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Rural small scale arable farmers' perceptions to rainfall variability as climate changes in southern Botswana

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Abstract: *The paper presents findings of the study on how rural small scale crop farmers in southern districts of Botswana perceive variability in rainfall trends and patterns over the past 20 years as climate changes. The study sought to evaluate the level of awareness among the arable farmers and to assess their reactions to the effects of rainfall fluctuations on their farming activities. A qualitative design was used in a multiple case study when one hundred and seventy arable farmers were purposively sampled from three rural communities, Kopong and Kumakwane in Kweneng district and Dikwididi in Kgatleng district. Questionnaire instruments were administered to the sampled farmers while structured interviews were done with the traditional leaders of the three communities to validate farmers' responses. A total of 173 participants took part in the research. The study found that farmers were generally aware of changes in climate as 89% confirmed having experienced rainfall pattern decrease and fluctuations over the past 20 years. The farmers were implementing adaptation and mitigation measures to reduce the negative effects on their activities. From the farmers' responses, the study concluded that on average, rainfall has been very low for several years, and insufficient for agricultural activities, confirming dry conditions with very little rain. Farmers perceived this to be impacts of climate change causing crop failure and food insecurity in their communities. The study recommended collaborations between farmers in developing and implementing improved climate strategies in line with climate change. The study further recommended increasing of the number of weather stations in rural communities to enable farmers to make timely decisions on when, what and how to plant, rather than the use of estimations on weather forecasts.*

Key Words: *rural, small scale arable farmers, perceptions, rainfall variability, climate, Botswana.*

1. INTRODUCTION:

Climate variables, rainfall and temperature, contribute to climate change which is affecting agricultural production worldwide (1). As climate changes, there are variations in the mean pattern of rainfall and increase in temperature (2). Rainfall variability, that is, floods and droughts, has affected health and agriculture in the 21st century globally (3). Such trends, generally affect the sensitive agricultural sector, mainly crop production, which relies largely on precipitation levels (4). Rural livelihoods are increasingly affected by excess or unavailability of water resources, which in turn, impact food security (5). Similarly, variations in patterns and trends of climate are experienced in various districts and regions of Botswana, resulting in rainfall fluctuations (1). The country is highly vulnerable to climate change which is evidenced by the higher incidence of both droughts and floods, impacting mainly small scale arable farmers with limited resources (5). The communities normally experience low humid conditions, and one rainy season with minimal rainfall annually (6). Farmers in rural communities of Botswana depend on mixed crop farming for livelihoods and food security, therefore variations in rainfall levels and patterns significantly affect their farming activities (7). The research focused on evaluating the knowledge and perceptions of farming communities on the changing rainfall trends and patterns as well as their adaptation and mitigation practices.

2. RESEARCH OBJECTIVES

The research sought to achieve the following objectives:

- To assess the level of awareness on variability in rainfall trends and patterns as climate changes
- To evaluate perceptions of small scale farmers on rainfall variability as climate changes in Botswana

- To examine the adaptation and mitigation measures implemented by farmers to reduce impacts of rainfall variability on their agricultural activities.

3. LITERATURE REVIEW:

Farming activities in developed and developing world are impacted by rainfall scarcity and extreme high temperatures as climate changes, as a close relationship exists between these parameters (8). Many countries, are making efforts to either mitigate or adapt to negative impacts of climate change on their activities. Common strategies being adopted by countries are in line with reduction of pollutants from transport and industrial systems (9). Countries like Bangladesh's crop production activities are negatively impacted by climate change in form of floods and decreasing precipitation, which contributes to crop failures (10). Previous researches, for example (11) predicted a rise in atmospheric carbon dioxide, contributing to climate change with rainfall patterns shifting and temperature increases mainly by year, 2050.

Small scale farmers in Africa are aware of climate change, and the increased negative effects, with reduced precipitation levels and extreme temperatures which are contributing to prolonged droughts and crop failures, impacting on food security ((10). Changes in climate contributes to heat waves, flooding and erratic rainfall which decreases crop yield (12). Livelihoods in rural set up are continuously affected by scarcity of water resources. Taking an example of small-scale farmers in South Africa, are impacted by climate change and the effects increased over the past years with prolonged droughts, reduced rainfall, seriously causing crop failures (10). The farmers respond to low rainfall by harvesting water, minimum tillage, mulching and planting drought resistant traditional crops (13). Many households in Zimbabwe's rural farming communities perceive climate variability, and they are supplementing food security and income with mixed farming and other economic activities like buying and selling goods (14) East African countries, for example some Ugandan districts, are experiencing low rainfall, with recurrent drought years, affecting farming activities, though future projections show more rainfall could be experienced by the end of this century (15). In Southern Africa, same trends of declining annual rainfall had been experienced by farmers in Zimbabwe's Low veld region, from 1980 to 2012 (14). In Botswana, climate stressors to farmers' economic activities are drought and scanty rainfall which impact maize and sorghum production in most parts of the country (7). The Inter-Tropical Convergence Zone (ITCZ) to the north, and the El Nino Southern Oscillation (ENSO) phenomenon to the east, affect the country's climate which cause recurrent droughts (5). The country's southern rural communities depend on mixed farming, including arable farming, but the shift in rainfall pattern trends, water stress and security impact small scale farmers, efforts (1). Water stress is due to decline in precipitation since 2010, resulting in crop failure and food insecurity (16). Staple crop, sorghum, is negatively affected across the country. The Northern districts record average annual rainfall of 650mm to 500mm, the same is experienced in Southern districts (17).

