Credibility and Scale as Barriers to Uptake and Use of Seasonal Climate Forecasts in Bobirwa Sub-District, Botswana

Submitted by

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DECLARATION OF AUTHORSHIP

I know the meaning of plagiarism and declare that all of the work in the dissertation, save for that which is properly acknowledged, is my own.

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ABSTRACT

Seasonal climate forecasts (SCF) can play a crucial role in reducing vulnerability to climate variability, particularly for rural populations reliant on agriculture for their livelihood. The use of disseminated SCF by farmers in decision-making could reduce losses and maximise benefits in agriculture. Despite the potential usefulness of SCF, incorporating them into farming decisions is a complex process that navigates through several barriers which constrain their effective use. The first two barriers, namely credibility (trust on SCF) and scale (relevance of SCF in geographical space and time), originate from the limitations of SCF associated with the form in which they are produced. In this study, credibility and scale are investigated as limitations of SCF, which potentially bar the uptake and use of SCF in Bobirwa sub-district. The second group of barriers are beyond the SCF themselves but limit their effective use and emanate from biophysical, socio-cultural and economic factors. This study examines whether credibility and scale are barriers to the use of SCF in Bobirwa farmers' decision-making, investigates how SCF are used in decision-making, and seeks to find out how the barriers are overcome. To make these investigations, qualitative data was collected from subsistence agro-pastoral farmers in eight villages in Bobirwa sub-district of Botswana using semi-structured interviews. Data was collected considering gender to allow for gendered analysis. Themes related to the main study questions were identified from the data and analysed for the number of people who mentioned the themes.

It was found that all 47 farmers interviewed coincidentally had access to SCF and the majority used SCF in their decision-making, while only a handful of farmers were non-users of SCF. The results show that scale (both temporal and spatial) is a barrier for users of SCF, whereas credibility is a major constraint for non-users of SCF in Bobirwa. To cope with the barriers, farmers mainly use local knowledge to complement SCF. Additionally, farmers apply advice from Ministry of Agriculture (MoA) and use economic information in their decisions to deal with the barriers. Despite the barriers, some farmers indicated that using SCF was beneficial in increasing harvests, providing warnings and minimising losses of crops and livestock. However, disadvantages of using SCF were also highlighted, including lost crops, seeds and harvest, and missed opportunities to plant because of lack of temporal and geographical detail in the forecasts. The barrier of credibility has contributed to a few

non-users resorting to using traditional planting, possibly making them vulnerable to the impacts of climate variability.

A gendered analysis shows that almost equal proportions of both males and females use SCF. Moreover, women use SCF for crop farming while men use it for livestock management, which is aligned to traditional roles in Botswana. It is also revealed that, unlike women who only use local knowledge and MoA advice to overcome SCF limitations, a few men also use economic ventures, which could make men less vulnerable than women farmers.

Strong networks between scientists and farmers can reduce the perceived credibility barrier, and innovative ways of reducing the scale barrier can be devised. Therefore, recommendations from the study include continuous engagement with farmers to understand their decision-making context in order to tailor the information to their local context as much as science permits. Government programmes should be designed to integrate SCF to build farmers' resilience to climate variabilities. The impacts on livestock farming, which is dominated by men, need to be given as much prominence in SCF information as arable farming. Forecasters should continue to improve credibility and scale without compromising either factor to avoid chances of contributing to the vulnerability of farmers particularly women, who mostly rely on SCF for crop production.

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TABLE OF CONTENTS

LIST OF ABBREVIATIONS

ASSAR	Adaptation at Scale in Semi-Arid Regions
DMS	Department of Meteorological Services
FMD	Foot and Mouth Disease
GCM	General Circulation Model
ISPAAD	Integrated Support Programme for Arable Agriculture Development
MLG	Ministry of Local Government
MoA	Ministry of Agriculture
MEWT	Ministry of Environment, Wildlife and Tourism
LIMID	Livestock Management and Infrastructure Development
NMS	National Meteorological Service
RCM	Regional Circulation Model
SADC	Southern African Development Community
SARCOF	Southern African Regional Climate Outlook Forum
SCF	Seasonal Climate Forecasts
SSA	Sub-Saharan Africa
SSTs	Sea Surface Temperatures
UCT	University of Cape Town
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations International Children's Emergency Fund
USA	United States of America
WMO	World Meteorological Organization

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: INTRODUCTION

Climate variability is one of the extensive pressures that farmers and communities in rural areas face (Ziervogel & Calder, 2003). A majority of rural communities in Africa, particularly Sub-Saharan Africa (SSA), are dependent on rain-fed agriculture for livelihoods, making them vulnerable to climate variability and change (Challinor et al., 2007; Bryan et al., 2009; Antwi-Agyei et al., 2015). Additionally, the high incidences of poverty, low adaptive capacity, resource constraints and weak institutional capacity contribute to Africa's vulnerability (Antwi-Agyei et al., 2015).

Like other African countries, Botswana is dominated by rain-fed agriculture practised by subsistence farmers as well as by the majority of commercial farmers (Chipanshi et al., 2003). Aridity and highly variable rainfall, with an annual average spanning between 650mm in the extreme north-east to less than 250mm in the southwest, characterise Botswana's climate (Batisani, 2012; Chipanshi et al., 2003; Ministry of Environment Wildlife and Tourism (MEWT, 2012). Botswana is also vulnerable to climate risks such as droughts and floods (Batisani & Yarnal, 2010). Some past drought episodes have resulted into crop failure and livestock mortality (Chipanshi & Ringrose, 2001; Dube & Sekhwela, 2008). Rainfall variability is one of the main obstacles to agricultural production in most developing countries such as Botswana. Despite the climatic challenges, agriculture still plays a significant role in the rural communities as it provides food, employment and income to 70% of the rural population (Batisani, 2012; MEWT, 2012).

Seasonal Climate Forecasts (SCF) can be used by communities and farmers in decision-making to adapt to climate variability at a seasonal timescale to reduce their vulnerability (Hansen, 2002; Ziervogel, 2004; Makaudze, 2014; Roudier et al., 2014; Winsemius et al., 2014). The production of SCF in Southern Africa since 1997 has been marked by improvement, leading to greater demand for accessibility to farmers (O'Brien et al., 2000; Ziervogel & Calder, 2003; Churi et al., 2012). The lead time of SCF information gives farmers an opportunity to plan, which can lower risks or leverage opportunities. Farmers could use SCF to make farming decisions such as changing planting dates, planting suitable varieties, conserving soil moisture, planting feed and restocking or destocking livestock

(Ziervogel, 2004; Mogotsi et al., 2011c).

Despite the potential usefulness of SCF, many scholars argue that the availability of SCF does not guarantee usage as many factors influence farmers' decision-making. These could include constraints like the structure of SCF encompassing the scale not relevant to farmers and probabilities which are less understood by farmers, institutional limitations for the dissemination, farmers' capacities to use SCF as well as social barriers relating to cultural norms and values, which have limited SCF uptake and use (Ziervogel, 2004). Research has found that constraints that hinder the use of SCF are credibility, legitimacy and, lastly, salience comprising scale, cognition, choices and procedures (Patt & Gwata, 2002; Hansen et al., 2011). It is explained that credibility relates to trustworthiness and quality of forecasts, scale refers to their relevance to users in time and space, while legitimacy encompasses fairness of information to users (Patt & Gwata, 2002; Hansen et al., 201). 'Cognition' is users' understanding of SCF, 'procedures' alludes to institutional process, whereas 'choices' relates to availability of information for farmers to make rational decisions (Patt & Gwata, 2002).

The main limitations to the use of SCF in Botswana have been identified to be scale, cognition, credibility and procedures (Mogotsi et al., 2011b; Fitt, 2012). There was agreement that scale was a barrier in Botswana but the studies diverged on the credibility barrier. Credibility limitation was consistently mentioned as a major limitation in Chobe (Fitt, 2012). Conversely, in Kgalagadi and Bobirwa, SCF were found somewhat more credible than traditional forecasts (Mogotsi et al., 2011b). While there have been efforts to find out how farmers perceive SCF in Botswana, there is still a gap in research as to the use of SCF by farmers. Johnston et al. (2004) mention that additional research is needed to elaborate on constraints to the uptake of SCF and their possible solutions. Moreover, Ziervogel and Opere (2010) state that, although extensive work has been conducted on the application of SCF, the bulk of it has been theoretical, hence calling for empirical studies detailing the dissemination of SCF and their potential use from the end-user side. Therefore, based on these findings, it was worth conducting an in-depth qualitative investigation on credibility and scale as potential constraints to uptake and use of SCF in Bobirwa sub-district. Botswana's SCF dissemination procedure highlighted in the next chapters rendered procedures and cognition limitations not a priority area on which to research.

1.1 Research aim and questions

The primary aim of the study is to assess how credibility and scale affect farmers' use of SCF in decision-making in Bobirwa sub-district, Botswana. The study is supported through the Adaptation at Scale in Semi-Arid Regions (ASSAR) project. It will contribute to the ASSAR objective of knowledge systems, particularly the availability, access and use of knowledge resources in semi-arid regions and the associated adaptation responses across gendered actors. The intention of the ASSAR project is to improve understanding of climate vulnerability and adaptation in semi-arid regions and to provide information to enable the transformation of adaptation practices in semi-arid regions. The study seeks to address the following research questions:

1) How credible and scale-relevant are seasonal climate forecasts that reach communities in Bobirwa sub-district?
2) How do the credibility and scale relevance of these seasonal climate forecasts influence decision-making and livelihoods in Bobirwa sub-district?
3) How have the farmers in Bobirwa sub-district dealt with limitations of credibility and scale relevance of seasonal climate forecasts in their decision-making?

CHAPTER 2: LITERATURE REVIEW

2.1. Seasonal climate forecasts

Seasonal climate forecasts have demonstrated to have potential in increasing resilience against climate variability for farmers in Africa, where agriculture is rain-fed and rainfall is highly variable (O'Brien et al., 2000; Koppler et al., 2006; Roudier et al., 2014). Since 1997, seasonal forecasting took off in SSA and regional centres were established to facilitate SCF at regional level and national capacity development took place in National Meteorological Services (NMSs) (Johnston et al., 2004; Hansen et al., 2011).

2.1.1 Seasonal climate forecasts in Southern Africa

In response to the historic 1997/98 El Niño event, the Southern African Regional Climate Outlook Forum (SARCOF) was organised to generate a consensus seasonal climate forecast for the region for food security planning (O'Brien et al., 2000; Patt & Gwata, 2002). The SARCOF facilitates the World Meteorological Organization (WMO)-mandated process of producing annual forecasts for the region in collaboration with the 14 member states (O'Brien et al., 2000; Johnston et al., 2004). The facilitation of SARCOF is done through the SADC Drought Monitoring Centre, currently operating as SADC Climate Services Centre with an expanded mandate (Cash et al., 2006; Mubako et al., 2014). The objective of the forum is to develop technical and scientific capacities in the generation, application and dissemination of SCF and to share information among climate scientists, decision makers and users of SCF (O'Brien et al., 2000; Johnston et al., 2004).

Capacity building in the first ten years of SCF production made significant progress for use by various climate reliant sectors, including agriculture and water resources (Ingram et al., 2002; Ziervogel, 2004; Johnston et al., 2004). Forecasts can be produced by the use of statistical models and general circulation models (GCMs) which simulate the physical processes and dynamic interactions that control the climate (Hansen et al., 2011; Kim et al., 2015). SARCOF primarily uses statistical models and incorporates dynamic forecasts from other centres, as part of its consensus forecasts (Programme Officer Climate Services, personal interview, 26 July 2016). Despite the usefulness of the skill of forecasts generated from statistical models, the downside of this approach is that the relationship between rainfall (predictand) and SSTs (predictor) is assumed to remain the same hence climate variabilities could be missed (Diez et al., 2005; Landman, 2014). South Africa generates autonomous forecasts from SARCOF, using multi-model ensemble forecasts for the Southern Africa region (Hansen et al., 2011). Landman (2014) also states that advances in SCF in South Africa result from development of seasonal forecasting expertise and the improvement of complex modelling systems. This entails GCM and Regional Circulation Models (RCM), empirical downscaling, multi-model ensembles, ocean-atmosphere coupled model development, and applications of forecasts with contributions from the International Research Institute for Climate and Society (Landman, 2014). Application of these various methods can capture climate variabilities through the use of RCM, and resolve scale issues to local through empirical downscaling (Landman, 2014). Despite such climate forecasting development, literature mention that most African NMSs and regional climate centres like SARCOF are experiencing capacity constraints. There has been little production of user-tailored scientific information and at relevant local scales, which is much more impactful than conventional forecasts (Sivakumar et al.; 2014, Singh et al., 2016). It is reflected in the Intergovernmental Panel on Climate Change Fifth Assessment Report that access and relevance of climate information are critical for adaptation to climate variability and change, but limited by resource-constrained NMSs, lack of expertise on climate science and modelling (Singh et al., 2016). Sivakumar et al. (2014) also mention that NMSs have insufficient technology capacity to conduct climate modelling activities. Additionally, human resource capacity is not abreast with the demands for climate services caused by climate change (Sivakumar et al., 2014).

At the national level the NMSs are responsible for the production of the national seasonal forecasts prior to the SARCOF (Johnston et al., 2004). The probabilities for national forecasts are also assimilated to constitute an input towards a regional consensus forecast (Johnston et al., 2004). Seasonal forecasts are generated using the relationship between the sea-surface temperatures (SSTs) and the global atmospheric circulation (Mason et al., 1996; Goddard et al., 2001). Ziervogel and Calder (2003) mention that the slow development of the SSTs, allows for rainfall and temperature prediction. A country is demarcated into homogeneous rainfall regions, by assembling stations with same features of rainfall variability using principal component analysis (Johnston et al., 2004). However, Johnston et al. (2004) state that this technique overlooks annual mean rainfall, hence stations with different annual rainfall means could be clustered into one homogeneous region. Subsequently statistical models are then developed for each region based on multiple regression analysis to obtain empirical analogues and the forecast will then be generated from the relationship (Johnston et al., 2004; Hansen et al., 2011).

The generated forecast for the upcoming season depicts probabilities for total rainfall in the season to be below normal, normal or above normal for each region (Ingram, 2002; Johnston et al., 2004; Ziervogel, 2004). The probabilities depict percentage likelihood of cumulative rainfall for the next three months of the season to be above-normal, normal or below-normal (Ziervogel, 2004; Johnston et al., 2004). It is explained by Ziervogel and Calder (2003) that the probabilities do not account for the temporal distribution of the rainfall within the season. Hence even if the total expected rainfall occurs during a week, the forecast will be evaluated as correct despite the devastating impacts or uneven distribution (Ziervogel & Calder 2003). In contrast, a deterministic forecast indicates total rainfall for the season to be in only one of the categories of either below-normal, normal or above-normal (Diez et al., 2005).

Goddard et al. (2001) highlight that it is important for the probabilistic part of SCF to be stressed, to avoid turning it to a deterministic forecast, as that will likely reduce its accuracy. The use of probabilities and lack of detail in space and time emphasise uncertainties, boundaries and difficulty within which the methodologies and technology used to generate SCF operate (Johnston et al., 2004). It is highlighted by Johnston et al. (2004) that the unpredictable parts referred to as uncertainties, need to be communicated to the users when disseminating SCF. This will make SCF to be used as a guide for seasonal timescales and not specific to a location and instantaneous time (Johnston et al., 2004). However, the deficiency of detailed information required by the farmers and the probabilistic nature, could be perceived by farmers as misleading and reduce the utility of the forecasts. Inherently, interacting with SCF users is still paramount to comprehending the challenges encountered by the users in interpreting and applying the SCF (Johnston et al., 2004).

2.1.2 Seasonal climate forecasts in Botswana

In Botswana, the Department of Meteorological Services (DMS), with a permanent representative at the WMO, has a national responsibility, among others, to provide weather and climate forecasts (National Meteorological Service Act, No. 14 of 2014, 2014:s4). Botswana is split into four large-scale homogeneous regions which are mostly larger than the size of a district, and probabilities are assigned for each region (Figure 1). The figure indicates the seasonal rainfall forecast for October, November and December 2015 which was generated by DMS for Botswana.

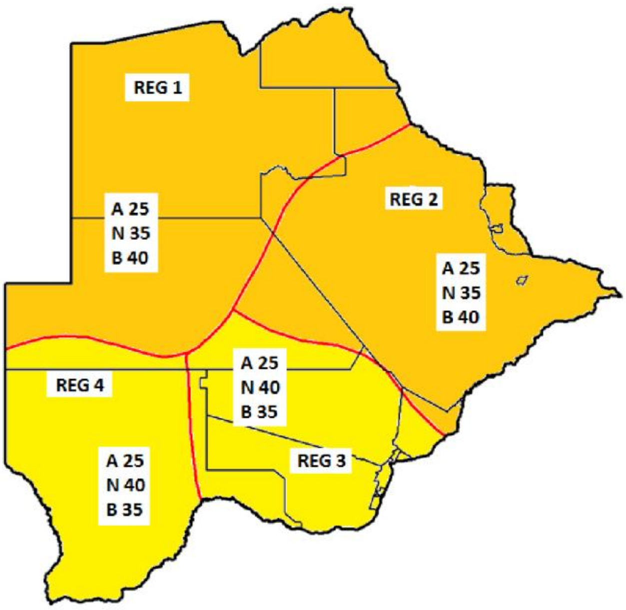

Figure 1 Seasonal rainfall forecast for four regions in Botswana during October – December 2015 issued by DMS (source: DMS)

It is widely noted that accessibility and dissemination of SCF can meet the information requirements that will certainly diminish impacts associated with climate variability (O'Brien et al., 2000; Ziervogel & Downing, 2004). A survey conducted in SSA to assess the support for SCF application for agriculture, indicates that Botswana's SCF are disseminated through workshops, media and internet (Hansen et al., 2011). Furthermore, media dissemination in Botswana includes radio, national television broadcasts and newspapers, both in English and Setswana, the local language (Mogotsi et al., 2011b). The forecast is primarily disseminated to the MoA but other ministries include Ministry of Health, Ministry of Minerals Energy and

Water Resources as well as farmers and their associations, public meetings and recently to the cabinet ministers (Meteorologist, personal interview, 26 July 2016). Botswana’s dissemination strategy includes partnership between agricultural extension officers with DMS (Hansen et al., 2011; Meteorologist, personal interview, 26 July 2016). Therefore, meteorological officers and agricultural extension officers across the country enable SCF to be accessible to remote areas (Mogotsi et al., 2011b).

2.2 Use of seasonal climate forecasts for decision-making in agriculture

In Southern Africa and other parts of the world, the application of SCF has been used to provide for agricultural management (Ziervogel et al., 2006; Cobon et al., 2008). The uptake and use of SCF is a form of adaptation to seasonal climate variability because awareness and capacity to use it during the season allow users to cope (ibid.). Despite the potential of SCF to minimise vulnerability of farmers to adverse impacts of climate variability, a small proportion of farmers in Africa and the rest of the world use the forecasts (O'Brien et al., 2000; Patt & Gwata, 2002; Luseno et al. 2003; Johnston et al., 2004; Ziervogel & Downing, 2004; Crane et al., 2010; Dilling & Lemos, 2011; Marshall et al., 2011). Constraints to the use of SCF will be covered in section 2.4. A review of empirical literature elaborates that in instances where SCF have been used in the USA and Australia, it is due to factors like the existence of networks between forecasters and potential users, building of technical capacity to understand SCF, users’ perception of benefits like reduction of costs and institutional support to infuse climate issues into decision-making (Dilling & Lemos, 2011).

Illustrations of the use of SCF to make farming decisions involves a variety of practices in Africa and abroad. Changing planting dates is a popular action taken by farmers in response to SCF in Namibia, Tanzania, South Africa and USA (O'Brien et al., 2000; Vogel, 2000; Crane et al., 2010). Adjusting the planting area is another use of the SCF by farmers in Namibia, Tanzania, South Africa (O'Brien et al., 2000; Vogel, 2000; Ingram et al., 2002; Roncoli et al., 2009). For example, in Tanzania, farmers indicated reducing planted area to minimise losses from floods. The other common use is selection of seed varieties, substitution of crop types and diversifying crops practised in most of Southern Africa, Burkina Faso, as well as the USA (O'Brien et al., 2000; Vogel, 2000; Crane et al., 2010). However, literature mentions that, instead of using SCF entirely to select ideal crops for a particular season, traditionally farmers choose a combination of crop varieties based on what worked sufficiently well in the past while generating minimum risks and high yields in any type of season (Gibberd et al., 1995; Lemos et al., 2002; Patt & Gwata, 2002). Ziervogel et al. (2006) argue that such precautionary measures practised by resource-poor farmers are critical in reducing risks during unfavourable forecasts, unlike monocropping practised by wealthier farmers, which could make them more vulnerable when the forecasts differ from reality. Ingram et al. (2002) mention that diversification in Burkina Faso entails governance of a group of fields in response to prevailing conditions and SCF. This is done by deciding planting times and the use of staggered order, suitable seed varieties with different maturity levels and varying water needs as well as locations to plant according to soil types (Ingram et al., 2002). Some farmers in South Africa, Burkina Faso and the USA even plant drought-resistant crops for dry forecasts and flood-resistant crops for wet forecasts (Vogel, 2000; Ingram et al., 2002; Crane et al., 2010).

