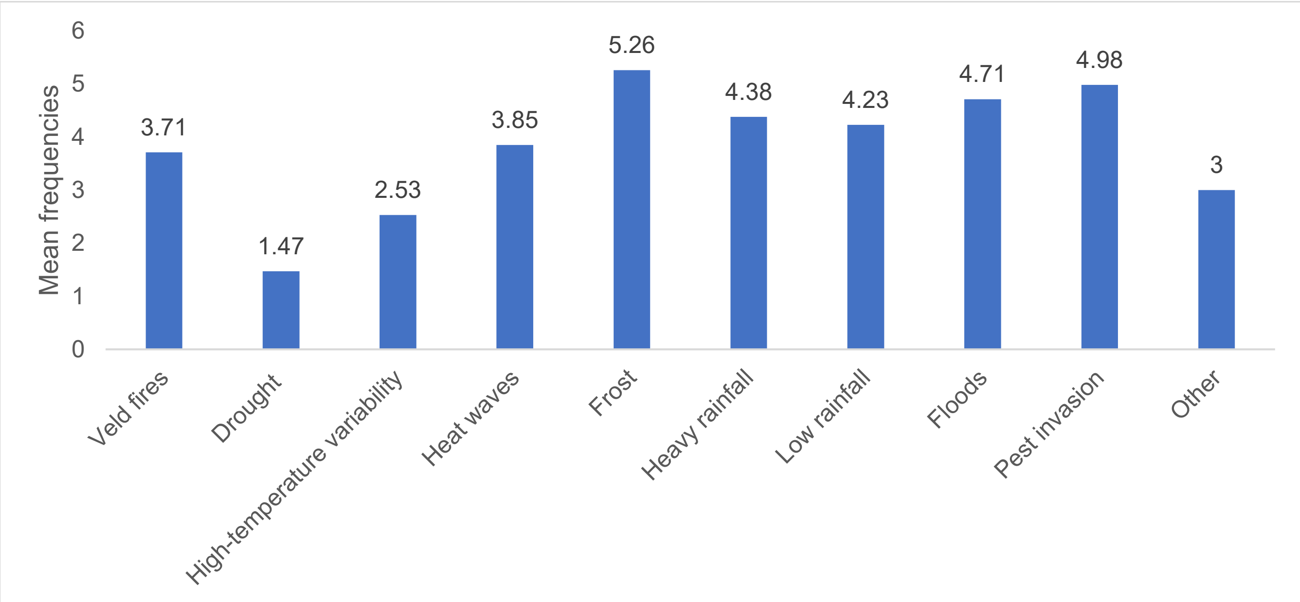


Figure 21: Farmers' adaptation level to climate change impacts

6.6. Current/existing climate adaptation programmes/strategies in Namibia targeted at crop farmers

6.1.1. National Policy on Climate Change for Namibia 2011

The Ministry of Environment, Forestry and Tourism (MEFT) is the custodian of the National Policy on Climate Change for Namibia (Ministry of Environment and Tourism, 2011) whose overall aim is to address climate change as a challenge by responding in a timely, effective and appropriate manner via exploring adaptation and mitigation approaches relevant to different sectors at the local, regional and national level to improve the quality of life of its citizen. This Policy's objectives are:

a) To develop and implement appropriate adaptation strategies and actions that will lower the vulnerability of Namibians and various sectors to the impacts of climate change;
b) To develop action and strategies for climate change mitigation;

c) To integrate climate change effectively into policies, institutional, and development frameworks in recognition of the cross-cutting nature of climate change;
d) To enhance capacities and synergies at local, regional, and national levels and at individual, institutional, and systemic levels to ensure the successful implementation of climate change response activities; and
e) To provide secure and adequate funding resources for effective adaptation and mitigation investments on climate change and associated activities (e.g., capacity building, awareness, and dissemination of information.

It is, therefore, worth noting that several interventions aimed at addressing the impacts of climate change in the crop industry are aligned with good legal frameworks, such as this policy and others, including the National Climate Change Strategy and Action Plan 2013–2020.

6.1.2. Dry Land Crop Production Programme (DCPP)

The Dry Land Crop Production Programme (DCPP), complemented by the Cereal Value Chain Development Programme (CVDP), is a subsidy-based intervention by the Ministry of Agriculture, Water and Land Reform (MAWLR) aimed at increasing food production and productivity along the cereal value chains. The government, through this programme, provides subsidies to farmers for services such as tillage, provision of improved seeds, provision of fertilisers, provision of wedding services, and subsidy on machinery (i.e., milling machines, threshers, storage facilities). Overall, the DCPP enables the Namibian government to address the challenges posed by climate change on agriculture, to secure food security, and consequently improve the livelihoods of the nation.

6.1.3. Green Scheme Policy

The Green Scheme Policy was established in 2008, and its main goal is to enhance the country's agricultural productivity by promoting the development of irrigated agriculture along perennial rivers in Namibia. The policy seeks to increase food production, achieve self-sufficiency, and stimulate economic growth through the efficient use of water resources and modern farming techniques. It is through this policy that the Green Scheme Irrigation Projects in Namibia are operating. The same policy also makes provision for access to land to individual farmers by way of leases of plots to such farmers to produce their crops. Overall, the Green Scheme Policy represents a strategic initiative to strengthen Namibia's agricultural sector while addressing the challenges and opportunities presented by climate change.

6.1.4. Comprehensive Conservation Agriculture

This is an intervention programme under the Ministry of Agriculture, Water and Land Reform (MAWLR), a key component of the Dry Land Crop Production Programme (DCPP), which aims to reduce and reverse land degradation in Namibia. The programme also promotes the adoption of Conservation Agriculture (CA) practices such as minimal soil tillage, crop diversification, and maintaining crop cover, as means of mitigating the impacts of climate change. This programme is being implemented throughout the country and, therefore, benefiting the majority of farmers in Namibia (Haraseb B. 2022).