To cope with the effects of low rainfall, rural farmers in Botswana and other Southern African countries concentrate on planting drought-resistant seed crops and harvest higher yields, mostly when combined with mixed cropping of different early maturing crops on the same field (18; 19; 20). Farmers in South Africa responded to low rainfall by mulching, planting traditional crops with minimum tillage which proved to be boosting food security (13). Planting hybrid seedlings and disease resistant root crops are climate smart agricultural systems used by cocoa farmers in Ghana to increase yields and improve food security (21). While in Nigeria's Ikwere Local Government Area, farmers respond to low rainfall by cultivating early-maturing crops and intercropping with root crops like cassava, yam and sweet potatoes to boost food production (2)

Small scale arable farmers in Botswana accumulated local knowledge on climate variability, and perceived the negative impacts, though, with limited adaptation options. Previous researches have realized water scarcity, a result of recurrent droughts as negatively impacting future arable farming and food production for rural communities (22). This resulted in collaborations and adopting climate smart strategies of planting drought resistant crops such as sorghum, sweet reeds, water melons, basing on perceptions, to achieve food, income and livelihood security (23).

4/ MATERIALS AND METHODS

Small scale farmers with different crop farming backgrounds took part in the study, thus, a multiple case approach was adopted. This allowed assessment of farmers' perceptions to rainfall variability and climate change and the evaluation of effects of such changes in real life context and across a broader area over the past 20 years. Rural farmers involved in crop farming, in communities namely Kopong and Kumakwane in Kweneng district, and Dikwididi in Kgatleng district, were purposively sampled. The districts lie south of the Tropic of Capricorn within the sub-tropical zone (Omari, 2010). The criteria for inclusion in target populations from which the samples were derived, was strictly being involved in arable farming activities. Agricultural extension officers from each community who work in the field, directly with farmers, provided the populations of community members involved in crop production. Structured

individual interviews were conducted with 3 traditional leaders from the 3 communities while questionnaires were administered to the sampled farmers. The interview questions where mainly on the rainfall trends and patterns as climate changes experienced over the past 20 years on, with key variables as rainfall variability, drought recurrences and flood frequencies. Community leaders were interviewed in the study to validate the farmers' responses as they are also all practicing arable farming.

Purposive sampling was used to select 170 farmers, above 18 years at the time of the study, with arable farming knowledge and experience. Involvement of youth in the study was essential as the young population of Botswana is increasingly getting involved in agricultural activities. Research has shown that engagement of youth in agricultural activities reduce unemployment and social unrest in low- and middle-income countries (24). A total of 173 participants took part in the study. Key variables in the questions included changes in rainfall patterns observed, frequencies of floods and droughts over the past 20 years. The respondents had choices from strongly agreeing to strongly disagreeing statements as they related their experiences on rainfall patterns observed, floods and droughts experienced in relation to climate change.

5. FINDINGS :

Rural small scale farmers who participated in the study perceived and indicated observing rainfall fluctuations in connection with climate change over the past 20 year period. Farmers' perceptions of rainfall changes were transcribed into SPSS version 25.0 and finally cross-tabulation in order to understand the various perceptions over the period. Table 1 below shows the responses of farmers to rainfall patterns observed.

Table 1: Farmers responses to changes in rainfall patterns

What changes in rainfall patterns have you observed over the past 20 years?												
	Strongly agree		Slightly agree		Agree		Disagree		Strongly Disagree		No response	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Rainfall pattern changed over the past 20 years	92	53	27	16	34	20	9	5	6	3	5	3

Table 1 shows that of the 173 farmers who took part in the study, 92 respondents (53%) strongly believed that the rainfall pattern has changed in the past 20 years, 27 farmers (16%) , and 34 (23%) believed the same respectively, while 9 (5%) did not believe so, and six (3%) strongly disbelieved while five (3%) did not respond. The results showed that majority of the respondents believed that the rainfall pattern has changed in the past 20 years. The 3% who did not respond were mainly the discouraged farmers who had given up on arable farming due to low produce and turned to livestock production.

Table 2: Frequencies of floods and droughts observed over the past 20 years.