Changing crop location is common in Tanzania, where farmers have a choice to plant in either lowland farms when a dry season is expected or highland farms or reserved lands when a wet season is expected (O'Brien et al., 2000). In Burkina Faso, farmers alter the furrow direction during farm preparation to either enable flow of water when above-normal rainfall is expected or to resist flow to conserve water when rainfall is expected to be largely below-normal rainfall (Ingram et al., 2002). Furthermore, for an above-normal SCF, farmers apply fertiliser during planting time and extra herbicide to reduce weeds that flourish with rain, but would use less herbicide for dry forecast (ibid.). Making food contingency plans such as increasing food in the storage facilities is highlighted by farmers in Namibia and Tanzania when lower rainfall is expected in anticipation of low productivity (O'Brien et al., 2000). Water conservation practices including straw mulching and planting in small troughs are carried out by farmers in Burkina Faso to respond to a dry forecast (Ingram et al., 2002).

In terms of livestock management strategies, in response to SCF, the most common practice undertaken by farmers in West and East Africa as well as Australia, is livestock migration to better pastures (Luseno et al., 2003; Roncoli et al., 2009; Marshall et al., 2011). Regulating stocking rates for livestock to match pastures that could be available for predicted forecast is done among farmers across Africa and elsewhere in the world (Gibberd et al.,1995; Luseno et al., 2003; Crane et al., 2010; Marshall et al., 2011; Mogotsi et al., 2011a). However, reducing stock herds could be an unpopular decision in Africa due to the socio-cultural significance of livestock (Gibberd et al.,1995; Luseno et al., 2003; Ziervogel, 2004; Mogotsi et al., 2011a). In Burkina Faso, according to Roncoli et al. (2009), frequent vaccination routines for livestock and shelter constructions for small stock, is practised when above-normal rainfall is forecast, to reduce vulnerability of the animals to wet conditions and diseases. Another but rare practice in Botswana and Burkina Faso is planting fodder crops, and harvesting and storing forage when below-normal rainfall is expected (Ingram et al., 2002; Roncoli et al., 2009; Mogotsi et al., 2011a).

There is evidence of converging literature stating that there are more responses to SCF in the crop sector than in the livestock sector (Gibberd et al.,1995; Luseno et al., 2003; Ziervogel, 2004; Roncoli et al., 2009). One explanation for this is that most livestock management decisions take place in response to actual rain situation than SCF (Luseno et al., 2003; Roncoli et al., 2009). This is because livestock is moved towards areas with better water availability and pastures (ibid.). Furthermore, Luseno et al. (2003) note that the large-scale resolution of SCF is more applicable to crop production than livestock because finer spatial variation is required for an assessment to move livestock. Gibberd et al. (1995) also mentioned that reliable SCF with enough detailed information are crucial for stocking and destocking livestock for managing numbers, protection of grazing areas and supply of livestock feed.

Besides crop production, farmers in Burkina Faso also mentioned diversifying livelihoods to livestock production in response to SCF to minimise risks (Ingram et al., 2002). Alternatively, deserting farm activities to engage in non-farm activities like commercial businesses to avoid making losses caused by climate extremes was an option for farmers in Tanzania (O'Brien et al., 2000). The use of SCF is well captured by Crane et al. (2010), who note that SCF would not be impulsively accepted, but farmers' decision-making is cautionary and requires testing SCF over a period because their decisions are also dependent upon biophysical, social, economic factors as well as local to international scale influences. Although this context is for USA and Australian farmers, it agrees with findings from Africa. In the Northwest Province of South Africa, smallholder and emerging farmers' decision-making to avoid risks associated with forecasts is limited by biophysical and socio-economic constraints (Vogel, 2000).

2.3 Consequences of using seasonal climate forecasts

The benefits of SCF occur when their use translates into reduction of vulnerability to extreme impacts of climate variability (Hansen, 2002). There are few documented benefits of SCF, especially to resource-poor farmers (Hansen, 2002). Ziervogel et al. (2006) mention that the current benefits of SCF to farmers are difficult to assess because of the limited use of SCF in agricultural management. Hansen (2002) states that there has been inadequate experience of farmers and agricultural institutions using SCF and the constraints to SCF use have not been sufficiently addressed at different levels. Hansen (2002) further argues that the emphasis to the use of SCF has been to reduce risks associated with adverse climate extreme, such that possible benefits associated with suitable SCF, which farmers could maximise, have not been scrutinised.

A study by Roudier et al. (2014), conducted in Senegal, illustrates that the benefits to SCF use are most evident when farmers intensify agricultural practices by using organic or non-organic inputs and a combination of strategies. However, changes in management practices such as crop varieties and adjusting planting dates, common among subsistence farmers, bear neutral outcomes or could result in yield loss or gain (Roudier et al., 2014). Goddard et al. (2001) reasons that the expected benefits of the use of SCF should include increased production or profits, and reduced risk and costs. Other benefits could be enhanced food security during unfavourable years and better marketable surplus in favourable years (Goddard et al., 2001). In this way, Gibberd et al. (1995) highlight that SCF could also form a vital component in early warning systems for drought management and enhance trade in the market for agricultural products.

Vogel (2000) argues that in South Africa, the use of SCF has minimal proof of direct benefits to farmers because lack of ownership and access to land, lack of useful SCF and economic and political constraints faced by farmers must firstly be addressed. The benefits to farmers using SCF are only secondary and limited to contingency planning and mitigating drought and climate extremes (Vogel, 2000). Similarly, O'Brien et al. (2000) state that in Namibia, SCF were ineffective in preventing crop loss among subsistence farmers because initially, SCF were directed towards commercial farmers and agricultural organizations, who had better understanding of SCF than subsistence farmers. Therefore, subsistence farmers were marginalised by the dissemination procedure as end-users of SCF and could not benefit from SCF due to limited access. After reviewing literature on the economic value of SCF, most of which was from the USA, Canada, Australia and South America, Meza et al. (2008) resolve that SCF are beneficial, but uncertain in relation to average income and crop production value.

In contrast, Ziervogel et al. (2006) mention that reliance on SCF without a risk reduction plan could result into losses. For example, emerging farmers who undertake mono-cropping are likely to incur such losses rather than resource-poor farmers who normally diversify crops to avert risk (Ziervogel et al., 2006). This parallels a caution that a wrong forecast could result in loss of investment in crops and livestock and consequently poverty (Ingram et al., 2002). Roudier et al. (2014) also state that the effect of simultaneous occurrence of a dry year and a wrong forecast is yield loss, which can increase vulnerability of farmers. Likewise, O'Brien et al. (2000) assert that an incorrect SCF could have negative economic, social and political impacts both for users and producers of SCF. On one hand, impacts for users could be loss of agricultural investments and loss of trust in the producers of SCF and associated policies. On the other hand, for producers of SCF, impacts could be loss of reputation among users and loss of resources in production of SCF.

Overall, research has stalled in evaluating the magnitude and impact of SCF use by subsistence farmers. Roudier et al. (2014) explain that theoretical models which are based on assumptions have been used to gauge the impact of SCF use which could result in bias of the outcomes. However, where empirical valuations have been conducted through dissemination of SCF, analysing the use of SCF and impact of changes made by farmers in agricultural practices, inferences cannot be drawn because of limited periods of observations or small sample sizes (Roudier et al., 2014). This aligns with Meza et al. (2008)'s findings that SCF valuation studies assessed in the developed world have mostly used quantitative models, while those in the developing world have used qualitative methods. Meza et al. (2008) contend that a complete understanding of SCF value using a combination of the two methods across the world has been missed. Thus, there is need for continuous empirical research that SCF have significant benefits to farmers (Vogel, 2000; Meza et al., 2008; Roudier et al., 2014). Vogel (2000) underscores that such research needs validation in developing countries because of the associated limitations of using SCF at farm level. This agrees with Meza et al. (2008), who state that the vulnerable rain-fed tropical regions and various farming systems such as livestock and subsistence farming have not been adequately represented in past SCF valuation studies. The debate around the value of SCF to farmers needs to be resolved through detailed impact assessments, following extensive and continuous dissemination, uptake and use of SCF, to build experiences for valuation (Meza et al., 2008). The review of the value of SCF has been useful to this study for several reasons. It exposed a gap in literature on continuous assessment of value of SCF to farmers across the world using empirical studies, calling for such research particularly in developing countries. Moreover, the research is a great opportunity to address issues raised by Vogel (2000). Firstly, there is critical need to tackle constraints in the uptake and use of SCF (section 2.4) for farmers ultimately to benefit from SCF. Secondly, SCF benefits need to be translated from indirect benefits to direct economic benefits to farmers through appropriate institutional design and policy (Vogel 2000; Hansen, 2002; Vogel 2010). To address the gap of assessment of value SCF, this study included a question on value of SCF to farmers during the interviews (Appendix 1).

2.4 Constraints to uptake and use of seasonal climate forecasts

According to numerous studies around the world there are a number of barriers that impede farmers' uptake and use of seasonal climate forecasts (O'Brien et al., 2000; Vogel, 2000; Goddard et al., 2001; Ingram et al., 2002; Lemos et al., 2002; Patt & Gwata, 2002; Luseno et al., 2003; Ziervogel & Calder, 2003; Johnston et al., 2004; Ziervogel, 2004; Ziervogel & Downing, 2004; Ziervogel et al., 2006; Roncoli et al., 2009; Crane et al., 2010; Marshall, 2011; Mogotsi et al., 2011b; Mase & Prokopy, 2014). On one hand, these constraints could be intrinsic, having to do with the production, nature and dissemination of SCF which in the study are referred to as limitations (section 2.4.1). On the other hand, barriers (section 2.4.2) would be used for external factors beyond SCF, but impeding its effective use.

2.4.1 Limitations of seasonal climate forecasts

Studies in Africa and the rest of the world found that there are several limitations constraining SCF uptake and use by farmers. A study by Patt and Gwata (2002) in Zimbabwe outlined some of the limitations of SCF including credibility, legitimacy and salience. Firstly, credibility has to do with its trustworthiness, reliability and dependability upon which to base decisions (Patt & Gwata, 2002; Ziervogel, 2004). Credibility is discussed further in section 2.4.1.1. Secondly, legitimacy is when there is scepticism about the communicators' political agenda and unfairness in the accrued benefits from the change of behaviour among actors (Patt & Gwata, 2002). An example where legitimacy is evident is in Brazil as farmers believe SCF are produced to propel the political agendas of state government, but never to benefit the people, which has lowered the legitimacy, and consequently credibility, use and uptake of SCF (Lemos et al., 2002). Thirdly, salience is perceived relevance and the limitation occurs when the disseminated SCF do not meet the desires of the farmers to make decisions (Hansen et al., 2011). This is caused by lack of detail of SCF about farmers' location and agricultural impacts and related management interventions (Hansen et al., 2011).

Patt and Gwata (2002) expanded on the above three limitation concepts elaborating that the forecast salience is also limited by scale, cognition, procedures and available choices. Scale limitation to the use of SCF relates to lack of relevance of information in spatial extent as well as temporal resolution (Patt & Gwata, 2002; Luseno et al., 2003; Ziervogel, 2004). SCF provided represent extensive areas beyond local scale while ignoring local implications (Patt & Gwata, 2002; Mogotsi et al., 2011b). Scale is discussed in detail in section 2.4.1.2.

Lack of cognition comes about as an impediment when users do not understand SCF and interpret and apply them incorrectly (Patt & Gwata, 2002). This is also consistent with the rest of literature that the limitation of lack of understanding of SCF arises because of their presentation in probabilistic format (Ziervogel, 2004; Vogel, 2000; Goddard et al., 2001; Mogotsi et al., 2011b; Lemos et al., 2002; Luseno et al., 2003; Hansen et al., 2011). Usually most farmers find probabilities difficult to understand without regular interactive explanations through established networks (Patt & Gwata, 2002; Hansen et al., 2011). It is said that cognition improvement reinforces both credibility and legitimacy (Patt & Gwata, 2002; Crane et al., 2010).

Procedures become a limitation when institutional bureaucracies and rules result in late or ineffective dissemination, which impedes the use of SCF (Patt & Gwata, 2002). In addition, Ziervogel (2004) explains that problems associated with dissemination include channels of delivery, the message that is communicated and the timing that results in late delivery of SCF, which can make forecasts unusable if farm decisions have already been made. There is also evidence in the literature that the majority of small-holder farmers in Africa and other parts of the world do not use SCF because of ineffective dissemination and limited access (O'Brien et al., 2000; Lemos et al., 2002; Luseno et al., 2003; Ziervogel, 2004; Dilling & Lemos, 2011).

A limitation of choices is dependent upon the scientific predictive capacity, available choices and incentives within which farmers make decisions (Patt & Gwata, 2002). An understanding of choices also requires consideration of the rest of SCF limitations discussed above as they influence farmers' decisions (Patt & Gwata, 2002). Lemos et al. (2002) mention that lack of resources constrains available options for poor farmers to use SCF. Literature highlights that if SCF do not contribute to additional information as compared to traditional forecasts and farmers' knowledge, farmers would ignore SCF (Lemos et al., 2002; Patt & Gwata, 2002; Luseno et al., 2003). Furthermore, Patt and Gwata (2002) argue that, naturally, farmers select the most initial accessible option that works and is also cost-effective. The authors explain that usually farmers have a prejudice on status quo rather than new risky possibilities.

Furthermore, Dilling and Lemos (2011) examined the production and the use of SCF by identifying factors that inhibit or promote usability. Constraints to usable SCF information could emanate from where information is produced or the user's context (Dilling and Lemos, 2011). On one side, factors that determine usability on the production side include technical aspects such as accuracy, legitimacy and reliability of SCF, relevance in spatial and temporal scales (Dilling & Lemos, 2011; Soares & Dessai 2016). Accessibility and timing of SCF also determine the usability (Dilling & Lemos, 2011; Soares & Dessai 2016). Accessibility entails availability, language and communication, representation and format and cognition of SCF (Dilling & Lemos, 2011). Soares and Dessai (2016) contend that excess information and top-down production of scientific climate information by science producers for decision-makers do not translate to its usability.

On the other side, the users' context includes institutional procedures, competing information more suitable for policy goals, incentives of using SCF, organisational culture, availability of realistic alternative choices and cultural perspectives of use of SCF (Dilling & Lemos, 2011). It is proposed that translation of SCF to usable information requires regular networking and co-production of knowledge by both SCF producers and users (Dilling & Lemos, 2011; Lemos et al., 2012; Soares & Dessai, 2016). The strong network could ensure SCF production and provision are tailor-made for users, meet users' needs, and users could drive for development of problem-driven science (Dilling & Lemos, 2011; Soares & Dessai 2016). Furthermore, the constant interaction between the two parties could also unearth new forms of using SCF which have not been discovered (Dilling & Lemos, 2011). Lemos et al. (2012) present a usability model where climate information could move from being useful as per producers' view to users' perspective of being usable. Usability increases when information is incorporated into decision making as it is translated, communicated and transformed to users' needs (Lemos et al., 2012).

Among studies conducted in Botswana in the Chobe district, Kgalagadi district and Bobirwa sub-district, the main limitations of SCF identified were: scale, cognition, credibility and procedures (Mogotsi et al., 2011b; Fitt, 2012). The findings cite scale as a barrier because SCF are produced at large-scale resolution which does not depict rainfall local variation, temporal distribution of rainfall within the season as well as onsets and cessations of rainfall which are critical for making decisions (ibid.). Credibility was found to be a major limitation in Chobe because farmers perceived SCF as inaccurate (Fitt, 2012). Other contributing factors to the low quality of SCF were uncertainty of SCF in space and time as well as low cognition of probabilities (Fitt, 2012). Conversely, in Kgalagadi and Bobirwa, farmers found SCF reliable, reasoning that modern equipment is used and traditional indicators are less dependable because of climate variability, while others used SCF because of lack of alternatives to SCF (Mogotsi et al., 2011b).

2.4.1.1 Credibility as a limitation

Credibility has to do with meeting users' expectations for information to meet scientific and technical standards and quality (Cash et al., 2002). Seasonal climate forecast credibility is its perceived trustworthiness, reliability and dependability to inform decisions (Crane et al., 2010). Credibility also relies on the performance of the past SCF because if the forecasts have been deemed correct, then users will consider them credible and vice versa (Patt & Gwata, 2002; Ziervogel, 2004; Crane et al., 2010). However, lack of credibility is likely to occur when SCF are presented as deterministic instead of probability forecasts (Patt & Gwata, 2002; Ziervogel, 2004; Winsemius et al., 2014). There could be costly repercussions associated a simplified deterministic forecast that turns incorrect (Goddard et al., 2001; Challinor, 2009). A case in point is that of Zimbabwe in 1997, when the media shifted probability forecasts news from possible drought to certain drought, which never occurred, resulting in subsequent information from the meteorological department being regarded as of low credibility (Patt & Gwata, 2002).

The past and current trustworthiness of the communicator and sources of SCF also determine the credibility of SCF (Ingram et al., 2002; Patt & Gwata, 2002; Ziervogel, 2004). Patt and Gwata (2002) explain that if a communicator of SCF has been associated with wrong past forecasts, then SCF will be perceived not credible until the reputation is rectified and trust is earned. Improvement of trustworthiness of communicators requires strong network between meteorological experts and local institutions to provide trainings and technical services for interpretation of forecast (Ingram et al., 2002). Many studies in Africa and beyond associate lack of uptake and use of SCF with low credibility caused by perceived inaccuracy of forecasts and their lack of trust by farmers (Gibberd et al., 1995; Lemos et al., 2002; Ziervogel, 2004; Crane et al., 2010; Marshall et al., 2011; Mase & Prokopy, 2014).

2.4.1.2 Scale as a limitation

Scale relates to relevance of information in spatial context as well as temporal resolution (Patt & Gwata, 2002; Luseno et al., 2003). Ziervogel (2004) mention that SCF scales denote the limitation of scientific knowledge to represent the real complex climate system, therefore only coarse resolutions are provided both in time and space. Seasonal climate forecasts are provided at large regional scale by partitioning the country into a few regions which are too large for farmers to derive information from, for needed local context to make decisions (Goddard et al., 2001; Patt & Gwata, 2002; Dilling & Lemos, 2011; Mogotsi et al., 2011b).

Timescales are also a constraint to the use of SCF due to generalised three-month rainfall totals portrayed in the SCF (Goddard et al., 2001; Ziervogel, 2004). However, the onset of rainfall and its distribution as well as indications of dry spells within the season are all critical for the farmers' decision-making (O'Brien et al., 2000; Patt & Gwata, 2002; Dilling & Lemos, 2011; Mogotsi et al., 2011b). A bulk of literature acknowledge that the scale limitation is one of the main constraints to uptake and use of SCF in decision-making (Johnston et al., 2004; Ingram et al., 2002; Lemos et al., 2002; Patt & Gwata, 2002; Luseno et al., 2003, Ziervogel, 2004; Dilling & Lemos, 2011; Mase & Prokopy, 2014; Vincent et al., 2017). For instance, Luseno et al. (2003) explained that the use of SCF by pastoralists in the Horn of Africa fail to meet their needs because extensive grazing systems rely on spatial variation forage and water to migrate livestock to better areas.

It is cautioned that while scientific strides are made to improve scale to enhance salience for use and uptake of seasonal forecasts it should not be at the expense of credibility and legitimacy which can generate new uncertainties (Gibberd et al., 1995; Johnston et al., 2004). Hence change in scale limitation can also influence credibility of SCF (Cash et al., 2002).

2.4.2 Barriers to the effective use of seasonal climate forecasts

Smallholder farmers in Africa and other continents encounter limited choices to effectively use seasonal forecast because of socio-economic barriers linked to decision-making (Hansen et al., 2011). A lot of researchers also agree that farmers face multiple barriers that preclude the effective use of SCF in their decision-making (O'Brien et al., 2000; Vogel, 2000; Ingram et al., 2002; Klopper et al., 2006; Marshall et al., 2007; Mogotsi et al., 2011b; Lemos et al., 2002;). The barriers range from biophysical or environmental, economic, to socio-cultural factors as discussed below.

Economic barrier mostly constrains the effective use of SCF and overall agricultural production in Africa. Literature highlights that the common economic barriers mentioned by farmers include lack of resources, inputs, market and credit (O'Brien et al., 2000; Vogel, 2000; Roncoli et al., 2009; Orlove et al., 2010; Hansen et al., 2011). Despite farmers' knowledge of risks informed by SCF, these economic barriers prevent farmers from investing in better strategies. Hansen et al. (2011) highlight that empirical studies show that economic constraints do not hinder smallholder farmers from responding to SCF, but they inhibit employment of desired management strategies. Ziervogel (2004) mentions that economic factors may hinder resource-poor farmers to effectively use SCF despite accessibility to and cognition of SCF by the farmers. Subsistence farmers face challenges of lack of credit to buy farm inputs such additional seeds, pay for draught power and labour (O'Brien et al., 2000; Ingram et al., 2002; Lemos et al., 2002). Studies conducted in Africa cite draught power as a hindrance to timely response and use SCF (O'Brien et al., 2000; Ingram et al., 2002; Mogotsi et al., 2011b; Simelton et al., 2013). It is elaborated that in Botswana draught power governs the planting time and area planted which is limiting the response to SCF (Oladele & Monkhei, 2008; Mogotsi et al., 2011b; Simelton et al., 2013). Market for farm outputs is also a barrier because it is limited and unreliable (O'Brien et al., 2000; Ziervogel et al., 2006).