6.1.5. Climate Resilient Agriculture in Three Vulnerable Extreme Northern Crop-growing Regions (CRAVE)

This project is being implemented in the Zambezi, Kavango East, and Kavango West regions through funding from the Environmental Investment Fund (EIF). It is also serving as a complement to the CA programme, whereby it capacitates the beneficiaries to acquire skills and knowledge to adopt conservation agriculture and climate-resilient agricultural practices (EIF, 2024).

6.1.6. Namibia Agriculture Mechanization and Seed Improvement Programme (NAMSIP)

This is a programme aimed at increasing agricultural production and productivity through mechanisation and certified seed systems. The government procures tractors for distribution in communities to assist with ploughing services during the rainy season. Seed research is also conducted at various research stations to produce quality certified seeds, which are then sold to the community at a discounted price (Haraseb, 2022).

7 CONCLUSION

About 102 respondents/farmers from 5 different production zones were consulted for this study, which aimed to determine the impacts of climate change on white maize, wheat, and pearl millet. The study found that about 23 pearl millet farmers lost at least 1 hectare or less of their production during the 10 years under review (2012/13 to 2021/22). The majority of about 10 white maize farmers indicated having lost 1 or fewer hectares of production, whilst about 3 wheat farmers indicated a crop loss of less than 1 hectare of production during the same period.

For white maize farmers, the majority stated drought as the main cause of crop damage, with flood and frost being the least common cause of crop damage due to climate change. Pearl millet farmers also indicated drought and high-temperature variability as the main climatic causes of crop damage in pearl millet production. Wheat farmers also stated drought as the main cause of their crop damage due to the reduced availability of irrigation water needed for the cultivation of wheat. On the other hand, rainfall, which is essential for crop production, is noted to have been on a decreasing trend.

The majority of crop farmers interviewed in this study have adopted more responsive measures, such as crop rotation, intercropping, and reduced tillage practices, as measures to help cope with the impacts of climate change. As a result of these practices, most are, however, faced with challenges of a lack of funds, high cost of inputs (fertilisers, improved seeds, etc.), limited knowledge on climate change, etc. On a national level, the country, through the Ministry of Agriculture, Water and Land Reform (MAWLR), has implemented various programmes targeted at climate change adaptation measures such as the Dry Land Crop Production Programme (DCPP), Conservation Agriculture (CA), Climate Resilient Agriculture in three Vulnerable Extreme Northern Crop-growing regions (CRAVE), Namibia Agriculture Mechanization and Seed Improvement Programme (NAMSIP) etc which can be further explored and expanded.

The limitations of this study are, however, that it did not establish the level of impact the current national programmes have on agronomic crop productivity to determine effectiveness. It would be beneficial if a follow-up study could be carried out to assess the impacts such national programmes/strategies have on the production of agronomic crops, as well as their perceived acceptance by the targeted farmers in general.

8 RECOMMENDATIONS

Overall, the study concluded that the majority of crop farmers are being negatively affected by climate change impacts, which has resulted in reduced crop yields of cereal crops. This is a big threat to the country's food security, as the cereal crops under review in this study are considered staple foods in Namibia. Urgent and effective interventions are required to help farmers navigate the devastating climate change impacts. The interventions should, however, be more proactive in terms of preventing the impacts instead of reacting to them. Overall, based on the findings within this report, this study presents the following recommendations:

a) **Promote a climate-smart irrigation system and extend subsidies to promote irrigated crop production**. This includes improving the productivity level of the Green Scheme irrigation projects through the drafting of turnaround strategies and streamlining the Standard Operating Procedures to ensure smooth operations.
b) **Invest in more water infrastructure**. This involves the construction of more dams, especially in areas that are prone to flooding, to collect water for irrigation purposes.
c) **Boost awareness and upscale Conservation Agriculture (CA),** which promotes useful practices for permanent soil cover, minimal soil disturbance, and crop diversification. These are practised especially by small-scale farmers in the communal set-up. Such farmers are a bit reluctant to try new techniques, hence the need to set up more trials and demo practices for the farmers to see and appreciate the benefits of CA more.
d) **Invest in improved/certified seed provision.** The NAMSIP programme's seed provision section is underdeveloped, and the production of certified seeds is not sufficient for most, if not all, farmers in Namibia as required. The MAWLR is, therefore, encouraged to source more funds to invest in the seed production sector to produce enough certified and improved seeds that can sustain the prevailing harsh climatic changes and drought resistance.

e) **Extend the seeds and fertiliser subsidy scheme to surplus and commercial farmers** since the current dry land crop production programme focuses on communal smallholder farmers and not commercial and surplus farmers, which greatly influences food security in the country.
f) **Introduce crop insurance schemes for farmers**. Consider government-backed insurance products for crop farmers so that they are encouraged to produce more without the fear of failing. These products can also be considered for funding under other climate change advocacy organisations, such as the EIF.
g) **Awareness and training**. Many farmers have noticed the weather pattern changes, but do not seem to understand the causes and how to deal with the associated impacts. The government, specifically the Ministry of Agriculture, Water and Land Reform (MAWLR), as the lead, together with other private institutions with similar interests and knowledge in climate change education, is encouraged to invest in training farmers on how to deal with climate change impacts.
h) **Research and development.** Agricultural innovation and research remain crucial to developing climate-resilient crop varieties and new and improved farming techniques. The government, research/academic institutions, and any other private institutions are urged to prioritise research and development techniques that are aimed at addressing climate change challenges.

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