What frequencies of floods and droughts have you observed over the past years?								
Variable	**Increased**		**Decreased**		**No change**		**No response**	
	No.	%	No.	%	No.	%	No.	%
Frequency of floods	39	23	114	66	14	8	6	3
Frequency of droughts	121	70	17	10	22	13	13	7

Table 2 shows the frequencies of floods and droughts which were observed by the farmers. Of the 173 farmers who participated, the results showed that 114 (66%) had noticed a decrease in floods in the country in the past 20 years, while 39 (23%) perceived an increase in floods with 14 (8%) showing that they did not see any change. Furthermore, on the frequency of droughts, 121 (70%) noticed an increase over the past 20 years, 17 (10%) observed a decrease while 22 (13%) of the respondents could not tell if there was a difference in the past two decades. Generally, the results showed that the frequency of floods have decreased and the 23% of farmers who observed an increase were referring to the

1999-2000, 2006-2007 and 2016-2017's Cyclone Dineo which resulted in flooding in some parts of Botswana, mainly in areas with poor drainage systems and flat terrains. These became the major floods experienced over the past 20 years. The 70% of farmers who observed an increase in droughts also referred to the periods 1997-1998, 2005-2006 and the continuous dry spells of 2011-2014 which seriously affected farming activities, when very little rainfall was received which could not sustain crop growth throughout the planting season.

Therefore, the responses showed that farmers have observed rainfall trends and patterns changing which further revealed that there has really been a climate change affecting their crop production activities. In addition, from interviews with village traditional chiefs, when questions on the indicators, trends and patterns of climate change experienced over the past 20 years on rainfall variability, drought recurrences and flood frequencies, the responses concurred with farmers'. They highlighted an increase in drought recurrences, rainfall variability which had been decreasing seasonally and less floods.

During the interviews, one village chief (VC 2) remarked:

"Rainfall keeps changing every year such that in one season we receive rains and the next season there is nothing and yet it is supposed to be raining"

Another chief, VC 1, in relation to flood occurrences, reiterated:

"Occasionally, excessive rainfall can be received late causing floods because the soil is sandy, it cannot keep water for a long time"

In support of other traditional leaders' comments, VC 3 added:

"Rivers are drying and not flowing throughout the year and boreholes are dry because water table is too low due to continuous droughts"

All the above responses from the community leaders showed that farmers in crop production, were experiencing negative impacts of due to changes in rainfall trends and patterns. Figure 1 below is an example of rainfall records which were captured from 1997 up to 2017 for one of the sampled communities.

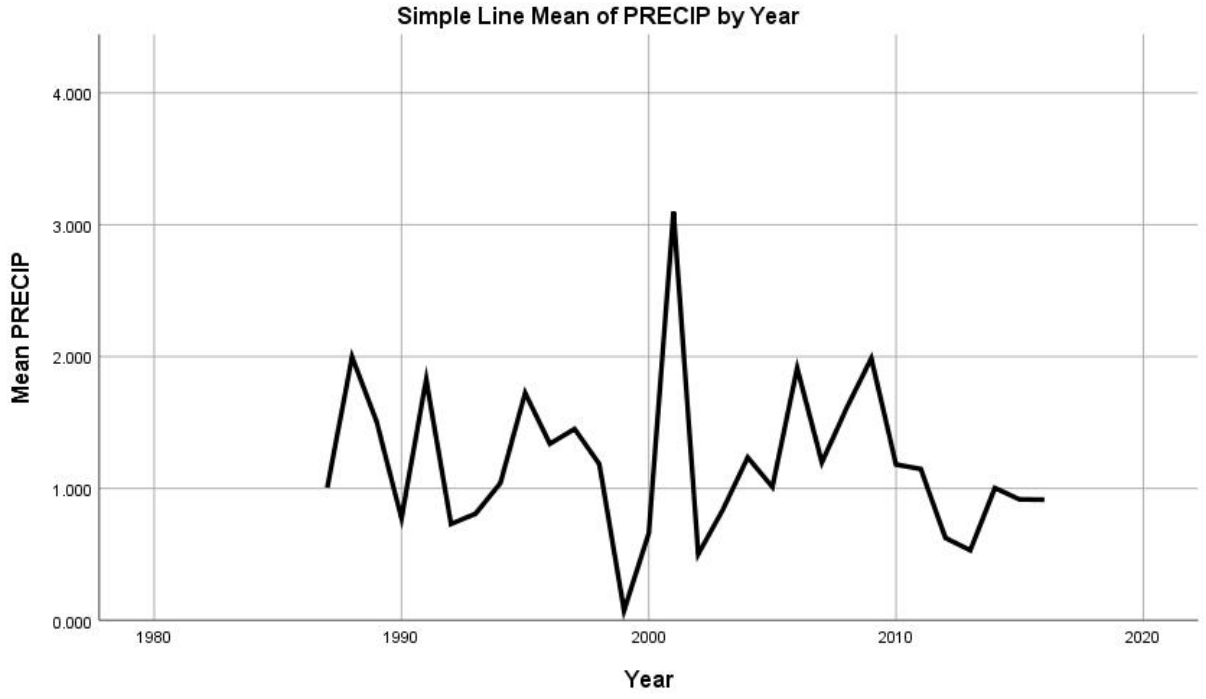

Figure 1: Mean annual rainfall in Gabane-Kumakwane from 1987 to 2017. (**Source**: Botswana Meteorological Services, 2019).