Labour availability for agricultural production as an economic barrier hinders poor households to properly respond to SCF (Ingram et al., 2002). In Burkina Faso for example, there is a compromise to providing extra labour needed in the fields to apply SCF as able-bodied young men have migrated away from villages to look for employment for extra household income (Ingram et al., 2002). Another dimension of labour scarcity is mentioned in South Africa and Uganda when the HIV/AIDS scourge robs households of physically fit members, leaving the elderly, women and children to dominate agricultural production (Ziervogel, 2006; Orlove et al., 2010). This impacts on planting timeliness and influence crops planted, therefore limiting response to SCF (Orlove et al., 2010). In sum, Vogel (2000) states that in South Africa and most of Africa, financial status determines the farmer's ability to respond effectively to SCF and the poorer the farmers are, the more constrained they become, making them more vulnerable.

Farmers in Africa and worldwide have a long history of producing seasonal forecasts using local knowledge. However, socio-cultural influence in farmers' decision-making may prohibit change needed to utilise SCF (O'Brien et al., 2000; Lemos et al., 2002). For instance, literature reflects that some farmers in west and southern Africa and Brazil believe that prediction are beyond human capacity and should be left to God because God holds the power to change the situation at any time (Gibberd et al., 1995; O'Brien et al., 2000; Lemos et al., 2002; Orlove et al., 2010; Roncoli et al., 2002). For example, in Uganda a dry year is believed to be God's reproach while in Burkina Faso it is taken as a reason to stay under God's authority by praying (Roncoli et al., 2002; Orlove et al., 2010). Similarly, in Brazil predictions from rain prophets are trusted and used more than SCF (Lemos et al., 2002). Gibberd et al. (1995) state that some deeply religious communities in Southern Africa may view drought and its non-preparatory implications as a vital form of penance. These religious practices and values to succumb to dire climatic conditions, perceived to be God's will, are an impediment to integration of SCF in decision-making. Moreover, lack of appropriate response from held values could contribute to increased vulnerability of farmers to climate variabilities.

Besides religion, some farmers in Africa rely on local forecasts derived from a combination of traditional indicators due to their simplicity, local context and availability despite signs of diminished credibility caused by climate variabilities (Luseno et al., 2003; Roncoli et al., 2002; Mogotsi et al., 2011b). In Botswana, cultural practices such as commencement of planting period ceremonies called *letsema* may prevent timely response to SCF. In the past, farmers were not allowed to plant until granted permission by the Chief, who used to regulate the agricultural calendar (Denbow & Thebe, 2006). Culturally, communal task forces categorized by age known as age regiments, were used to plough the Chief's farm before starting to plant their own (Denbow & Thebe, 2006). Although what is currently practised is a celebration, some farmers may still uphold the culture and wait for the Chief's declaration of *letsema* before starting their planting.

In Australia, rather than using SCF, most pastoralists have high confidence in their decisions derived from their own knowledge and experience (Marshall et al., 2011). Likewise, in Zimbabwe farmers opt to use traditional planting by planting a variety of crops annually to avert the risks instead of using SCF for maximum harvest (Patt & Gwata, 2002). In Botswana and North West Province, South Africa, livestock has a socio-cultural connotation; hence farmers are hesitant to sell livestock even when less rainfall is expected (McLeod, 1992; Hansen et al., 2011; Mogotsi et al., 2011a). This makes them less responsive to SCF. Gender issues also arise as a cultural impediment to effectively use SCF in Tanzania where women do not have freedom of authority in farming decisions after uptake of SCF (O'Brien et al., 2000). Socio-cultural factors can also hinder uptake and use of SCF, particularly if SCF are perceived to bring no new information as compared to local forecasts (Luseno et al., 2003).

Southern Africa's biophysical environment puts an excess burden on agricultural production and limits better response to SCF. Besides highly variable rainfall, the literature cites topography, diseases, pests and soil erosion or infertility, as additional barriers to agricultural production inhibiting effective use of SCF (Ingram et al., 2002; Harrison et al., 2007; Nthoiwa et al., 2013; Temoso et al., 2015a; Temoso et al., 2015b). It is indicated by Mogotsi et al. (2011a), that Bobirwa sub-district's susceptibility to foot and mouth disease (FMD) limits off-take of livestock to better priced markets, causing farmers to constantly hoard herds. This environmental and economic factor contributes to lack of responsiveness of pastoralists to SCF, which also strengthens the cultural barrier of unwillingness to sell livestock in Botswana. Migration of sorghum-eating *quelea* birds to Botswana presents a problem for sorghum crops planted late in the season (Gibberd et al., 1995). Fear of *quelea* birds could constrain the use of SCF to plant sorghum when late onset of rainfall takes place and even shift to maize despite its requirement of ample moisture. Roncoli et al. (2009) mention that topography and soil type like clay, as in the case of Burkina Faso, may require farmers to neglect some fields to avoid erosion and water-logging, resulting in minimised planting areas even when a wet forecast could be used to maximise planting areas.

2.5 Coping with climate variabilities and seasonal climate forecasts limitations

Farmers across Africa and other parts of the world incorporate local practices in their decision-making to deal with climate variabilities and limitations of SCF, such as uncertainty caused by insufficient reliability and relevance. The practices include the use traditional forecasts using local indicators like plant, animal, astronomical and atmospheric indicators of weather and climate. Additional practices are religious beliefs and practices, traditional farming and experience, and diversifying production and livelihoods. The common practice among farmers in Africa is to derive local forecasts from local traditional indicators and use them simultaneously with SCF (O'Brien et al., 2000; Patt & Gwata, 2002; Roncoli et al., 2002; Luseno et al., 2003; Ziervogel, 2004; Ziervogel & Opere, 2010; Mogotsi et al., 2011b).

In Zimbabwe, if SCF diverge from local indicators, farmers become sceptical about SCF but are cognisant of the complexity of prediction under climate variability (Patt & Gwata, 2002). Mogotsi et al. (2011b) note that unlike SCF, traditional forecasts are relevant to farmers because the indicators used are applicable at a local scale. Moreover, Roncoli et al. (2002) mention that traditional forecasts emphasise local rainfall parameters relevant to farmers, such as time of onset, duration and distribution. Roncoli et al. (2002) explain further that SCF are provided at low resolution and cannot predict rainfall distribution and duration with certainty, therefore complementing SCF with local forecasts can give better extrapolations. Additionally, the prevalence of traditional forecasts among farmers is due to socio-cultural acceptance, historic experience and confidence in them, and local relevance as opposed to newer SCF as external forecasts (Roncoli et al., 2002; Luseno et al., 2003, Ziervogel & Opere, 2010). However, literature also cites farmers' reduced confidence in traditional forecasts in recent years due to climate variability, hence the simultaneous use of the two types of forecasts (Roncoli et al., 2002; Orlove et al., 2010; Ziervogel & Opere, 2010; Mogotsi et al., 2011b).

Religious practices of prayer sessions for rain at public gatherings during the commencement of planting period ceremonies (*letsema*) are part of Botswana's tradition. In recent years, there have been pleas by the President of Botswana for nationwide prayer for rain in September as the reserved month of payer, despite meteorological rainfall predictions of possible satisfactory rains (*Sunday Standard*, 22 September 2013). Similarly, consulting prophets for prediction of the season is common in Burkina Faso and Brazil and they are well respected to give credible forecasts (Lemos et al., 2002; Roncoli et al., 2002).

Traditional farming and use of farming experience and knowledge is practised by farmers (Vogel, 2000; Patt & Gwata, 2002; Marshall et al., 2011). Vogel (2000) mentions that in South Africa, farmers incorporate their knowledge of traditional practice and SCF equally into their farming activities. In Australia pastoralists use their independent farming experience and knowledge which they regard highly, although they are hesitant to share knowledge through networks (Marshall et al., 2011). According to literature across the world, traditional farming practice entails planting the same selection of seed varieties annually to minimise losses and planting fields in different locations (Patt & Gwata, 2002, Ingram et al., 2002; Lemos et al., 2002; Luseno et al., 2003; Crane et al., 2010). Crane et al. (2010) explain that this practice is applied as a precautionary measure and is beneficial over time as compared to changing crops seasonally for short-term gains.

Diversifying production and livelihoods is a strategy used by farmers to minimise risks, uncertainties and climate variability (Ingram et al., 2002; Crane et al., 2010). In South Africa, besides agriculture, farmers venture into non-farm activities like crafts and baking; other services are strategies undertaken by farmers to complement agricultural revenue, as a safety net when crops fail and to cope with climate variabilities (Ziervogel et al., 2006). Similarly, in Burkina Faso migration for seasonal employment is done to top up farming income and in case crops fail (Ingram et al., 2002; Roncoli et al., 2009). Likewise, in Botswana farmers engage in the sale of natural resources like *Phane* caterpillars and temporary work, namely *Ipelegeng* (relief public works programme) and piecemeal jobs (Mogotsi et al., 2011a; Mogotsi et al., 2011c). On the extreme side, abandoning farming in response to failed crops and low market prices is an option practised by farmers to reduce vulnerability from climate variability (Ziervogel et al., 2006). This agrees with a finding in Botswana, that when low rainfall is expected the richer farmers invest their resources in livestock, whereas the poorest farmers abandon farming and await drought relief from the government to avoid losses (Simelton et al., 2013).

Overall, farmers operate in a complex environment controlled by biophysical, economic and social-cultural elements, manifesting across scales which farmers view as sources of information for consolidation into decision-making (Crane et al., 2010). Ingram et al. (2002) agree that farmers traditionally apply a risk management plan that prepares for any seasonal rainfall outcome and SCF are not their only information. Churi et al. (2012) also indicate that besides SCF, information concerning the market, agricultural input and food security is used in farmers' decision-making. Therefore, SCF are additional information that requires farmers to carefully consider and adopt it to contribute to optimal agricultural production under climate variabilities and limitations. Hence there is general agreement that the complementarity of traditional knowledge and SCF needs to be explored further as knowledge co-production to enhance farmers' decision-making (Mogotsi et al., 2011b; Orlove et al., 2010; Ziervogel & Opere, 2010; Luseno et al., 2003).

CHAPTER 3: STUDY SITE PROFILE

3.1 Study site

This chapter discusses the study site, its climate and agricultural activities. It concludes with challenges facing agriculture in the area. The study was conducted in Bobirwa sub-district of the Central district located in the eastern part of Botswana bordered by Zimbabwe and South Africa (Figure 2). Bobirwa sub-district is one of the sites selected for the ASSAR project; therefore any of the villages in the area were suitable for the research. MoA further divides Bobirwa sub-district into two crop production management areas, namely Selibe-Phikwe sub-district on the west side and Bobonong sub-district on the eastern part. The researcher was stationed in Bobonong village, which hosts Bobonong sub-district office. The Bobonong sub-district crop production officer assisted in scheduling interviews and therefore selected the villages under the management of Bobonong sub-district office for data collection. The villages were chosen because of the presence of agricultural extension officers in each village. Agricultural extension officers are posted where there are numerous farmers; hence they could assist in gathering farmers for interviews within the agricultural area they oversee. Thus, data was collected in eight villages categorised into areas each served by a different agricultural extension office. These are Kobojango, Mathathane, Motlhabaneng, Tsetsebjwe, Semolale, Moletemane, Molalatau, Bobonong North and South. A map showing the distribution of villages in Bobirwa sub-district is shown in Figure 3. Time did not allow for the interviews to be conducted in the villages which fall under the authority of Selibe-Phikwe sub-district office located in Selibe-Phikwe, 80km away from Bobonong. However, the farmers from the selected villages were representative of agro-pastoralist subsistence farmers in Bobirwa sub-district. Statistics Botswana (2014) also highlights that subsistence farming is most common in Botswana. Although Bobirwa sub-district may represent Botswana’s prevalent subsistence arable farming, its pastoral farming as in the northern parts of Botswana, has to face the challenge of FMD, which may require different livestock production management practices from FMD-free zones.

According to the 2011 Botswana Housing and Population Census, Bobirwa sub-district has a population of 71 936 (Statistics Botswana, 2015). Bobonong, the headquarters of the Bobirwa sub-district, is the largest village, accounting for 31.2% of the population in the sub-district

(McLeod, 1992; Statistics Botswana, 2015). The total number of subsistence crop production farmers in Bobonong sub-district is 3 605 for the 2015/2016 season, comprising 1 022 males and 2,583 females (Agronomist, personal interview, 22 July 2016). According to the livestock production and veterinary services offices in Bobonong extension area and Selibe Phikwe, the correct statistics for the livestock farmers is unavailable because it is still a challenge to register and monitor all livestock-keepers (veterinary officer, telephone communication 22 July 2017). Statistics Botswana (2015) states that in Botswana anyone in the age category of 18-35 years is regarded as youth, which amounts to only 27.1% of the sub-district population. The youth group is speculated to be uninterested in agricultural activities (Mogotsi et al., 2011c). Within the remaining adult group there is the elderly group, whose age is 65 years and above and which is regarded as economically inactive and a dependent group for provision of government pensions (Statistics Botswana, 2015). This elderly group generally makes up 6.4% of the sub-district population (Statistics Botswana, 2015).

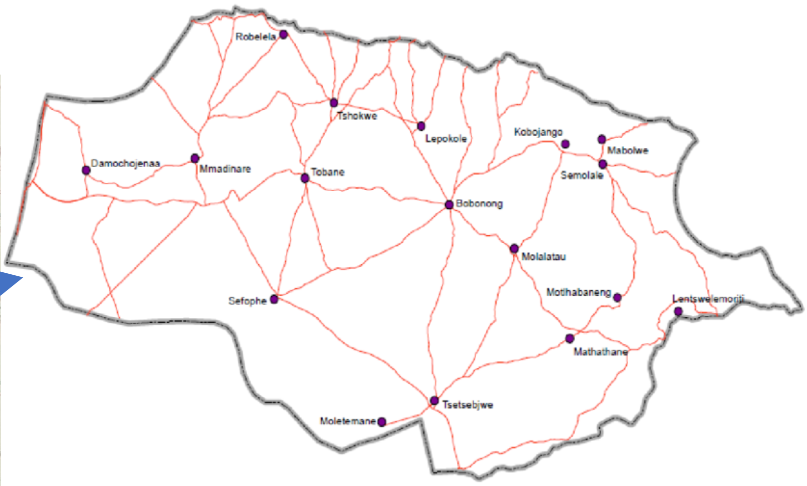

Figure 2. Map of Botswana
(Source: Botswana Second National Communication to the UNFCCC)

Figure 3. Map showing distribution of villages in Bobirwa sub-district
(Source: Statistics Botswana)

3.2 Climate

Like most places in Botswana, Bobirwa sub-district is an arid to semi-arid area with average annual rainfall of less than 350mm (MEWT, 2012; Mogotsi et al., 2011b). Figure 4 shows average annual rainfall distribution in the country and Bobirwa sub-district with annual minima in eastern Botswana. The whole country experiences localised showers and thunderstorms (Batisani & Yarnal, 2010). Rainfall is characterised by modest spatial variability, but high temporal variability inter-annually and intra-annually, hence making its predictability challenging (Batisani & Yarnal, 2010; MEWT, 2012). The rains occur in the summer from October – April and temperatures are normally higher than 33°C, leading to high evaporation rates (MEWT, 2012; Mogotsi et al., 2011b). According to Batisani and Yarnal (2010), long-term data depicts a decreasing rainfall trend countrywide with a decline in the number of rainy days. As in the rest of the country, Bobirwa sub-district is not spared by climate risks such as floods, heat waves, heavy rainfall and droughts (Batisani & Yarnal, 2010; Chipanshi & Ringrose, 2001).

Droughts are recurrent phenomena in Botswana due to semi-arid conditions (Chipanshi & Ringrose, 2001; Mogotsi et al., 2012; Mogotsi et al., 2013). It is projected that in future, dry spells would become regular and intense (Mogotsi et al., 2012). Interruptions associated with droughts affect subsistence farmers, increasing their vulnerability as they are unable to cope with constant drought shocks (Mogotsi et al., 2012). In this regard the traditional coping and adaptation measures have become unsuitable, requiring better adaptive options to be implemented (Mogotsi et al., 2011a).

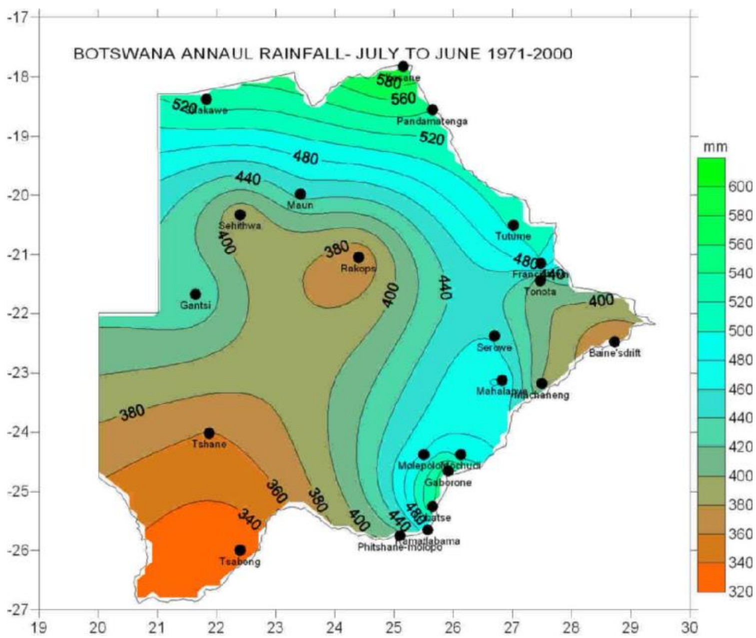

Figure 4. Average annual rainfall for Botswana
(Source: Botswana Second National Communication to the UNFCCC)

3.3 Agricultural activities

Agriculture plays a major role in the livelihoods of Bobirwa sub-district with subsistence farming being dominant (Mogotsi et al., 2011b). The area is characterised by both arable farming production and pastoral farming. Agriculture provides 57.9% of income from sales of agricultural produce, particularly livestock (Mogotsi et al., 2011a). Livestock are kept in shared grazing areas called cattle posts and include cattle, goats, sheep, donkeys, horses and poultry (Mogotsi et al., 2011b). It is noteworthy that livestock-keeping is a common lifestyle in Botswana: the national cattle population was just over 2 million in 2013 (Mogotsi et al., 2011a; Statistics Botswana 2016). Cattle shape the social, economic and political structures of rural communities. However, between 2013 and 2014 the cattle population decreased, partly due to birth rate, while the goat population increased (Statistics Botswana 2016). Other contributing factors which caused a decline in cattle population are discussed in section 3.3.

In Botswana, and so also here in Bobirwa, pastoral farming is culturally under the dominion of men; hence they mostly own the majority of livestock (Mahoney, 1977; Malope & Batisani, 2008).

The main crop production includes sorghum, maize and millet, with additional crops like melons, sweet reeds, beans and ground nuts (Mogotsi et al., 2011b). The staple crops are sorghum and maize, although maize has become a preferred consumption crop of cultural significance (Chipanshi et al., 2003). This is because maize, unlike sorghum, can withstand *quelea* birds (Statistics Botswana, 2016; Technical Assistant, personal interview, 15 July 2016). The bulk of farmers plant the crops using the traditional planting method of broadcasting[1] (Mogotsi et al., 2011b). However, the Integrated Support Programme for Arable Agriculture Development (ISPAAD) currently requires farmers to row-plant to improve productivity (MoA, 2013). Crop production is mainly the responsibility of women (Mahoney, 1977; Malope & Batisani, 2008; Omari, 2010).

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[1] Broadcasting planting method is the random scattering of seeds by using the hand (Hore et al., 2017). The field is prepared into several straight cuts called furrows using a plough, and seeds are broadcast on the seedbed (Hore et al., 2017). Due to the random scattering of seeds, the spacing between seeds is not determined, therefore crops can grow haphazardly in the field (Hore et al., 2017). Although this method is quick, cheap and requires no skilled labour, it results in seed loss from bird destruction (Hore et al., 2017).

3.4. Challenges to agricultural activities

A combination of challenges of climate, poor soils and diseases make subsistence livestock-keeping and crop cultivation risky (Mogotsi et al., 2011a). Livestock diseases, particularly FMD, are common in Bobirwa sub-district. The outbreak of FMD has in the past resulted in the mass killing of the infected cattle by government (Mogotsi et al., 2011a; Temoso et al., 2015a). FMD also contributes to a low market for cattle in the area because the Botswana Meat Commission, which monopolises exporting to the European market, prohibits the purchase of cattle from high-risk FMD areas (Mogotsi et al., 2011a). This leaves cattle sales at the mercy of butcheries who offer meagre prices (Mogotsi et al., 2011a).

The other challenge is that farmers are used to moving livestock across extensive rangelands and to better forage areas, but the current land tenure system in Botswana restricts such movement (Malope & Batisani, 2008; Mogotsi et al., 2011a; Temoso et al., 2015b). This system limits subsistence farmers' adaptive capacity during dry periods. The high evaporation and low rainfall result in lack of surface water for livestock; hence farmers rely on alternative water sources such as man-made wells which also attract wild animals during droughts (Mogotsi et al., 2011c). The livestock are left at danger of carnivores while herbivores like elephants destroy crops. Because of some of these challenges, cattle-rearing has decreased in Bobirwa sub-district as it is considered risky (Mogotsi et al., 2011c). Conversely, the indigenous (*Tswana*) goats which are able to adapt to the harsh environment, withstand diseases and parasites in the area and can survive on inadequate feed resources of low value (Nsoso et al., 2004).

In addition to a fragile climate, Botswana's infertile soil is a limitation to crop productivity and vegetation (Chipanshi et al., 2003; MacLeod, 1992). The eastern part of Botswana is generally distinguished by hardveld and comparatively more fertile than the sandveld in the west. (Chipanshi et al., 2003; Atlhopheng, 2004). Bobirwa is covered by clay soils (black cotton soils) which has water-holding capacity but poor drainage (McLeod, 1992; Mogotsi et al., 2011c). Therefore, during heavy rainfall the soils become muddy and waterlogged. whereas during dry seasons the soils dry out fast and may easily be eroded, leaving behind a hard-compact surface (MacLeod, 1992). The non-compaction of the soil is a hindrance to the use of tractors on the farms (Mogotsi et al.,2011b). Furthermore, Mogotsi et al. (2011c) added that the soils lack sufficient vegetation cover, making them susceptible to erosion, hence negatively impacting crop production.

The predominant traditional farming technology used by subsistence farmers in Botswana has been draught animal power (Panin, 1995). Mogotsi et al. (2011b) state that draught power is the main constraint to crop production. In the past oxen were used, but gradually donkeys took over because of their resistance to dry conditions, accessibility and use as means of transport (Mogotsi et al., 2013). The introduction of tractors as an improved technology has been a challenge in Bobirwa. Access is limited to only 2% of the farmers because of shortage of tractors, non-conducive farms with stumps, and lack of other inexpensive options (Mogotsi et al., 2011b). One way of obtaining tractors is through a hiring process (Panin, 1995). The other is through the ISPAAD government programme which provides support for subsistence farmers and has resulted in increased demand for tractors (Mogotsi et al., 2011b).

A study by Mogotsi et al. (2012) found that a large percentage (68%) of households in Bobirwa are highly vulnerable and connect this to the fact that most households (64%) are female-headed. The authors explain that these households are usually resource-poor, therefore do not have the capacity to cushion themselves against climate variability such as drought. Incremental challenges include small farmed area, insufficient use of drought-resistant varieties and low yields which are worsened by low unreliable rainfall (Mogotsi et al., 2012).

3.5 Government programmes to enhance agricultural production

Government of Botswana intervention programmes aim at achieving household and national food security by supporting and developing agricultural production through ISPAAD and Livestock Management and Infrastructure Development (LIMID), as discussed below.

3.5.1 Integrated support programme for arable agriculture development

The Integrated Support Programme for Arable Agriculture Development (ISPAAD) was started in 2008 to deal with challenges surrounding arable farming (MoA, 2013). ISPAAD assistance to the farmers includes provision of draught power, potable water, seeds, fertilisers and herbicides, facilitation of access to credit and fencing as well as establishment of agricultural service centres. Under the ISPAAD programme farmers are segmented and supported according to farm area cultivated and the level of operation (MoA, 2013). Firstly, a subsistence farmer is defined as someone who cultivates up to a maximum of 16 hectares and normally utilises small equipment fitting for their production area. Secondly, emerging farmers plant up to a maximum of 150Ha and employ medium-size equipment for production. Finally, a commercial farmer cultivates over 150Ha and uses modern machinery and tools (MoA, 2013). Noting that farmers in Bobirwa are predominantly subsistence this study will therefore focus on subsistence farming.

Farmers within this group are supported with hybrid seed, free fertiliser, free herbicides to control weeds, ploughing and row planting and, where needed, harrowing (MoA, 2013). This assistance covers up to a maximum of 5Ha (MoA, 2013). The recommended seed rations to cover the whole 5Ha in kilograms per hectare are sorghum (3), maize (10), millet (2) cowpeas (10-15) lablab[2] (12-13) and other fodder crops as recommended by MoA. A condition in MoA (2013) is that hybrid seeds, fertiliser, herbicides and draft power will be provided to farmers who row-plant. Under the ISPAAD programme, to increase production, row planting is the accepted planting method rather than the conventional broadcasting planting method. The quantities of seeds provided to farmers also depend on how appropriate they are to farm environments. The rest of the farm area, to a maximum of 16Ha, is subsidised with open-pollinated seeds, but a farmer choosing only open-pollinated seeds gets 100% support to a maximum of 16Ha (MoA, 2013).

3.5.2 Livestock management and infrastructure development programme

The LIMID programme was first rolled out in 2007 as phase I and was thereafter succeeded by phase II, which commenced in 2010. The goal of the programmes is to enhance food security and eradicate poverty (MoA, 2010). Phase I of LIMID generally concentrated on resource-poor households and infrastructure development such as cooperative poultry abattoirs and borehole/well development and purchase (MoA, 2010). According to MoA (2010), the phase I evaluation conducted in 2009 showed that small stock numbers increased

[2] Lablab is a popular name given to *Lablab purpureus*. It is a forage legume with potential in Botswana because of its drought- and heat-tolerance and ability to adapt to different soil types (Madzonga & Mogotsi, 2014).

by 25.4% across the seven districts surveyed including the Central district.

The phase II goals expanded on phase I objectives, adding improved cattle productivity, livestock management and improved range resource utilisation and conservation (MoA, 2010). Qualifying for the LIMID programme varies according to a portfolio within the programme but generally, the targeted beneficiaries are resource-poor households, youth, farmers in communal areas (referred to as cattle posts) owning specific number of stock to avoid overgrazing (MoA, 2010).

3.6 Alternative forms of livelihoods

Although farmers are dependent on agriculture for livelihood they also engage in alternative sources of livelihood to supplement agriculture activities and adapt to drought (Mogotsi et al., 2011a). Other forms of livelihoods embarked on by farmers are harvesting and selling natural resources like firewood, *Phane* caterpillar, thatching grass and wild vegetables growing in ploughing fields (Mogotsi et al., 2011a). These engagements, although temporary, provide income to communities. For instance, it is estimated that *Phane* exports to South Africa totalled US$9million between 1991-1994, with each harvester producing around 150-250 kilogram per season (Dube & Sekhwela, 2007; Mogotsi et al., 2011a). However, looking at a variety of these alternative livelihoods to agriculture it can be noted that they have a dependence on the climate and therefore are prone to climate variability.

According to the Ministry of Local Government (MLG) (2012) the labour-based relief public works programme known as *Ipelegeng* provides temporary employment and relief for poor communities, at the same time contributing services to development projects. The programme was declared a poverty eradication strategy in 2008 (MLG, 2012). *Ipelegeng* provides basic-wage employment for poor households, particularly female-headed ones (Mogotsi et al., 2011c; MLG & UNICEF, 2012). Farmers also augment agricultural produce with pension income because the majority of them are beyond the retirement age (Mogotsi et al., 2011c; Statistics Botswana, 2016).

CHAPTER 4: METHODS

This chapter presents the methodology used to conduct the study. The procedures for data collection, analysing data and tools used are discussed. The method applied in this study is a qualitative approach in which data was obtained using semi-structured interviews. Data was collected during a field work exercise which took place for 16 days from 6 – 23 July 2016 across the Bobirwa sub-district.

4.1 Semi-structured interview design

The aim was to collect data showing whether SCF received by farmers are credible and relevant, how credibility and scale affect farmers' use of SCF in Bobirwa sub-district, what constraints were encountered in using SCF, and how farmers deal with limitations of credibility and relevance in decision-making. Therefore, a set of questions were developed for the semi-structured interview to obtain information on (1) demographic and farming information, (2) accessibility, credibility and relevance of SCF, (3) use of SCF in decision-making, (4) limitations of SCF and how farmers dealt with credibility and scale limitations, (5) SCF improvement (Appendix 1). Prior to field work, the questions were translated into Setswana, the local language spoken by farmers, for easy reference and communication (Appendix 2).

The interviews were conducted using open-ended questions which allowed farmers to express themselves by giving details of how, why, and what they do in their farming practices with regard to seasonal forecasts. Qualitative technique was found appropriate for this study because obtaining answers to the above questions depended on the respondents being able to express themselves without limitation. Lorenzoni et al. (2007) stressed that qualitative research is the best method to tackle such questions as it can unravel reasons why views and values are held, how they are influenced, how uncertainties are dealt with and the choices of actions thereof.

4.2 Data collection

The research was conducted simultaneously with a fellow researcher from University of Cape Town (UCT), who was doing a study on traditional forecasts. Upon arrival in Bobonong, village, the researcher of this study went to the deputy district commissioner who introduced her to the Ministry of Agriculture (MoA) sub-district crop production officer and tribal administration secretary for formalities on both the traditional and government processes. At Bobonong sub-district office, the agricultural extension officers had gathered in Bobonong for their periodic meeting, therefore there was an opportunity to brief them about the research and the assistance needed in gathering farmers in their respective areas for interviews. It was agreed that a schedule be drawn up in order for each officer to organise the farmers for the interviewees. On 11 July 2016, the researcher met the Chiefs for the introduction of the research and its main purpose, and they embraced it. On 13 July 2016, follow-up phone calls were made by the sub-district crop production officer and a schedule was finalised for meetings with the farmers on various dates in the eight villages, namely Mathathane, Motlhabaneng, Tsetsebjwe, Kobojango, Semolale, Moletemane, Molalatau and Bobonong divided into Bobonong North and Bobonong South areas. Overall, the period 7 -13 July was dedicated to planning and scheduling meetings in collaboration with Bobirwa sub-district government officials.

In this regard, farmers were selected with the assistance of the agricultural extension officers in the respective villages. To gather the farmers, the extension officers contacted the chairpersons of the farmers’ committees, who informed the farmers to gather for interviews on a particular day at a prescribed time and venue. The venue was either the extension office or the village’s traditional meeting place, referred to as the *kgotla*. In some villages, the day of the interview coincided with general *kgotla* meetings, hiring day for *Ipelegeng* or pension payments, so farmers at these events were invited by the extension officer to take part in the interviews. Most village activities and government offices are at close proximity to the *kgotla*, making it a central location. The criterion for qualifying for an interview was to be a farmer aged 18 years and above. In this study a ‘farmer’ means a person who is practising an agricultural activity, either arable or pastoral farming, and makes farming decisions in these activities. The extension officers were also informed to purposely include male and female gender groups, cutting across age groups of youth and adults when making invitations.

The protocol in every village was for the researcher to be introduced to the Chief, who would then grant her permission to address his assembly at the *kgotla* by introducing herself and the fellow researcher, the research overview, consent and the use of voice recordings. However, in some villages farmers were not gathered at the *kgotla* but the researcher was still taken to meet the village Chief to acknowledge her presence in the village, introduce the research and to sanction the interviews to take place in the village. After the introductory speech, she was assigned a place or office to conduct the interviews, where each participant was given a chance for the interview and could freely express themselves. As a researcher of the study, she conducted all interviews; the language used was Setswana, in which she and the respondents were fluent. Each interview took 30 to 50 minutes, depending on how expressive the farmer became. A fellow researcher was also conducting interviews at another secluded place nearby. Initially the first few farmers participated in both interviews but it became clear that the researchers were not getting the most out of the respondents because the interviews tended to be long and the farmers were eager to go back to their chores in the process of the second interview. Therefore, farmers were informed that there were two interviews taking place on scientific climate forecasts and traditional climate forecasts, and that they could choose to participate in either interview. However, if a farmer was eager to participate in both interviews they could do so. Most of the farmers tended to choose to participate in the category of interview with which they were most familiar and comfortable.

Some farmers who were gathered at the venue grew tired of waiting for their turn and dispersed before they were interviewed. To resolve this matter, after completion of interviewing farmers at the venue, household interviews were conducted to supplement the numbers. This also took care of farmers who were delayed at their homes and could not show up at the prescribed venue. Households were selected by researchers walking around and asking at the nearest household if there was a farmer, and interviewing them after concession. At first, when going into households, the two researchers went together into one household to share an interviewing platform, but that did not work as the interview became long and compromised the other researcher’s interview questions. Therefore, most of households’ interviews were conducted separately by each researcher picking their own households one after the next.[3]

Most of the participants were receptive and saw the interview as an awareness-raising exercise on the use of seasonal forecasts. Only one male was removed from the study because during the interview he revealed that he resided in the city and did not take any farming decisions. Thus, a total sample size of 47 farmers, comprising 22 male farmers and 25 female farmers, were interviewed. Mogotsi et al. (2011b) also reported that the sub-district was dominated by subsistence farmers. Based on this information, the resources and time allocated for the field study, the sample in this study is representative of the farming community in Bobirwa sub-district in size, gender and type of farming. This study divided the respondents by gender to understand the gendered implications of SCF uptake and use. Partitioning respondents by age or type of farming was insignificant because the dominant farming age was already adult and none of the farmers were commercial farmers. The study did not divide farmers into livestock production or crop production because normally subsistence households in Botswana practise both arable and livestock farming.

In addition to the farmers' interviews, government employees and SADC Climate Services Centre personnel were also interviewed for 50-60 minutes for more information on the production, dissemination, uptake and use of SCF at regional, national and local level. Firstly, an extension officer (Technical Assistant) was interviewed to understand how farmers and government use SCF in agriculture. The interview also sought to find out whether SCF were: found credible and relevant by the officer, incorporated in agricultural extension office planning and infused into advice given to farmers (Appendix 5). The other government employee interviewed (Meteorologist) was from the Department of Meteorological Services in Gaborone, as a national producer of SCF. This was done to get extra information on the production of SCF, dissemination procedures and stakeholders for SCF. Furthermore, the interview looked at limitations of SCF and how producers of SCF addressed them (Appendix 6). An interview with the SADC Climate Services Centre was conducted to obtain a regional perspective on production and limitations of SCF (Appendix 7).

[3] Household interviews took care of any possible sampling bias towards scientific forecast or traditional forecast because of choosing the nearest next household and interviewing any consenting farmer in the household.

Audio equipment was used to record the interviews. Each farmer's demographic and farming profile was recorded on paper and using audio equipment. The demographic information was needed for social differentiation and analysis. The rest of the interviews addressing the objectives of the study were recorded using only audio equipment in order for the conversation to flow smoothly. The information was archived for analysis.

4.3 Data analysis

The archived audio data was listened to and imported into Microsoft excel sheets. Where necessary the audios were listened to repeatedly to guard against omission of important data. Even though the interviews were conducted in Setswana, the responses were translated into English during coding into excel sheets. It must be noted that only the information given by respondents relevant to this study was logged into excel sheets and coded into themes for each gender group. Themes for each question of interest were developed based on whatever a farmer mentioned and every respondent mentioning that theme was recorded. Quotations indicating what the respondent mentioned concerning the theme were also recorded. Constant checks were made to match the theme with the responses and during the coding phase new themes were added in the two groups as appropriate. The number of respondents who mentioned each theme was totalled for males and females and percentages were also calculated. The themes were further analysed and used to calculate simple statistics. The coded data allowed for analysis of thematic responses, assessment by gender and to determine the number of respondents saying the same things. Translated quotations from respondents were used as illustrative examples of issues raised during the interview.

In calculating simple statistics for the themes, the percentages could be calculated as number of respondents in a theme out of the total respondents (47). However, to obtain further details, make comparisons about the two groups and avoid bias towards females who were a larger group (25) than males (22), percentages of each gender group were also calculated. There were also instances where respondents could give more than one answer, for example in the question about ways they use SCF (section 5.2.1). In such cases frequencies and their percentages were found to be suitable for analysis of responses. The frequencies were also calculated for each gender group as well as for the total number of respondents. For elaboration, data was presented in graphs and tables displaying examples for both male and female quotes.

Concerning the use of SCF, it was realised that the respondents were either users, partial users or non-users of SCF. The users were respondents who always used SCF for decision-making, either exclusively relying on it or using it in combination with other methods like traditional forecasts. The partial users were those who used SCF sometimes but at other times opted to use other familiar methods to make comparisons. Lastly, the non-users of SCF were respondents who did not use SCF in their decision-making and had resorted to using alternative methods. It should be noted that some non-users had used the SCF in the past but had become disappointed in them or decisions guided by them, leading to total abandonment. In general, when combining the users and partial users the respondents could be broadly sub-categorised into users and non-users of SCF making 41 users and six non-users. Thus, sections 5.4.1, 5.4.3 and 5.6 examined the 41 users' ways of utilizing SCF, the effects of use of SCF, and how they overcame barriers experienced with SCF while section 5.4.2 investigated the six non-users' decision-making methods. In the rest of the sections all 47 respondents and the two gender groups are considered.

4.4 Approvals and consent

Data collection was approved by the research ethics committee at University of Cape Town (UCT), which requires the interviewer to comply with research ethics. Furthermore, the government of Botswana ASSAR research permit for the University of Botswana (UB) and introductory letter were obtained from UB as ASSAR focal point in Botswana, confirming local approval of the study. Consent forms were prepared (Appendix 3) and translated in summary to Setswana (Appendix 4) for interviewer and interviewees' signatures. In accordance with the research ethics there was explanation of the consent and its voluntary signing by both the interviewee and interviewer prior to the interview, which was also audio-recorded.

Although the respondents mentioned their names when signing or verbalising the consent before the interview they were assured that confidentiality would be maintained and their identities would not appear on the report, be publicised nor given to a third party.

4.5 Fieldwork challenges

In the beginning of fieldwork, the research was conducted in parallel with a fellow researcher, which resulted in the interviews becoming too long and the respondents showing signs of fatigue, hence some responses could have been cut short. The challenge was met by probing similar questions differently. Therefore, for better management, the two concurrent interviews were held separately. The farmers who were gathered at the venue could choose to participate in either scientific forecast or traditional interview based on their familiarity with the forecasts. This meant some of the non-users of SCF could have preferred to go the fellow researcher. However, if the respondent wanted to participate in both interviews they could do so.

Another limitation of the study was that as a researcher and an employee of the Department of Meteorological Services recognisable to a few farmers from past TV broadcasts, they could give biased responses in favour of SCF. To reduce the prejudice, the farmers were reassured they could feel free to express their opinion whether negative or positive and that the research and researchers were university-based. On the other hand, this was also a bonus because those few farmers were excited to give their opinions, knowing that they are talking to the right person and their opinion would contribute to improving the SCF products.

Despite these challenge, the fieldwork was very successful as an abundance of data was obtained. The village Chiefs, government officials and the community at large were very welcoming, making the researcher’s work easier and gratifying.

CHAPTER 5: RESULTS AND DISCUSSION

This chapter presents the results of the study followed by a discussion of the results with the aim to address the research questions of the study. Firstly, the profile of sampled farmers and their accessibility to SCF are presented as important background information to responding to the research questions. Then follow the relevance and credibility of SCF; how the credibility and relevance influence decision-making of farmers; how farmers deal with the limitations of credibility, and the relevance of SCF in their decision-making. The chapter concludes with farmers' recommendations to improve SCF.

5.1 Respondents' profile and farming practices in Bobirwa sub-district

A total of 47 respondents were interviewed, comprising 22 male and 25 female farmers. The data shows that farming in Bobirwa sub-district is dominated by elderly persons. The age category of 56 years and above makes up 68.1% of the sample, 27.7% are between 36-55 years while the youth in the range of 22-35 years makes only 4.3%. It is noteworthy in this study that 76.6% of the farmers had farming experience exceeding 10 years.

Figure 5 shows that the most prevalent crops planted are beans (93.6%), maize (87.2%), sorghum (83.0%) and lablab (66%). Some farmers highlighting crop preferences said they no longer planted sorghum because it was labour-intensive and favoured by pests like *quelea* birds. Gender results indicate the percentages of women planting the major crops exceed those of men except in the case of lablab, which it is planted by more men (68.2%) than women (64%). Farmers indicated that the lablab planted is used for livestock feed.