Figure 1 shows the rainfall trends which were provided by the country's Department of Meteorological Services. The pattern shows some sharp fluctuations with very low rainfall in a limited range – for example, in the 1998 to 1999 season, with an increase from the 2000 to 2002 period. However, the average rainfall has been very low, and insufficient for agricultural activities. The records confirmed dry conditions with very little rain, which validated what the respondents in Kumakwane and other 2 communities had noted and observed, that rainfall pattern changed over the past 20 years.

Small scale arable farmers' coping strategies to rainfall variability

The study revealed that rural small scale farmers developed adaptation measures to cope with changes in rainfall patterns and boost food security. The farmers from all the three communities under focus (Kopong, Kumakwane and Dikwididi) used the first or early rains to plant drought-resistant crops such as sorghum, sweet reed and melons; exercised row planting as taught by Agricultural Extension Officers to control plant population and limit competition for water and nutrients, though some farmers from all areas, argued that they still practiced broadcasting in mixed crop farming to increase plant population; planted early-maturing varieties, and used treated hybrid seeds with short seasons of maturity; as well as cultivating at the correct depth to preserve moisture. From the farmers' responses, there was evidence that some of the farmers' coping strategies were effective in reducing effects of rainfall variability and boosting food for family consumption, though some had mixed perceptions on the effectiveness. The later argued on the importance of venturing into mixed farming by incorporating livestock production to boost food security as climate changes.

6. ANALYSIS AND DISCUSSION:

The study findings, reflected that the respondents who noticed the increase in trends to seasonal variations were the same who had noted a decrease in rainfall, and drought occurrences. Precipitation patterns and trends observed in rainfall distribution and variability showed a decrease in amounts received across the communities. Results showed that much rainfall is received out of season with planting months of September to January being dry, while February to April are sometimes wet. Farmers perceived climate change's effects on the rainy season which shifted, starting in late December to January and ending in March, unlike in the past when the season could start in August to September. This shifted the planting season. Furthermore, very low annual average rainfall of 30mm to 50mm could be recorded across the communities, a sign of real drought. This was validated by farmers' responses who observed rainfall pattern decreasing over the past 20 years, too low and insufficient precipitation received annually to sustain agricultural activities.

However, from research findings, rarely, floods were affecting some communities in southern Botswana, with some of the farmers indicating a decrease in flood occurrence. In addition, extreme dry spells in the country, for example in period, 2011-2014, caused very little rain to be received across the southern region, causing crop failure and further food insecurity. Similarly, other researchers had noted sudden floods or decreased precipitation as occurring globally due to climate variability (25). Therefore, from farmers' responses and interpretation of the records, there is a general decrease in precipitation patterns over the years, with more recurrent droughts. Adaptation strategies implemented include growing drought resistant crops such as sorghum and sweet reeds, row planting and use of hybrid seed supplied by the Ministry of Agricultural Development and Food Security.

7. CONCLUSION:

There is low and fluctuating rainfall trends and pattern across southern region of Botswana over the past 20 years, affecting activities of arable small scale farmers' activities. The farmers, perceived climate change with low rainfall, and recurrent droughts and have developed coping strategies to improve food security. The downward rainfall trends and patterns had been noticed in both Kweneng and Kgatleng districts, with records showing that the onset of rainy season has changed, with September to January being dry while February to April are wet, this has shifted the farming season. The farmers believed that the rainfall pattern has changed in the past 20 years, fewer floods are experienced and more droughts over the years. Therefore, there is a close relationship between observed rainfall trends and patterns, recurrent droughts, climate change, crop failure and increased food insecurity in Botswana.

8. RECOMMENDATIONS:

Small scale arable farmers in rural areas must work together when dealing with climate variability and share ideas to develop effective adaptation and mitigation smart strategies. Weather stations are essential in all rural farming communities, for continuous capturing of rainfall records. This enhances forecasting, development of adaptation strategies, and making decisions on when, what and how to plant, rather than the use of estimations. Ministry of Agricultural Development and Food Security should educate small scale farmers more on developing climate smart strategies to boost subsistence food production. More funding and initiatives for rural farmers can improve productivity and diversification to other farming branches to supplement rain fed crop farming.

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