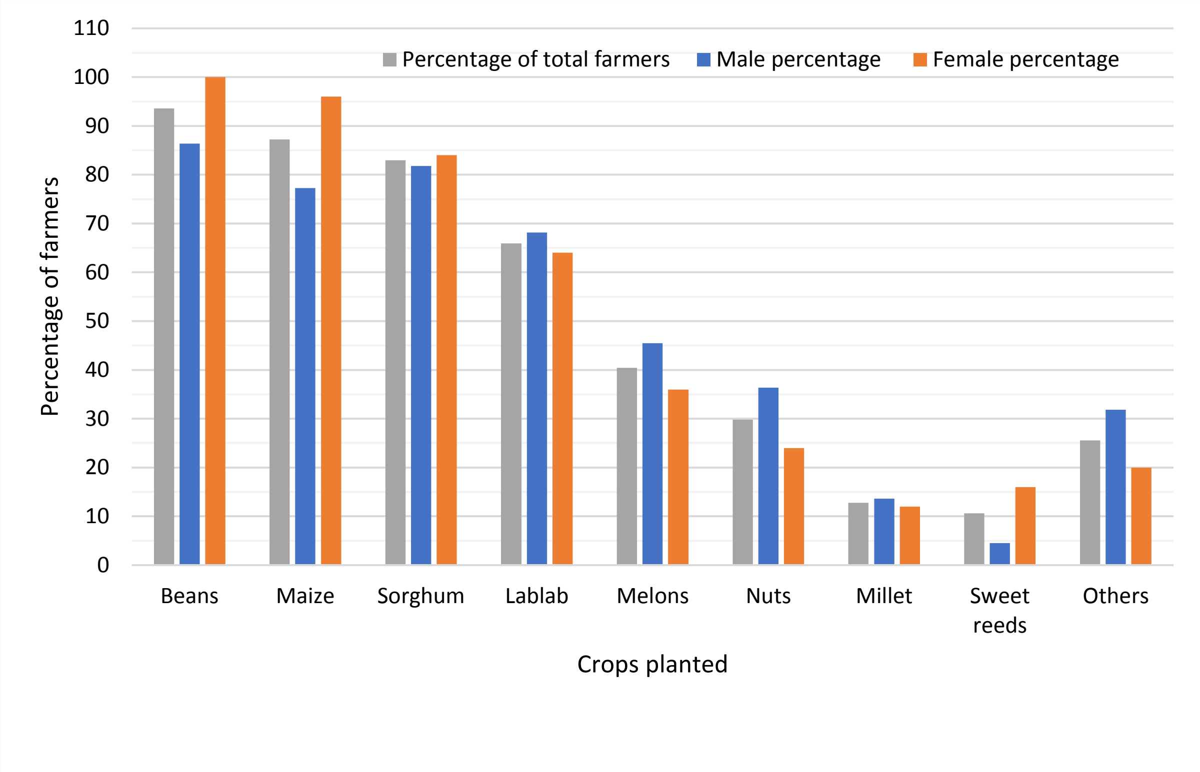

Figure 5. Percentage of total farmers planting the crops shown by whole bar (blue bar is male percentage of total and orange bar is female percentage of total while numbers in each bar indicate male and female group percentages planting each crop)

The percentages of livestock kept by farmers are: goats (74.5%), cattle (63.8%), donkeys (25.5%), chickens (21.3%) and sheep (12.8%). Farmers explained that they used donkeys for draught power and transporting farming goods within the farm areas. The proportion of men keeping any type of livestock surpassed that of women (Figure 6). The results also show that goats were the most commonly kept livestock. Gender results reveal that a higher proportion of women (68%) either exclusively or communally owned goats compared to cattle (52%). During the interviews farmers mentioned that they kept goats because they could withstand drought as they could feed on tree foliage, unlike cattle. Others stated that they obtained goats through government assistance programmes.

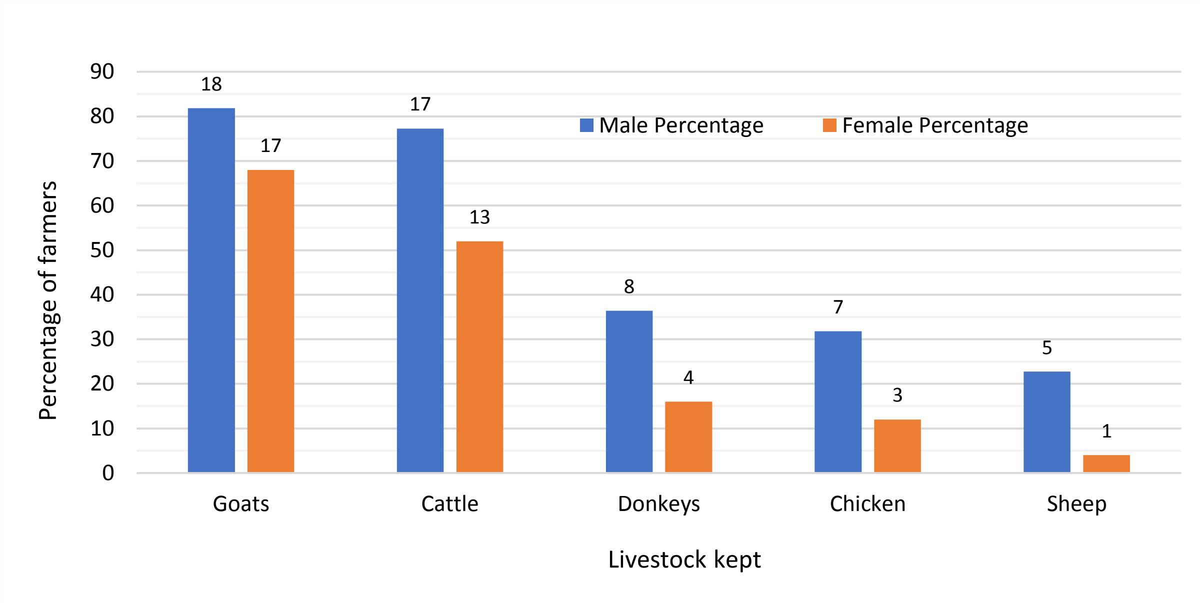

Figure 6. Percentage of male and female farmers keeping livestock (with number of males and females keeping livestock represented above the bars)

The age profile of farmers confirms previous findings that farming in Botswana is dominated by older persons (Nsoso et al., 2009; Mogotsi et al., 2011c; Statistics Botswana, 2016). For instance, figures from the national agricultural survey conducted in 2014 revealed that there were 120 317 subsistence farmers in Botswana, and 1 693 were from Bobirwa sub-district (Statistics Botswana, 2016). Furthermore, out of Botswana's subsistence farmers, 4.4% were aged between 15 and 39 years and the majority (63.7%) were 60 years and above (Statistics Botswana, 2016). Kolawole et al. (2014) state that older farmers' long farming experience could equip them with local knowledge to adapt to climate variability. The youth in Bobirwa seemed not to be attracted to agricultural production (Mogotsi et al., 2011c).

The crop ranking in this study differs slightly from countrywide data, which indicates that maize is the principal crop under subsistence farming while sorghum is common among commercial farmers (Nthoiwa et al., 2013; Statistics Botswana, 2016). Chipanshi et al. (2003) found that sorghum is more suitable for semi-arid conditions than maize. However, sorghum is more susceptible to *quelea* birds than maize (Statistics Botswana, 2016; Technical Assistant, personal interview, 2016 July 15). Therefore, farmers in Bobirwa could be slowly adapting to climate variability by resorting to beans. Although the ISPAAD government assistance seed rations for maize, sorghum, millet, cowpeas beans, lablab and other fodder crops are provided annually to farmers using extension officer's prerogative to issue suitable amounts for the area (MoA, 2013), it is the farmer's decision which crops to plant after getting rations for each crop.

In the study, the proportion of farmers keeping goats outnumbered those rearing cattle. This is similar to the 2014 national agricultural survey indicating that more farmers kept goats (63.9%) compared to cattle (54.7%) and sheep (15.5%). The survey further stated that goat rearing was stimulated by implementation of the LIMID programme, with an objective to increase small stock production, among others (Statistics Botswana, 2016). MoA (2010) reported that in seven districts including the Central district, the average number of small stock increased by 25.4%, showing an advance in productivity. Another reason is that Bobirwa sub-district is a FMD zone, and in the past has had recurrent droughts resulting in cattle mortality, while the number of goats increased (McLeod, 1992; Mogotsi et al., 2011c). Literature also points out that farmers in high temperature areas opt to keep goats more than beef cattle because goats can survive in high temperatures and a dry climate (Juana et al., 2013; McLeod, 1992). This is also emphasised by Nsoso et al. (2004) that indigenous Tswana goats can adapt to the severe environments as they can browse trees, graze grass of meagre available feed resources and tolerate diseases.

Gender disparities in crop and livestock farming across Botswana are distinct and similar to literature. It is recognised that only a small percentage of women keep cattle because women in rural areas practise arable farming more than pastoral farming (Mahoney, 1977; Malope & Batisani, 2008). Omari (2010) also noted that in Botswana crop farming is a woman's dominion. Therefore, women mostly plant crops, except lablab, which falls in the male livestock territory. The gender difference is also picked up by the 2014 national agricultural survey, that males are the majority owners of livestock in the traditional sector, owning 64.8% of cattle, 56.3% of goats and 69% of sheep (Statistics Botswana, 2016). These roles originate from traditional households in Botswana in which livestock is under the control of men while women take care of crops. Malope and Batisani (2008) explain that currently women face barriers in keeping cattle like inadequate production resources, skills, male-dominated cultural practices and customary laws.

5.2 Accessibility of seasonal climate forecasts

The survey indicates that all farmers interviewed have access to SCF (Figure 7). The most common mode of access to SCF is the radio (76.6%), followed by television (63.8%) and extension officers (38.3%), whereas other sources had less than 10%. The disparity for each access source between the two gender groups is very small except for radio, where male access is 86.4% as compared to female access at 68% and the *kgotla* where none of the females indicated obtaining SCF (Figure 7).

The results on accessibility of SCF differ from a study conducted in Botswana and some parts of Africa. A study conducted by Mogotsi et al. (2011b) found that only a minority of farmers in Bobonong North (44%) and Kgalagadi North (39.5%) had access to SCF[4]. In some parts of Africa, farmers have limited access to SCF (O'Brien et al., 2000; Luseno et al., 2003; Ziervogel, 2004; Hansen et al., 2011). Furthermore, it is stated that in South Africa and Burkina Faso access to SCF is segregated by ethnicity, whereas in Limpopo Province of South Africa gender had an influence (Hansen et al., 2011). This study's high accessibility[5] to SCF could be associated with a robust SCF dissemination procedure adopted by DMS three years ago, inclusive of extension officers, workshops, media, farmers' association events and in the past year, *letsema* ceremonies, and cabinet ministers (Meteorologist, personal interview, 26 July 2016). Moreover, high access through radio and television is linked to ownership of equipment. According to the 2011 national census, household ownership of a working information and communication technology (ICT) is quite high in Botswana, even for rural areas. The percentage of rural households owning working equipment is 85% for a mobile phone, 64% television, 27% radio, 1.3% computer and 7.9% fixed telephone line (Statistics Botswana, 2014). A national analysis by gender groups revealed that television household ownership is almost equally partitioned between males and females while a slightly higher percentage of men owned a radio (Statistics Botswana, 2014). The high

[4] It should be noted that Mogotsi et al.'s(2011b) study that took place in Botswana was conducted in the 2009/2010 season. In Bobirwa sub-district, the study was centred in Bobonong North covering villages of Lepokole and surrounding communal areas of Sekgopswe, Mmamanaka and Mmaditshwene.

[5] The fieldwork for this thesis was conducted in 2016, almost seven years following the study by Mogotsi et al. (2011b) and covered more villages including Lepokole under Bobonong North. A predisposed bias towards SCF was overcome by carrying out households surveys and allowing any farmer who wished to participate in the interview to do so.

ownership of radios explains greater access of SCF through radio by men. The main mode of access to SCF being the radio agrees with other studies in Africa in which radio is said to be affordable and far-reaching in rural areas (Ingram et al., 2002; Luseno et al., 2003; Hansen et al., 2011; Churi et al., 2012). In Tanzania, where SCF accessibility is reasonable, cell phones have become a mode of dissemination as they are widely owned by farmers (Churi et al., 2012). Concerning the *kgotla* where none of Bobirwa women indicated getting SCF, there is an attached history. In the past, *kgotla* meetings could be attended only by males but women were excluded except during planting and harvests ceremonies (Denbow and Thebe, 2006). However, at present women are allowed in *kgotla* gatherings, but men remain the majority of those in attendance (Denbow and Thebe 2006).

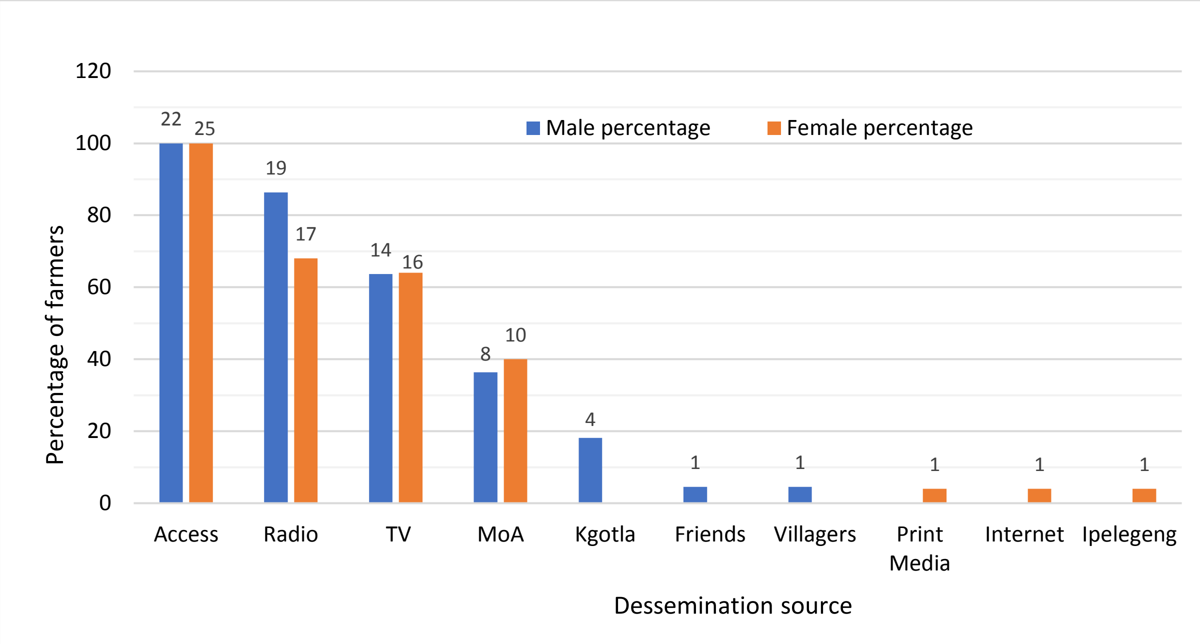

Figure 7. Percentage of male and female farmers accessing seasonal climate forecasts and for each of the various dissemination sources (with number of males and females for each source represented above the bars)

5.3 Credibility and relevance of seasonal climate forecasts for farmers in Bobirwa sub-district

When farmers were asked whether they trusted the SCF, more than half of them (57.4%) indicated that they trusted the SCF, 21.3% partially trusted them and only 21.3% did not trust them at all. There were no distinct differences displayed between male and female positions as 59.1% of the males trusted SCF as opposed to 27.3% not trusting SCF, while for the females, 56% trust SCF and 16% had no trust in them. The most common reason for trusting SCF was that of accurate forecasts (63.8%) as shown in Table 1. The accuracy of the daily weather forecasts broadcast over the radio, television and social networks was also another the factor determining the credibility of the SCF by farmers. The daily forecasts disseminated on radio and television, was trusted by 57.4% of the farmers, 19.1% had partial trust while 8.5% had no trust in them and 14.9% did not indicate their position. A few farmers (8.5%) mentioned that they trusted the SCF because of their recent significant improvement compared to the past. They elaborated that in the past they never used to trust SCF because of frequent incorrectness. It should be noted that during the interviews, farmers could clearly recall the past two rainfall seasons and the forecasts disseminated which they perceived to be correct. Beyond two years they gave only a general observation that the forecasts were correct in the immediate past years but inaccurate a couple of years previously. One man said, "I trust the forecast entirely but some years ago it used not to be correct; these days it has improved so much …". Farmers attributed improvement of the SCF to knowledge of the use of technology. Other factors mentioned contributing to trust of SCF included government's DMS as the provider of information, trained forecasters and the fact that SCF usually agree with the traditional forecasts.

Table 1. Male and female reasons for trusting seasonal climate forecasts

	MALES		FEMALES	
Theme	**n**	**Illustrative Quotation**	**n**	**Illustrative Quotation**
Correct/Accurate Forecast	12	"I trust the forecast because last season it predicted there would be low rainfall and indeed there was no rainfall…" "I trust the forecast because it tells the truth…" "The forecast becomes correct like this year the forecast said low rainfall is expected and indeed it happens we saw it."	18	"I trust it because last year it was correct. What they say comes to reality and this year they said less rain is expected and indeed there was less rain." "Whenever the forecast says something it does happen. Even though sometimes the forecast can be slightly off like this year we were told there is less rain and later on in the season it rained." "They get the forecast right but even if there could be changes differing from the forecast, the atmosphere belongs to God, human are human cannot get it all the time."
Improved forecast	3	"I trust the forecast but some time ago I used not to trust it because the technology seemed to have been confusing them as they would predict rain and the forecast would be wrong but these days unlike in the past the forecast	1	"I trust it by assessing the situation, the forecast used not to benefit us because it was not accurate but now it has improved…" "I have observed the forecasts they make and I can see that sometimes signs of what they forecast happening."

		becomes correct." "I trust the forecast entirely but some years ago it used not to be correct these days it has improved so much…"		
Trained and Supplier of Forecast Information	0	-	2	"I trust it because of the training and knowledge the forecasters have and they are our informants and advisors."
Warns Farmers	2	"The forecast tells farmers of the upcoming season whether there will be less rain and what types of crops to plant, so I trust it."	0	-
SCF Agrees with Traditional Indicators	2	"I trust it because when the forecast is released and I observe the clouds also I see that indeed from my observations confirms SCF."	1	"I usually confirm it with traditional forecasts observed by parents and mostly the two forecasts are in agreement."
Farming is Important	1	"I trust it because I need to farm to sustain myself and not give up."	0	-
Trust Daily Forecast	5	"I trust SCF because I can see even the daily forecast becomes correct hence indeed I see all forecasts are correct." "I trust the SCF because from recent years whatever the daily forecast predicts it happens so it gives me confidence that what is forecast is the truth."	1	"They use equipment to look ahead unlike us who don't use anything so we trust the forecasts."

When asked for reasons for mistrusting SCF, inaccurate forecasting was mentioned by both males and females (Table 2). Of the 20 farmers who either totally did not trust or partially trusted the SCF, 90% picked inaccurate forecast as the main hindrance to trusting the forecasts. An example of the reasons given by respondents was, "I don't trust it because the forecast can state that less rain is expected but we then experience a lot of rainfall at the end of the season …" (Table 2). Looking at percentages in the two genders groups, all men who did not trust SCF highlighted inaccuracy in their reasoning while the percentage of women was slightly lower at 81.8%. The religious beliefs and practices theme was the next highest frequency among women at 63.6%. They explained that rain is controlled by God who has the power to change the situation at any time (Table 2). Male farmers had more reasons for mistrust than female farmers, stating shifted seasons and lack of trust in daily forecast at 40% in each theme contributing to the mistrust in SCF.

Table 2. Male and female reasons for not trusting seasonal climate forecasts

	MALES		FEMALES	
Theme	**n**	**Illustrative Quotation**	**n**	**Illustrative Quotation**
Incorrect or Inaccurate Forecast	9	"I don't trust it because the forecast can state that less rain is expected but then we then experience a lot of rainfall at the end of the season, this leaves us confused…" "The forecast predictions are sometimes not correct as sometimes the forecast will say a very wet season is expected and the season becomes dry or forecast will say drier conditions are expected and it rain abundantly, however, other times the forecast are correct." "The fact that sometimes the forecast becomes correct and other times wrong makes me not to trust it, the quality is still not satisfactory."	9	"The forecast would say less rain is expected then it will rain so much…" "We were told there is less rain but it rained towards the end of season." "The forecast leaves us uncertain because sometimes it is correct other times it is incorrect."
Religious beliefs and Practices	2	"I end up trusting God as I don't have an option." "Rain is controlled by God."	7	"Rain is a natural phenomenon made by God so humans cannot totally get it as they can say it won't rain and God makes it to rain." "I also trust in God because He can change the situation anytime." "Also rain is from God which makes us uncertain about SCF."
Seasonal variations not captured	4	"Seasons have changed as in our experience we knew the onset was in September, and different types of rain came at known times but with climate change the atmosphere is confusing to everyone even to the forecasters…" "I don't trust it because there is climate change which make the forecast incorrect most of the time."	0	-
Misled on crops to plant	0	-	2	"I don't trust it because last year I was told not to plant sorghum and maize as there was no rain but I went ahead and planted them anyway and I got a bag of maize and plenty of sorghum."
Poor Distribution in time	1	"It also doesn't rain in the months of season like it used to rain from September like last season it started in December."	1	"I sometimes not trust it because the forecast will say less rain is expected and then so much rain occurs towards end of season in December or January like this season when it is too late."
Broad areal coverage	1	"The forecast does not pick our areas so but we don't blame the forecast as we will wait upon the day it will rain."	2	"Sometimes it over generalises information and we expect rain and it doesn't fall in our area."
Traditional beliefs and Practices	1	"I use the forecast together with the traditional forecast."	1	"We plant the way parents taught us."
Lack of Understanding	0	-	1	"I don't understand the forecast and not so familiar with it."
Difficulty to Predict Atmosphere	1	"The prediction of the atmosphere is a difficult so sometimes the forecast will predict something and then the situation changes."	0	-
Inaccurate Onset	1	"I don't trust the forecast because the forecast can indicate the month of onset as November and a bit of rain	0	-

		comes in December."		
Inaccurate Dry Spells	1	"Last season the forecast indicated January as dry spell but then a lot of rain came in January and February when we expected dry spell in January."	0	-
Lack of trust in Daily Forecast	4	"The forecasts are sometimes not correct so we end up not believing it The two forecasts are usually inaccurate....we no longer know what to do so we now trust in God."	0	-

Credibility is gauged by accuracy of past SCF, source of information and communicator reputation, which can be hindrance to uptake of SCF (Patt & Gwata 2002; Ziervogel, 2004). Generally, it can be said that a majority of farmers in Bobirwa sub-district perceive SCF that they receive as credible because of their overall accuracy. This finding contradicts the low credibility of SCF hypothesised before the study based on most literature such as in Australia, Zimbabwe, Horn of Africa (Kenya and Ethiopia), Burkina Faso and a study in Chobe District in Botswana. Marshall et al. (2011) mention that in Australia, the low use of SCF by graziers is attributed to the forecast inaccuracy. Most of the graziers did not trust that SCF could be accurate, but indicated they needed an overall picture of what the season would be like (Marshall et al., 2011). In the case of Zimbabwe, many farmers indicated that SCF received over the radio were inaccurate, hence decreasing their trust in the forecasts (Patt & Gwata, 2002).

Several reasons could be contributing to Bobirwa farmers' regard of credibility of the SCF. Firstly, Mogotsi et al. (2011b) mention that in Botswana SCF are disseminated in their probabilistic form, indicating whether to expect below-normal, normal or above-normal rainfall. However, unlike the English version, the Setswana version of SCF leaves out the numerical probabilities categories of normal, below-normal or above-normal while retaining the language of likelihood. Ingram et al. (2002) state that disseminating probabilistic forecasts reduce a scenario where forecasts are entirely incorrect as each of the three categories of below-normal, normal and above-normal have possible occurrence no matter how minute the probability is. Patt and Gwata (2002) also agree that the credibility of SCF is compromised by disseminating SCF as deterministic instead of in their pure probabilistic form.

Secondly, the credibility of the SCF to Bobirwa farmers emanated from the wide accessibility of SCF and consistent exposure, translating into better understanding. This was evident for a few farmers in Zimbabwe who had previous exposure to SCF workshop discussions, and who indicated that their trust in SCF had increased (Patt & Gwata, 2002). In contrast, a greater percentage of pastoralists in the Horn of Africa revealed that they did not have confidence in the SCF mainly because of lack of access to SCF, but displayed high confidence in indigenous forecasts (Luseno et al., 2003).

The third factor highlighted in literature is the credibility of the communicator and source of SCF (Ingram et al., 2002; Patt & Gwata, 2002; Ziervogel, 2004). Bobirwa farmers professed that they trusted the forecast because of the trained staff as the suppliers of information., The use of meteorological station officers and extension officers across Botswana, as well as other credible dissemination sources like workshops and media talk shows conducted by DMS, could be contributing to the recent credibility of forecasts (Meteorologist, personal interview, 26 July 2016). However, the Burkina Faso government-private cotton institution tried to use village-based field agents to disseminate SCF widely to farmers, but they were poorly trained and could not interpret SCF (Ingram et al., 2002). It resulted in farmers having low confidence in the agents and therefore they were reluctant to take up the forecasts (Ingram et al., 2002). This illustrates the importance of SCF being disseminated from a credible source and communicator (Ingram et al., 2002; Patt & Gwata, 2002; Ziervogel, 2004).

Lastly, Bobirwa farmers associated improvement of SCF with the appropriate use of technology. This relates the expansion of the meteorological station network across Botswana having resulted in better data, monitoring and dissemination of SCF (Mogotsi et al., 2011b; Meteorologist, personal interview, 26 July 2016). Similarly, in the Horn of Africa, where the pastoralists indicated confidence in SCF, they linked it to use of modern equipment and trained meteorological staff (Luseno et al., 2003). In summary, it can be said that the perceived credibility of SCF in Bobirwa agrees with literature suggesting that increasing credibility of SCF can be done by improvement of SCF, data and better communication of SCF, which do not deviate from their probabilistic nature (Ziervogel, 2004). Goddard et al. (2001) also state that routine climate observations and monitoring are important for constructing and validating statistical climate models used for generating SCF. Some of the percentage of farmers in this study, who perceived SCF as not trustworthy, found it a barrier to using SCF (section 5.4.2).

Relevance of SCF is gauged by procedures for dissemination, cognition and scale (Patt & Gwata, 2002; Drilling & Lemos, 2011). In this study, farmers indicated that SCF were relevant due to the dissemination procedure and cognition, but scale was a concern. A bulk of farmers (76.6%) regarded the procedure for dissemination as timely and appropriate. They reasoned that the one-month lead-time dissemination of SCF in September coincided with their known historical start of the rainfall season as well as the cultural event, *letsema* (planting season celebration). A few farmers (10.6%) indicated that August was a better month for dissemination to allow them to do farming preparations.

Upon investigating the cognition factor, Bobirwa farmers indicated that they understood the SCF because it was delivered in the local language, Setswana. Farmers responded that the Setswana version was easy to understand and the terminology used in SCF showed human limitation because rain is created by God and they do not expect humans to know everything about its occurrence.

Botswana's one-month lead-time forecast dissemination approval by farmers is consistent with Ingram et al. (2002) and Mogotsi et al. (2011b), who also mentioned that most farmers need SCF of one - two months' lead-time which would enable them to prepare fields, employ moisture conservation techniques, optimise labour and acquire seeds. However, the accuracy of forecasts should not compromise its timeliness (Ingram et al., 2002; Mogotsi et al., 2011b). This happened in Tanzania, where farmers complained that SCF reached them too late to use them to plan for the rainfall seasons, although they perceived them as valuable (O'Brien et al., 2000). There was uncertainty in the dissemination process in Tanzania as agricultural institutions speculated that the forecast could have been released on time but did not reach some farmers, while others said socio-economic constraints hindered timely use of the forecasts (O'Brien et al., 2000). Tanzanian farmers' needs list included six-month lead time forecasts, which was beyond what SCF could provide (O'Brien et al., 2000).

Literature links cognition of the forecasts with the language of dissemination and probabilistic presentation of SCF. It is mentioned that the presentation of the forecasts as probabilities confuses farmers as they find them difficult to understand therefore continuous interpretation is vital (O'Brien et al., 2000; Hansen, 2002; Lemos et al., 2002; Patt & Gwata, 2002; Mogotsi et al., 2011b). Although farmers in Bobirwa expressed satisfaction with the language of dissemination and presentation format, there is a high chance that the probabilistic nature of the forecast is lost during language translation by extension officers and could be reaching farmers mostly as deterministic forecasts. An interview with a producer of SCF also indicated that the English version of SCF is purely probabilistic but there is difficulty in translation of probabilities into Setswana, resulting in loss of meaning and the Setswana version becoming largely deterministic (Meteorologist, personal interview, 26 July 2016).

Many Bobirwa farmers raised the issue of scale, both in space and time, as an area of concern that needs to be improved for SCF to be more relevant for their decision-making. Their needs for SCF to be at local scale resolution to indicate intra-seasonal distribution and onset of rainfall were consistent with literature. Ingram et al. (2002) and Ziervogel (2004) mention that scale becomes problematic when SCF do not detail local influences, rainfall distribution, onset and cessation of rainfall in the season. Lemos et al. (2002) elaborated that spatial and temporal distribution of rainfall is key for decision-making in a semi-arid environment, hence farmers in Ceará, Brazil also required information detailing rainfall in space and time. Lemos et al. (2002) explained that the current SCF provided are unable to meet that need because they cover large spatial scale and do not give within season rainfall distribution. Mogotsi et al. (2011b) also established that SCF issued in Botswana cover a large scale an area the size of a district or more, hence missing details of local variabilities required by farmers. Lemos et al. (2002) concluded that the disparity between users' needs and what could be provided scientifically limit the use of SCF. Scale as limitations of SCF is exhaustively discussed in section 5.5.1

5.4 Credibility and relevance of seasonal climate forecasts' influence on decision-making in Bobirwa sub-district

On analysing the users (36), partial users (5) and non-users (6) of SCF in decision-making for farming practices, the following information was derived from the responses:

An overwhelming 76.6% of the total farmers indicated that they used the SCF in decision-making (Figure 8). Only 10.6% were partial users, whereas 12.8% were non-users. It is worth noting that 75% of users trusted the forecasts while the remainder partially trusted them. Furthermore, four of the farmers who initially specified not trusting SCF indicated using them in decision-making anyway. Almost all non-users did not find SCF credible and relevant; this will be covered in detail in section 5.4.2.

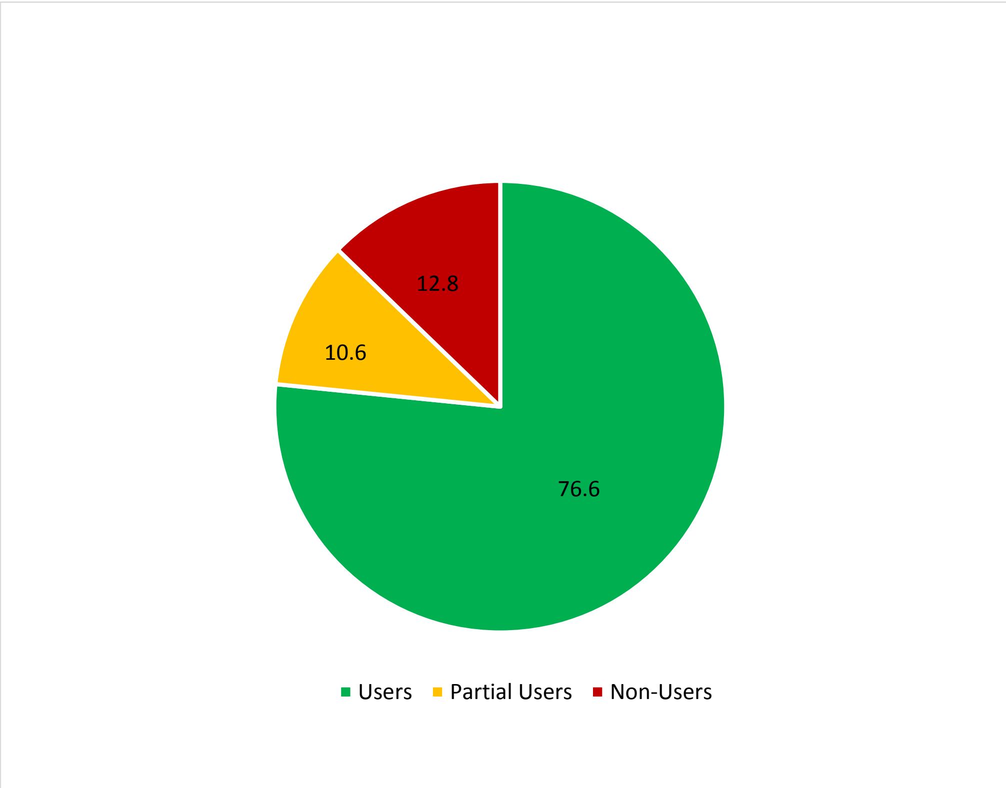

Figure 8. Percentage of seasonal climate forecasts users, partial users and non-users

Categorising the responses by gender shows that slightly more female farmers use the forecasts for decision-making than their male counterparts. Twenty females (80%) as opposed to 16 males (72.7%) used the forecasts. However, this gender difference is statistically insignificant[6]. There were few partial users of SCF, totalling three males and two females. Concerning non-use of SCF, only three farmers in each gender group were non-users.

5.4.1 Ways of using seasonal climate forecasts in decision-making

Among the various applications of SCF by farmers in decision-making, the most common is to determine seed choice (80.9%) for the season (Figure 9).

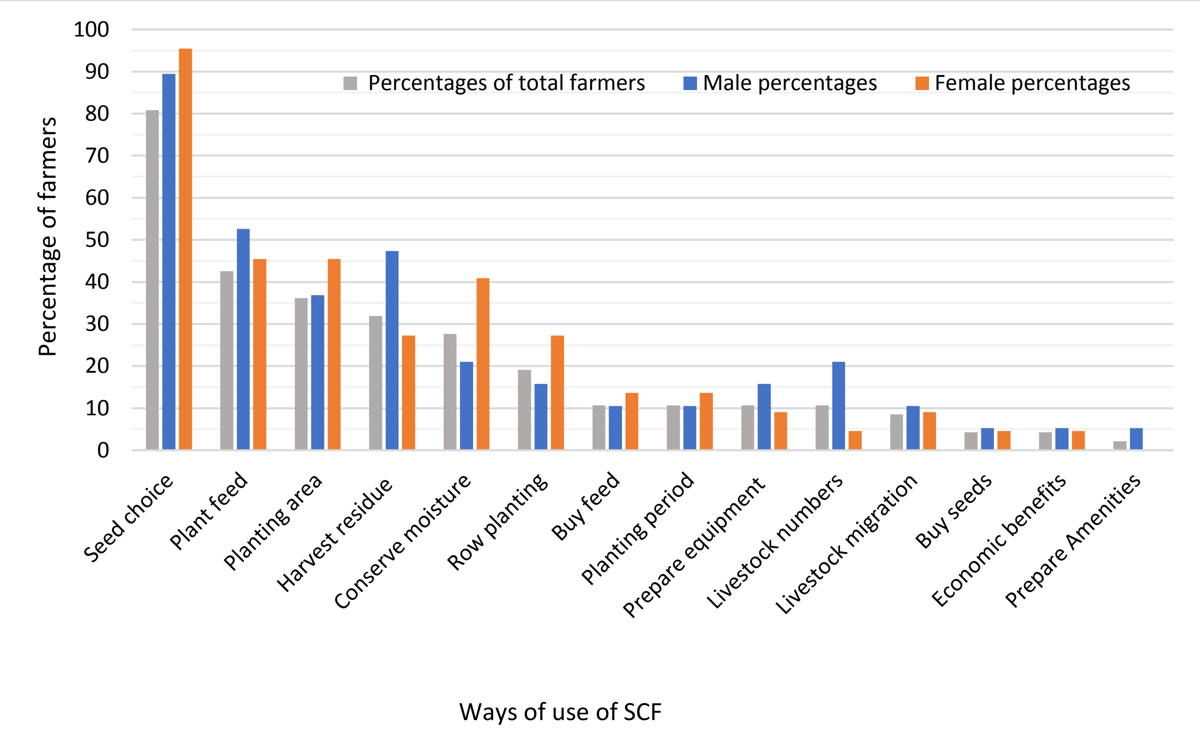

Figure 9. Percentage of total farmers' way of using the seasonal climate forecasts shown by whole bar (blue bar is male percentage of total and orange bar is female percentage of total while numbers in each bar indicate male and female group percentages)

Gender analysis also shows that seed choice has the highest frequency for both male (89.5%) and female (95.5%) farmers (Table 3). Farmers mentioned that even though traditionally they

[6] The chi-squared test rejects the hypothesis that the overall use of SCF is dependent of gender at 95% significance level. From the test the calculated chi square value (0.03) was less than the chi-square tabulated (3.84).

planted a variety of crops in their farms, they used forecasts to select drought and heat tolerant crops or short maturity crops if there was less rainfall expected. They further elaborated that they used SCF to decide whether to plant maize extensively or limit its area as it require so much rain. For instance, one said, “I plant maize when a lot of rain is expected but I plant sorghum and beans when less rain is expected”. Planting lablab for livestock is one of the practices employed by farmers to complement grazing in drier periods.

Table 3. Different themes and illustrations on ways in which seasonal climate forecasts are applied by male and female users

	MALES		**FEMALES**	
Theme	**n**	**Illustrative Quotation**	**n**	**Illustrative Quotation**
Seed choice	17	“When less rainfall is forecast, I plant tolerant crops like sorghum, beans, melons and plant less maize as it requires more rain.” “I plant early maturing crops when less rain is expected.” “I plant maize when a lot of rain is expected but I plant sorghum and bean when less rain is expected.”	21	“I don’t plant maize but plant sorghum and beans when less rain is expected because they can withstand the heat.” “I use it to choose short variety seeds that can withstand short rainfall season like a type of short sorghum that doesn’t grow tall, instead of the tall one which takes a long time to reach harvest maturity.” “I plant drought resistant crops when less rain is expected but when more rain expected I plant even maize and a variety of other crops.”
Plant livestock feed	10	“I plant lablab because our area does not have much grazing and I also store it to later grind it and feed livestock.”	10	“I also plant livestock feed for my livestock and even sell for government small stock programs.” “I plant feed for my livestock like lablab and store it so that when there is no grazing I feed them.”
Planting Area	7	“I plant the whole farm when the season is predicted to be a wet one unlike when it is dry season where my planting area would be determined by availability of soil moisture.” “We reduce the size of hectares for maize if less rain is expected but if it is a wet season I increase the size.”	10	“I decide on the size of the farm to plant based on the forecast; I plant a smaller area when less rain is forecast and only increase the size or plant the whole farm when more rain is expected.” “I plant maize in small area when low rainfall is expected as it need more rain. When more rainfall expected is expected I increase area for maize.”
Harvest plant residue as livestock feed	9	“I harvest the crop remains and store it so that when the grazing situation becomes bad I grind the remains and mix with lablab and feed my livestock.” “I harvest the crop remains and store to give to livestock during drought.”	6	“I harvest plant residue and store it for my livestock to feed them during dry period.”
Conserve moisture by managing Tillage	4	“I till or turn the soil so that when the first rain comes moisture is conserved and also there is no run-off.”	9	“I use it to prepare my farm in order to conserve available moisture from the first rains when less rain is expected in the season.” “I use the few drops to plant during the year that less rain is expected and I quicken my planting to take advantage of the moisture. Unlike during a wet season when I can just plant slowly knowing that the moisture will always be available.”
Row planting	3	“We have now started row planting and no longer broadcast seeds and	6	“I practice raw planting for plants to grow fast and for me to remove weeds easily.”

		one advantage is that it makes weeding very fast and also helps conserve moisture as rain is collected in farrows and penetrate the soil."		"I practice row plant my farm because row planting conserves moisture and it also produces a better harvest."
Buy supplementary feed	2	"I buy livestock feed and nutrient supplements to give to my livestock."	3	"I buy nutrient salts to mix with stored feed and feed cattle when there is no grazing." "I buy other feed (*lesereng*) and store it so that when there is no grazing I feed them."
Change planting period	2	"I plant my farm intermittently as it rains and avoid the risk of planting all at once only to lose my crops to the heat. Even where some earlier crops have wilted I can replant them during the season. In the past we used to plant crops all at once in the whole farm and that is risky."	3	"I decide which seeds to plant first or later in the season depending on the seasonal forecast. If less rains are expected, I use the first rain to plant and don't wait for subsequent rains."
Preparation of equipment	3	"I prepare the farming equipment and repair it knowing I will use it non- stop when a wet season is expected." "It helps me prepare for farm equipment before to get ready before rain starts."	2	"I prepare my farm and farming equipment to get it ready for the first drops."
Managing livestock numbers	4	"I constantly reduce my livestock numbers especially the older livestock so that I only keep numbers I can feed." "I sell some of my livestock when a dry season is expected so that when drought comes I remain with just a few ….." "…I only keep the numbers I can manage, unlike traditional where livestock of up to 200 was kept for prestige."	1	"I sell cattle when less rain is expected and leave manageable numbers, but goats can survive by eating trees."
Livestock migration	2	The forecast helps me migrate livestock to better grazing areas.	2	I usually take my livestock to where there is rain if it skipped my area. I take my livestock to where grazing is better in the sub-district.
Buy seeds	1	"Other preparations can be buying seeds to complement what I have."	1	"I use it to buy seeds and supplement government seeds supplies."
Economic benefits	1	"I intend to sell some of the feed and If a lot of rainfall is expected I plant a variety of crops extensively to sell and make money."	1	"I also plant livestock feed and even sell for government small stock programs."
Small Stock Amenities Preparation	1	"I use it to prepare shelter, heating equipment, for my chicks to protect them from adverse weather that comes along with seasonal forecasts."	0	-
Abandon crop farming	1	"When low rainfall is expected like last season I intend on abandoning crop farming in that season and focus on livestock feeds to maintain my livestock."	0	-

The results also show that a greater proportion of female farmers (66.7%) than male farmers (50.7%) actively use the seasonal forecast for decision-making in arable farming such as seed choice, determining planting area, row planting, conserving moisture and changing planting period. On the other hand, a higher percentage of males (41.8%) than females (29.3%) focused on using SCF in livestock-keeping activities like planting livestock feed, harvesting plant residues for livestock feed and managing livestock numbers. The percentage of males engaged in equipment preparation (7.5%) is slightly greater than their female counterparts (4%). One farmer said, "I prepare the farming equipment and repair it knowing that I will use it non-stop when a wet season is expected" (Table 3).

This study revealed that the bulk of farmers in Bobirwa sub-district incorporated SCF in their decision-making. This could be because most farmers found forecasts credible to apply in their farming practices. The main application of SCF to choose seed variety and determine planting area are consistent with the findings by Vogel (2000) and Ziervogel et al. (2006) in rural South Africa, that small-scale farmers use SCF to determine planting time and area as well as plant a variety of crops. It is also found that farmers in Namibia, Tanzania and Burkina Faso usually use the forecasts to alter planting dates, determine planting area and select crop types (O'Brien et al., 2000, Ingram et al., 2002; Roncoli et al., 2009). Additionally, in Tanzania, changing crop location to planting on highland or lowland was the most common decision taken by farmers in response to SCF (O'Brien et al., 2000). Making seed choices resonated well with farmers as traditionally they plant a variety of crops on one farm to minimise risks (Gibberd et al., 1995; Lemos et al., 2002; Patt & Gwata, 2002). Seed selection could be a much easier option for Bobirwa farmers, as they get seed rations from the government ISPAAD programme, unlike other decisions which are resource-intensive, like moisture conservation. This is confirmed by Vogel (2000), who found that in South Africa financial constraints limit rural small-scale farmers from effectively applying SCF, which will be discussed further in section 5.5.2.

Similar to Bobirwa farmers, farmers in Burkina Faso practise soil and water conservation methods and intensive land preparation such as contouring and ploughing to enhance permeation of water into their clayey farms (Roncoli et al., 2009). Another use of SCF in Namibia and Tanzania is being equipped for emergencies by storing harvests to cater for low productivity periods (O'Brien et al., 2000). However, unlike in Namibia and Tanzania, Bobirwa farmers emphasised livestock feed storage of plant residues or planting lablab to feed livestock during dry periods. This also happens in Burkina Faso, as few farmers harvest and store fodder for expected dry seasons (Ingram et al., 2002; Roncoli et al., 2009). In Bobirwa, similar to North West Province in South Africa, planting feed was more popular than reduction of livestock herds because traditionally farmers were reluctant to reduce livestock numbers for economic and socio-cultural reasons (McLeod, 1992; Hansen et al., 2011; Mogotsi et al., 2011a). However, for Bobirwa, FMD and drought have changed trends by reducing the number of cattle, whereas the number of goats increased (McLeod, 1992; Mogotsi et al., 2011c).

In Tanzania, women could not make crop farming decisions like planting dates without the consent of men in the households, hence limiting them from effectively utilising SCF (O'Brien et al., 2000). This contradicts Bobirwa findings, where women use SCF as much as men. This finding is linked to traditional roles of men and women and the need for SCF in those roles. The traditional role of women in rural households in Botswana, is to oversee crop production. Crop production depends on seasonal rainfall. This motivates women to use SCF. According to this study, both men and women indicated that in a household, the authority to make decisions on crop production like seed choices and planting area lies in the purview of women whereas livestock production decisions are men’s domain. Malope and Batisani (2008) found that more women in rural areas practise arable farming than pastoral farming. Factors inhibiting women from pastoral farming include limited access to productive resources, male-dominated traditional practices and customary laws (Malope and Batisani, 2008). Despite, constraints for women in pastoral farming, women in Bobirwa, unlike in Tanzania, can exercise this delegated authority in crop production to make decisions after accessing SCF. The packaging of SCF information also promotes crop production response actions. Ziervogel (2004) recognised that there are limited interventions for optimal livestock production with regards to SCF as compared to crop production. Therefore, this could explain the active use of SCF by women in Bobirwa[7].

[7] The study shows that a higher percentage of women use SCF for arable farming more than men. However, the chi-square test renders this finding statistically insignificant at 95% level of significance. From the test, the calculated chi square value (3.80) was less than the chi-square tabulated (3.84).

Conversely, the men's role and jurisdiction in Botswana's traditional households of livestock management require expanded information beyond what current SCF offer. Luseno et al. (2003) argue that pastoralists find SCF of little use because they desire rainfall onset date and total rainfall at local scale; however, the present SCF scale resolution is too large and the information contained is focused on crop production rather than livestock. Migration of livestock to better pastures across the Bobirwa sub-district was an important livestock management decision for farmers. Roncoli et al. (2009) stated that many livestock management decisions are an aftermath of rain because livestock is migrated towards water and pastures. Moreover, Gibberd et al. (1995) mentioned that reliable SCF is crucial for stocking and destocking livestock for managing numbers protection of gazing areas as well as provision of livestock feed. Furthermore, it is underscored that spatial scale detail could benefit livestock owners who want to move their livestock to potentially better areas across the region (Gibberd et al., 1995).

To sum up, Bobirwa farmers largely use SCF they receive in their decision-making for crop and livestock production. Credibility and accessibility of SCF to farmers could be the main factors influencing the use of SCF by Bobirwa farmers. It can be said that the credibility of SCF largely influenced farmers to become either users or non-users of SCF, hence it determined the uptake of SCF. Although the large scale of SCF is highlighted as the major problem of SCF even by users of SCF, it has not prevented the use of SCF by farmers in their agricultural practices. This could be because farmers have devised ways of dealing with the limitation of scale in SCF as discussed in section 5.6 and 5.6.1.

5.4.2 Farming decision-making for non-users of seasonal climate forecasts

It is noteworthy that among the six non-users of SCF, made up of three farmers from each gender group, five did not trust SCF while only one man partly trusted them. Contributing factors for lack of trust were inaccuracy of SCF (4), lack of understanding of SCF (1), being misled on crops to plant (1), climate variabilities not captured in SCF (3), use of traditional practices (1), and 'God is rainmaker' (1). Presenting the results according to gender, female non-users reasons were spread as one of each of the above reasons except climate variabilities, while all men cited both inaccuracy of forecast and climate variabilities as reasons for mistrust. Only one man gave 'God as rainmaker' as reason for distrusting SCF.

When asked what they used to guide their farming practices, the non-users stated that their methods of planting were to diversify crops (5) and prepare farming equipment (1) before the rain season commenced, as it was the traditional norm to do so (Table 4). One man stressed that since he did not rely on SCF, preparing equipment well before the rainfall season was key to making use of the first rains. Diversifying crops is a popular traditional practice among non-users. One farmer said, "Traditionally I plant every year no matter what the forecast says and I plant a variety of crops by assessing my farm, seeing what is appropriate and depending on what seeds I have … for example, I never miss planting sorghum and maize as they are our staple food." There were no distinct gender differences in the way non-users made farming decisions except that preparation of equipment was stated by a male, and additional to traditional planting practice, row planting was mentioned by only one female. The woman was quoted as saying "I no longer broadcast seeds but use sophisticated row planting. I don't use the forecast even when I hear it".

Table 4. Ways of planting applied by non-users of seasonal climate forecasts in their farming practices

		MALES		**FEMALES**	
Theme category	**Theme**	**N**	**Illustrative Quotation**	**n**	**Illustrative Quotation**
Traditional Planting	Diversifying crops	2	"Traditionally I plant every year no matter what the forecast says and I plant a variety of crops by assessing my farm, seeing what is appropriate and depending on what seeds I have…. for example, I never miss planting sorghum and maize as they are our staple food."	3	"I diversify crops and apportion them in my farm." "I plant several crops in the farm but plant maize at a later stage."
	Preparation of equipment	1	"I am always prepared and have equipment ready so that when it starts raining I plant and I always get ready no matter what the forecast says."	0	-
Government Programme	Row planting	0	-	1	"I no longer broadcast seeds but use sophisticated row planting but I don't use the forecast even when I hear it."

Supplementary to the cropping practices presented above, the six non-users of SCF generally used local knowledge to make their farming decisions (Table 5). They pointed out that they used their farming experience derived from the traditional way of planting and traditional forecasting methods. Additionally, three of the farmers used this local knowledge in faith that

God would provide rain. One farmer declared, “I personally just observe the atmosphere and clouds myself to figure out if rain is coming or not. Like this year there are pregnant clouds persisting this winter which is not common; it looks like this coming season God will bless us with a good season”. The non-users also stated that traditionally when the rainfall season started they went to the farm so that “when the cloud thunders”, signifying the first rains, they started planting their crops.

Table 5. Different methods used by male and female non-users of seasonal climate forecasts to make farming decisions

		MALES		FEMALES	
Theme Category	**Theme**	**n**	**Illustrative Quotation**	**n**	**Illustrative Quotation**
Local knowledge	Farming experience from tradition	2	“As a farmer my virtue is I plant every year irrespective of the forecast because farming is our way of life, when the rain comes I am busy preparing my field to plant.”	3	“I end up farming the traditional way where I just plant every year no matter what the forecast says.” “I am not familiar and I don’t understand this SCF because what I do traditionally, is that at the start of the season when the cloud thunders we go to plant.”
	Traditional forecasts	2	“I personally just observe the atmosphere and clouds myself to figure out if rain is coming or not, like this year there are pregnant clouds persisting this winter which is not common, it looks like this coming year God will bless us with a good season.” “Seasonal forecasts use technology to look ahead, I also use traditional indicators like flowering of trees to see how the season will be like.”	2	“I use traditional forecasts because I don’t trust the seasonal forecasts so I use traditional forecasts by observing trees.” “I use traditional way by just observing flowering of trees and knowing it will soon rain.”
	Trust in God	2	“When I plant I trust in God even when the forecast says there is no rain I tell myself only God knows and may bless us with rain, by the time it rains I am busy planting.”	1	“I don’t use the forecast I just trust in God because He knows everything and is creator of everything.”

Analysing the non-users in Bobirwa, it can be said that the main reason for non-use of SCF has to do with credibility. The findings from this percentage of respondents correlate with literature on credibility as a constraint to uptake and use of SCF and as discussed in section 5.3. Furthermore, in Brazil, the majority of farmers in Ceará rejected SCF and did not make farming decisions based on the forecasts, mainly because they perceived them as inaccurate (Lemos et al., 2002). Although the forecast accuracy is an important factor, Dilling and Lemos (2011) say that the forecast skill does not translate into increased SCF usage as government policy programmes may influence usage more than skill. This is also expressed by Kolawole et al. (2014), that in Botswana, government programmes to promote food security encourage farmers to plant using first rains despite the forecasts. This is because the government is committed to fulfil specific objectives for agriculture such as increasing the contribution of agriculture to the economy (Kolawole et al., 2014). It is noted by Lemos et al. (2002) that Ceará farmers' understanding in the probabilistic forecast is low, resulting in the forecasts being regarded as incorrect. This is similar to the case of one female farmer in Bobirwa who expressed lack of understanding of SCF. Although scale was also picked by few non-users as SCF limitation, this study reveals that for non-users in Bobirwa, lack of credibility is the main hindrance to uptake of SCF.

The non-use of SCF by farmers in Bobirwa is also related to dependency on the familiar local knowledge which encompasses traditional forecasts, religious practices and farming experience. Lemos et al. (2002) highlighted that besides mistrust of SCF, cultural practices and values contribute to how communities view the forecast. For example, Lemos et al. (2002) stated that community members in Ceará have more faith in nature controlled by God than in the science and human ability to predict it, which was also professed by some non-users in Bobirwa. Farmers in Ceará and Burkina Faso placed high value on locally produced forecasts by local experts or prophets because they are perceived as more reliable and widely available than SCF (Lemos et al., 2002; Roncoli et al., 2002). In Bobirwa's case, resorting to planting with faith in God among farmers, is propelled by a nationwide religious practice of praying for rain in September. The religious practice is institutionalised, also initiated from the President's office and cascaded to local communities where prayers for rain take place regularly at the *kgotla* and various community assemblies. A local newspaper article highlighted that prayers are a realization, as beseeched by President Ian Khama for the nation to pray for rain in September, the earmarked month of prayer (*Sunday Standard*, 22 September 2013). The President himself concluded his Botswana 50th Independence celebration speech, on 30 September 2016, with a prayer for rain quoted by the *Monitor* (3 October 2016), "Dear Lord, we celebrate our people, your people … As we cast our eyes to the blue skies, we pray for rain from up there to fall and cause blue water to flow down here ... Amen".

Farmers' traditional practice to plant every year during the start of the rainy season, prepare equipment and diversify seeds in the farm, was also stipulated in literature as a popular practice among subsistence farmers (Gibberd et al., 1995; Vogel, 2000; Lemos et al., 2002; Kolawole et al., 2014). This also happens in Zimbabwe, where farmers acquire seeds from external sources and plant similar seed varieties annually (Patt & Gwata, 2002). As specified by non-users in this study, Lemos et al. (2002) also noted that in Ceará, the availability of traditional forecasts results in incorporation for decision-making because farmers normally practise traditional planting. This traditional planting is also a precautionary method to minimise risks and maximise crop production as some annual seeds selected are drought-tolerant and early maturing, but with low outputs, while others may thrive in moisture and mature later with high productivity (Lemos et al., 2002).

5.4.3 Consequences of using seasonal climate forecasts

When enquiring on the benefits of use of SCF, less than half of the users (48.8%) indicated to have benefited from using SCF. The frequent benefits mentioned were increased harvests (59.1%), followed by provision of warnings (31.8%) and reduced losses in investment (9.1%). Farmers mentioned that they had used the forecast for wet years and had made bumper harvests. Moreover, during dry years they used the forecast to plant suitable crop varieties at an appropriate time and still made sufficient harvests that made them food-secure (Table 6). Gender group analysis displays that a higher proportion of males (57.9%) benefited from SCF than females (40.9%). Women largely mentioned that they benefited from getting early warnings while men mostly indicated getting tangible benefits of harvest (Table 6). Furthermore, women used SCF as warning tools in crop production, although they decided to plant crops even when a dry season was expected because they believed that a below-normal rainfall forecast should not be an excuse not to produce food. However, the few men who benefited from using SCF as a warning guide made decisions in livestock management, whether to stock or destock. Regarding the benefit of reduced losses in investment, farmers explained that they did not make much loss in their agricultural investment when using SCF as compared to when not using SCF. One woman mentioned, “I don’t lose much money in planting huge lands when there is no rain these days ...”. During the interviews, it was noted that not all farmers could give a response to the question on the benefits of using SCF, and for some, it took some time to remember what they had gained from past seasons of using SCF.

Table 6. Benefits of the use of seasonal climate forecasts by males and females in making farming decisions

	MALES		FEMALES	
Theme	**n**	**Illustrative Quotation**	**n**	**Illustrative Quotation**
Gained Harvest	9	"I once followed the forecast and it said there was less rain expected and I planted a lot of sorghum and melons and didn't plant maize. So I made bumper harvests and sold quite a lot." "I once used the forecast in one wet year and made a harvest and I was happy as I want food."	4	"Now when I plant using the forecast I make a harvest enough I can survive with." "I remember during one wet year I listened to the forecast and made a big harvest. Even this season I didn't plant much at the beginning of season so I harvested few bags at least."
Early warning	2	"It warns farmers because I can decide whether to sell livestock or not."	5	"The forecast warns us because it is guidance but it doesn't say don't plant at all when less rains are expected"
Reduced losses in investment	1	"I realise that when I use the forecast even though it can be a bit inaccurate but I don't make much losses than when I don't use it."	1	"I don't lose much money in planting huge lands when there is no rain these days. In 2014, I refused to use it and lost all my crops."

On investigating the disadvantages of using SCF in the past, farmers popularly reported lost harvest and crops (59.3%), lost planting opportunity (37%) and missed opportunity to benefit from the government programme (3.7%). Of farmers who had ever used the forecast, only 25.6% mentioned being disadvantaged from using SCF. Most of the farmers complained that in the immediate past season, they had planted using SCF that gave the likelihood of less rain, hence they planted early to take advantage of first rains. However, the dry period was prolonged until February when it rained plentifully but their crops had already died (Table 7). They said only those who had planted late in the season made harvests. A higher percentage of women (34.8%) were more disadvantaged than males (15%) in their past use of SCF.

Table 7. Disadvantages of the use of seasonal climate forecasts mentioned by males and females in making farming decisions

	MALES		FEMALES	
Theme	**n**	**Illustrative Quotation**	**N**	**Illustrative Quotation**
Lost harvest and crops	11	"This past season I planted lablab and melons early in the season but the melons wilted and I lost because it only rained late in the season. I only harvested a bit of lablab." "I lost my harvest this year and many other farmers in the village because it was so dry, even the drought tolerant crops like beans and resistant sorghum died. This is so unusual as	5	"I started planting with the early rains to take advantage of available moisture but it became dry for a long time so I lost my crops but those who planted later got harvests."

		we have never seen anything like this."		
Lost planting opportunity	6	"Many farmers including myself lost planting opportunity in January and February as we did not anticipate it to rain as we followed the forecast. Those who planted late in the season made harvests."	4	"This year we were told less rain is expected so I didn't plant much but it rained a lot later in the season around February and those who planted extensively despite the forecast got big harvests which I missed out on because of the forecast."
Missed government programmes	0	-	1	"I missed out on government programmes as they were stopped because of the forecast and we could not benefit from the programmes this year and missed."

Analysing the above results, farmers' limited memory of the benefits of using SCF is equivalent to literature that currently states that the benefits of using SCF are difficult to gauge as farmers have recently started using SCF (O'Brien et al., 2000; Ziervogel et al., 2006; Hansen, 2002). Roudier et al. (2014) argues that the recorded benefits are modelled, hence theoretical, which calls for empirical assessments on benefits of use of SCF to farmers. Meza et al. (2008) concluded that there are benefits to the use of SCF but there is uncertainty in terms of average income and value of production.

The proportion of Bobirwa farmers who mentioned benefits of increased harvests and minimised losses is consistent with a few documented studies conducted in Africa and the rest of the world (Gibberd et al., 1995; Goddard et al., 2001; Churi et al., 2012; Roudier et al., 2014). In Tanzania, the receipt of SCF resulted in farmers reaching their aspirations, including better income and food security (Churi et al., 2012). In Senegal, the use of SCF by farmers resulted in increased crop yields and reduced losses (Roudier et al., 2014). However, Roudier et al. (2014) illustrated that increased crop yield occurred when farmers intensified production and applied various management strategies. The benefit of SCF as an important component of an early warning system for drought is mentioned by Gibberd et al. (1995). The gender disparities of few women experiencing benefits could be linked to them mostly using SCF for crop farming, which is more susceptible to climate variabilities than livestock. This is because Botswana's dry climate and variability is more favourable for livestock production than crop production (Nsoso et al. 2010; Mogotsi et al., 2011b).

The disadvantages professed by Bobirwa farmers are also captured in literature, as possible outcomes of using SCF. Ingram et al. (2002) state that less credible forecasts could cause a loss in resources, exacerbate poverty and put life at risk. It is also evident among Bobirwa women that the limitations of SCF, particularly lack of rainfall distribution, impact them negatively. The women who are larger users of SCF but benefit less, are more disadvantaged from the use of SCF than their male counterparts. Apart from women taking up riskier crop farming, it could be that over and above SCF, men apply more risk strategies, use economic information and have greater capacity than women. For instance, Ziervogel et al. (2006) state that in Limpopo Province, South Africa, even though women are conscious of the market they apportion plant production between market and household consumption but with greater focus on household consumption than men. Omari (2010) also mentioned that women are burdened with maternal and care-giving roles, making them more vulnerable to climate variabilities. It is also mentioned that the use of SCF in Africa to change crop management decisions, such as crop varieties and changes in planting dates, when solely used without intensification of crop production, may result either in loss or gain of yield (Roudier et al., 2014). Furthermore, Roudier et al. (2014) elaborate that low yields tend to occur when false SCF coincide with dry years. This means that farmers are caught unprepared for an adverse dry climate. Therefore, Roudier et al. (2014) reiterate that the accuracy of SCF, translated to credibility, is important to avoid making farmers more vulnerable.

5.5 Factors constraining the use of seasonal climate forecasts in decision-making

The SCF limitations and barriers to effective use of SCF are discussed in the following sub-sections. Dilling and Lemos (2011) noted that although the use of SCF has recently increased, there are still numerous constraints which hamper their exhaustive use.

5.5.1 Limitations of seasonal climate forecasts

In this study farmers gave numerous limitations of SCF, such as broad spatial scale, poor temporal rainfall distribution, technology limitation[8], low-quality product, inaccurate SCF, human limitation, variations not captured by SCF, and no information on onset of rainfall (Figure 10). The most complained-about limitation was the broad geographical scale of the

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[8] Technology limitation refers to limited technology capacity to produce credible and relevant forecasts. This could be the knowledge of using various modelling techniques and, computing and observation infrastructure to generate SCF. The challenges facing NMSs in Africa fall are under the umbrella of technology, including the difficulty to operate the technology designed for conditions in the developed world, limited capacity to procure, use and maintain the technology needed to produce credible weather and climate information (Snow et al., 2016).

forecasts mentioned by 53.2% of the farmers. They said the SCF did not depict specific areas because when the actual rain comes it omits other areas. They explained that this leaves a grey area, making it difficult for them to take appropriate decisions as they did not know exactly how it would rain in the season. One female farmer said, “The forecast doesn’t specify areas where it will rain, so we end up making assumptions that it will also rain in Bobonong area”, while a male farmer mentioned that, “the forecast does not give me enough information on where exactly in Bobirwa it will rain, it just generalises the Central district. But when it rains and doesn’t reach my area it is a loss because as farmers we will be ready and have deployed resources expecting rain in our area only for it to rain in other areas” (Table 8). There were no significant gender disparities on spatial limitation.

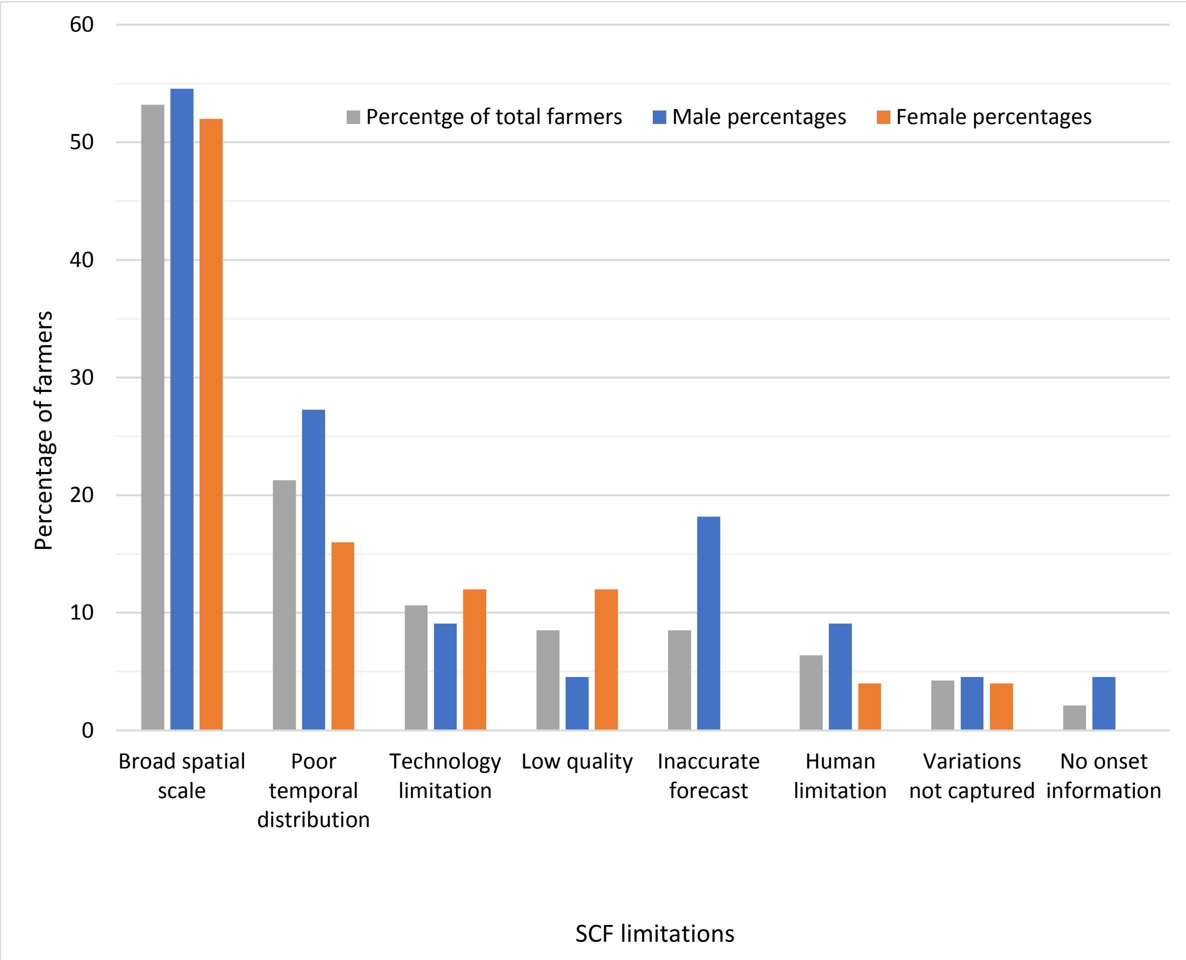

Figure 10. Limitations of seasonal climate forecasts that constrain their effectiveness (whole bar shows percentage of farmers, blue bar is male percentage of total and orange bar is female percentage of total while numbers in each bar indicate male and female group percentages)

The second most frequently limitation mentioned is poor temporal rainfall distribution (21.3%). However, the male group percentage (27.3 %) was slightly higher than females (16%). The farmers criticised the SCF for not showing how it would rain within the season, the dry months and wet months. They gave an example of the past season in that although below-normal rainfall was expected, it rained well at the start of the season and was dry the rest of the season until the very end of the season when it rained heavily. This pattern, they said, is deceiving because they become hopeful and waste seeds on the first rain. One man said, “The forecast doesn’t explain which months exactly it will rain and we want to know when it will rain and when it will be dry. If January will be dry, let the forecast state so” (Table 8). According to the results, poor spatial and temporal distribution as components of scale are the main limitations of SCF mentioned by farmers, depicting a frequency percentage of 64.8%. Low-quality product and inaccurate SCF, which are contributors of credibility, both accounted for a much lower percentage (14.8%) than scale. Additional limitations of SCF highlighted by farmers at much lower percentages were human limitation, technology limitation, variations not captured by SCF, and lack of information on onset of rainfall.

Table 8. Limitations of seasonal climate forecasts for male and female respondents

Theme Category	**Theme**	**MALES**		**FEMALES**	
		n	**Illustrative Quotation**	**n**	**Illustrative Quotation**
Scale	Broad spatial scale	12	“The forecast does not give me enough information on where exactly in Bobirwa it will rain, it just generalises the Central district but when it rains and doesn’t reach my area it is a loss because as farmers we will be ready and have deployed resources expecting that it will rain in our area only for it to rain in other areas.”	13	“It covers broad areas but it should explain where it will rain exactly so that we are informed of where the rain will cover.” “The forecast uses large area and our area could be skipped by rainfall.” “The forecast does not tell exactly where it will rain but as farmers when making preparations, we need to be sure that when it rains it will rain in our area and not in a neighbouring village.”
	Poor temporal rainfall distribution	6	“It doesn’t explain when it will rain exactly like last year it rained very late.” “The mentioning the onset and not showing rain distribution within the season it is a problem because we might end up wasting our seeds by	4	“The distribution is not elaborated by the forecast like last year it ended raining sufficiently in one month but the overall season had less rainfall.” “The rainfall could be poorly distributed but when it first rains it is deceiving and I plant, only for the rain to go for good.”

			planting in the months when there is no rain." "The forecast doesn't explain which months exactly it will rain and we want to know when it will rain and when it will be dry. If January will be dry let the forecast state so."		
Credibility	Inaccurate forecast	4	"Sometimes the forecast will say rain is coming and the farmers will heed to the forecast and get their ration seeds and prepare farming equipment and it doesn't rain." "The forecast alternates between wrong and correct."	0	-
	Low quality product	1	"The quality of the forecast is still unsatisfactory."	3	"The quality makes us end up saying SCF doesn't tell the truth and it makes us uncertain."
Capacity	Technology limitation	2	"Technology used to forecast also has its own limitations."	3	"There is need to improve the equipment for them to show specific sides of Bobirwa (North, south, east, west) where it will rain."
	Human limitation	2	"No one can entirely predict the rainfall to accuracy especially how it will be distributed over the season because rain is from God."	1	"The forecasters are not God they can't get everything right."
Climate variability and change	Variations not captured	1	"Seasons have changed and making prediction difficult and confusing for those doing the forecasts."	1	"Rainfall season have shifted to later so if one plants early it becomes a problem. Now it rains around January to February in our farm area."
	Lack of information on onset of rainfall	1	"Traditionally we are used to rain starting in September and that is when we start ploughing but now it can come as late as November."	0	-

Scale as the main limitation of SCF in Bobirwa is consistent with what was found in other studies conducted in Africa and around the world (Lemos et al., 2002; Patt & Gwata, 2002; Luseno et al., 2003; Ziervogel & Calder, 2003; Ziervogel, 2004; Mogotsi et al., 2011b; Dilling & Lemos, 2011). Regarding spatial scale limitation, Ziervogel (2003) concluded that it emanates from incomplete knowledge on the physical atmosphere. Studies in Botswana and the Horn of Africa found that SCF are produced on a large scale and neglect spatial rainfall variations required by farmers in their localities (Luseno et al., 2003; Mogotsi et al., 2011b). Luseno et al. (2003) explain that the low spatial resolution of SCF limit farmers because they rely on detailed spatial data for extensive grazing systems to organise livestock migration. However, Marshall et al. (2011) found that graziers in Australia were interested in whether it would rain in their general area rather than directly over their farm.

The dissatisfaction of Bobirwa farmers with lack of temporal distribution in SCF as a limitation is also expressed by Ziervogel (2004), that farmers' view of SCF not being useful is due to lack of detail on commencement of rain and the number of rainy days in the season. This also coincides with the Burkina Faso study where farmers said cumulative seasonal rainfall in SCF had restricted their use, therefore useful SCF should include rainfall duration and distribution within the season (Ingram et al., 2002). Thus, according to Ingram et al. (2002) and Mogotsi et al. (2011b), vital SCF information needed by farmers for its better use, is onset and cessation of rainfall, dry spells, rainfall distribution and total distribution. On the other hand, Patt and Gwata (2002) noted that resolving temporal rainfall distribution limitation could result in a useless skill; hence farmers should be alerted of this challenge. Despite SCF scale being the most mentioned limitation by Bobirwa farmers, it did not hinder them from taking up and using SCF but rather, limited SCF usability in decision-making and agricultural practices.

In this study credibility limitation, which is depicted as inaccurate SCF and low-quality product, is mentioned by a handful of Bobirwa farmers, particularly non-users (as also discussed in section 5.3 and 5.4.2) as aligning with previous studies on a constraint to the uptake of SCF (Gibberd et al., 1995; Lemos et al., 2002; Patt & Gwata, 2002, Ziervogel, 2004, Ziervogel & Downing, 2004; Crane et al., 2010; Marshall et al., 2011). The human and technological capacity limitations brought up by Bobirwa farmers, although at lower percentages, also contribute to scale and credibility limitations. Human and technological capacities are reflected in literature as requirements for the production of credible and relevant forecasts (Cash et al., 2002; Ziervogel & Downing, 2004). In summary it can be stated that credibility is not a major limitation to Bobirwa farmers' use of SCF, but scale is a limitation. However, (as discussed in 5.4.2) credibility is a major limitation for non-users of SCF, but when adding users, the issue of credibility is minimised and scale becomes a prominent limitation.

5.5.2 Barriers to effective use of seasonal climate forecasts

Farmers highlighted several barriers that hamper them from effectively using SCF. These can be broadly grouped into local beliefs and practices, agricultural services, economic, environmental and personal barriers (Table 9). It should be noted that these categorised barriers are used for the purpose of the study, but in reality, several barriers interact with one another at varying degrees to impact on farmers' decision-making and practices. Local beliefs and practices composed of passiveness caused by religion and late start of *letsema*, was the highest mentioned barrier (12) to use of SCF. The barrier was widespread among both men and women. Farmers professed that they will go ahead and plant crops even with full knowledge of a negative forecast because they trust God will change the situation as the creator of rain. Moreover, a woman cited a barrier of late celebration of cultural practice of *letsema* (a ceremony marking the start of the planting season and a time when the Chief declares the commencement of the planting to farmers). She explained that she could lose the planting opportunity if she secured equipment earlier than the ceremony because it is culturally unacceptable to start planting before the Chief's declaration. There were no apparent gender disparities regarding local beliefs and practices.

The next common barrier mentioned by farmers was shortage of farming equipment (7), which is an agricultural service. The service is provided in the sub-district by the MoA through the ISPAAD programme. Shortage of farming equipment can also be an economic barrier. Farmers pointed out that they plant late because they do not have resources to buy or rent private tractors, so have to line up for ISPAAD programme tractors. Some farmers mentioned that they still used donkeys, which were ineffective. One farmer said, "I planted very late because I don't have farming equipment, so I had to wait my turn for the tractors and by the time I secured it the moisture had evaporated". There were no gender differences on equipment as a barrier.

The economic barrier was mostly mentioned by male farmers, who complained of lack of markets for their agricultural produce, including livestock. They explained that even if they wanted to reduce livestock numbers in alignment with the forecast they could not do so because of limited markets to sell the livestock and farm produce. The other economic challenge is lack of communication equipment to get direct information about SCF for decision-making. One male farmer said, "The other limitation I have is that I don't have communication equipment like radio or TV to get information directly, so I depend on conversation with people for information."

Pests and soil types or landscape, which can be grouped as an environmental barrier, were also reported by farmers. Pests also were said to influence types of crops farmers choose to plant, as one farmer reported: “We plant drought-resistant sorghum – the problem was pests like birds as they are many and they like sorghum and ate all of it”. Other farmers say they prefer maize over sorghum and do not plant sorghum at all because of the problem of sorghum-eating birds. Farmers explained that Bobirwa is a red zone for FMD and has low market opportunities, which limits them from timely reducing livestock numbers in response to SCF. Therefore, FMD is both an environmental and economic barrier impeding effective use of SCF.

The final barrier highlighted by farmers is a personal barrier relating to old age, which limits their ability to use SCF efficiently, like planting lablab for livestock during drier years. One male farmer stated that planting feed for livestock in his old age was cumbersome, therefore his livestock relied solely on grazing.

Table 9. Barriers inhibiting the effective use of seasonal climate forecasts to improve livelihoods

Grouped Themes	**Theme**	**MALES**		**FEMALES**	
		n	**Illustrative Quotation**	**n**	**Illustrative Quotation**
Local beliefs and practices	Passive values caused by religion	5	“Rainfall is made by God so we don’t expect much details from the forecast.” “These things (rain) are made/controlled by God.”	5	“Rain is made by God.” “I also trust in God because he can change the situation anytime.”
	Late declaration of *letsema* by Chief	0	-	1	“Our cultural start of the planting season which also grants us permission to plant from the Chief, *letsema,* takes place very late. Even if I secure planting equipment earlier I cannot start planting because permission is not yet granted in our area.”
Agricultural Services	Lack of farming equipment	4	“I planted very late because I don’t have farming equipment so I had to wait my turn for the tractors and by the time I secured it the moisture had evaporated and so I didn’t harvest anything except for melons.”	3	“I would like to conserve moisture but I don’t because I don’t have equipment. I need assistance in acquiring better equipment to improve harvests as I still use donkeys to plough.” “I need rippers to loosen up the soil for moisture conservation.”
Economic	Lack of market to sell crops and livestock	6	“The other challenge is lack of market in our area for our harvests as we don’t have a Marketing Board to sell to when we had made plenty harvests.” “There is no market to sell our livestock to if the numbers exceed our management capacity. And while waiting to sell the livestock die of starvation.”	0	-

	Lack of communication equipment	1	"The other limitation I have is that I don't have a communication equipment like radio or TV to get information directly so I depend on conversation with people for information."	1	"I don't have communication equipment like TV to have access to the SCF."
Environmental	Pests destroy drought resistant crops	1	"Even when we plant drought resistant sorghum the problem is the pests like birds as they are many and they like sorghum and ate all of it."	1	"I tried to plant sorghum once back in 2009 but I stopped it then because of birds."
	Nature of soils and landscape	1	"Our landscape is not flat there are many rivers on our side which take up a lot of water which could have penetrated the soils in the farms."	1	"Part of my farm being loam soil is a challenge when less rain is expected because when it dries up it compacts and prevents water to penetrate the soil for moisture conservation so I can't use my normal tractor and plough."
Personal	Old Age	1	"Planting feed for livestock requires energy and I am challenged at my age so I don't plant feed. My livestock depend solely on grazing."	0	-

It is clear from this study that besides limitations of SCF, the use of SCF is also constrained by local beliefs and practices, agricultural services, economic, environmental and personal barriers, which have also been discovered by research in some other parts of Africa. Firstly, local beliefs and practices, particularly passiveness caused by religion which was a major barrier among Bobirwa farmers, was also influential in farmers' use of forecasts and decision-making in Tanzania and Namibia. O'Brien et al. (2000) found that in Tanzania farmers perceived rainfall as an Act of God, hence they were resistant to contest it by responding to SCF. In Namibia farmers questioned the ability of humans to forecast rainfall because they perceived it was God's prerogative to make it rain or change the situation despite the forecast (O'Brien et al., 2000). These findings are also comparable to those in Burkina Faso, Brazil and Southern Africa, where some farmers thought matters of nature (including rainfall) are God's territory and unknown to scientists, but prophets could make accurate forecasts (Gibbert et al., 1995; Roncoli et al., 2002; Lemos et al., 2002). It can be inferred that some cultural and social beliefs hinder the use of SCF and appropriate responses to climate variability making farmers vulnerable.

Lack of access of draught power which is delivered to Bobirwa farmers as an agricultural service through the ISPAAD programme is also a major constraint to optimum use of SCF across Africa. A study by Mogotsi et al. (2011b) in Bobirwa also established that there was a scarcity of tractors in the sub-district, resulting in prolonged waiting by farmers for ISPAAD programme tractor services. This has been exacerbated by Botswana's policy (ISPAAD) to provide free support for the first 5Ha (Mogotsi et al., 2011b; Simelton et al., 2013). Therefore, draught power is the utmost non-climatic impediment to arable farming in Botswana because it determines the area a farmer can plant and the timeliness of ploughing activities, but not necessarily farmers' decision-making (Oladele & Monkhei, 2008; Simelton et al., 2013). These findings from Botswana are compatible with case studies in Africa that agricultural technologies such as draft power restrict the capacity of farmers to respond to SCF (O'Brien et al., 2000; Ingram et al., 2002; Lemos et al., 2002; Roncoli et al., 2009). Consequently, lack of draught power prohibits farmers to plough in accordance with the seasonal forecasts and even use an opportunity of good rain periods within the season (O'Brien et al., 2000).

Various studies in Africa agree with the outcome of this study that economic constraints such as lack of resources, capital to purchase farming inputs, and lack of access to market and credit bar the full application of SCF in decision-making (Vogel, 2000; Ingram et al., 2002; Lemos et al., 2002; O'Brien et al., 2000; Ziervogel, 2006; Roncoli et al., 2009). Lack of draught power is also an economic barrier because farmers find tractors expensive and some resort to animal draught power which is considered more economical (Mogotsi et al., 2011b). Market constraint in Bobirwa is also limited by the fact that Bobirwa is a FMD risk area, hence farmers are left to the mercy of the small local butchery market with paltry payments (Mogotsi et al., 2011a). Household assets such as a radio to access SCF are also key determinants of the degree to which SCF will be applied in conjunction with other ranges of activities (Ziervogel & Calder, 2003). This agrees with two Bobirwa farmers who brought up communication equipment as a barrier to get first-hand information.

Personal and environmental barriers highlighted by Bobirwa farmers in smaller percentages are also consistent with other studies in Africa (Ingram, 2002; Roncoli et al., 2009). According to Ingram et al. (2002), farmers in Burkina Faso noted that short variety crops could be accustomed to short seasonal rains but need fertile soils and are more susceptible to weeds and pests than local varieties. Therefore, farmers may choose varieties not based on SCF but also environmental factors as in Bobirwa, where maize is chosen over sorghum because of its resistance to birds despite its vulnerability to dry spells (Mogotsi et al., 2011b;

Statistics Botswana, 2016). Lack of labour, as stated by an elderly farmer in Bobirwa, is also found to be a constraint to response of forecasts, particularly for poor households (Ingram et al., 2002). The labour constraint can also be categorised as an economic constraint because capital determines the mobilisation of labour for crop production, hence a larger constraint for poorer households. Moreover, the age range of above 56 years is an impediment to the use of SCF when manpower is needed to work on the farm, which makes poor households vulnerable because they may not be able to implement some coping strategies.

The above barriers can further be categorised in two types. Firstly, barriers caused by economic or human factors include local beliefs and practices, agricultural services, and economic barriers. These inhibit acting on SCF, but acquiring resources, provision of services and awareness could enhance response to SCF. The second category occurs naturally, namely environmental and personal barriers. They are difficult to overcome because they constrain response to SCF and result in a poor agricultural outcome even when farmers apply SCF. To sum up above constraints, farmers not only use forecasts but the decision-making is derived from a wide range of information considering biophysical, socio-economic, local, national experimental and normative variables (Roncoli et al., 2009; Crane et al., 2010). It can also be noted that the barriers to use of SCF do not exist in isolation but interact and form a complex dynamic system that makes decision-making in agricultural production a risky endeavour for farmers.

5.6 Ways of dealing with limitations of credibility and relevance of seasonal climate forecasts in decision-making

To overcome limitations of SCF among the 41 users of SCF a majority (88%) confirmed that they apply additional methods in conjunction with the SCF for complementarity, validation and comparison. Additional methods to SCF are traditional forecasts, farming experience, religious practice, MoA advice, markets and diversifying livelihoods (Figure 11) which are clustered into broad themes of local knowledge, scientific information and economic ventures (Table 10). Traditional forecasts are used by most the SCF users (53.7%). There were 50 mentions of methods made by users and 44% of them were traditional forecasts (Figure 11). They indicated using it to validate or complement the SCF. Those who stated traditional forecasts said they are familiar method and the indicators are readily available in their environment.

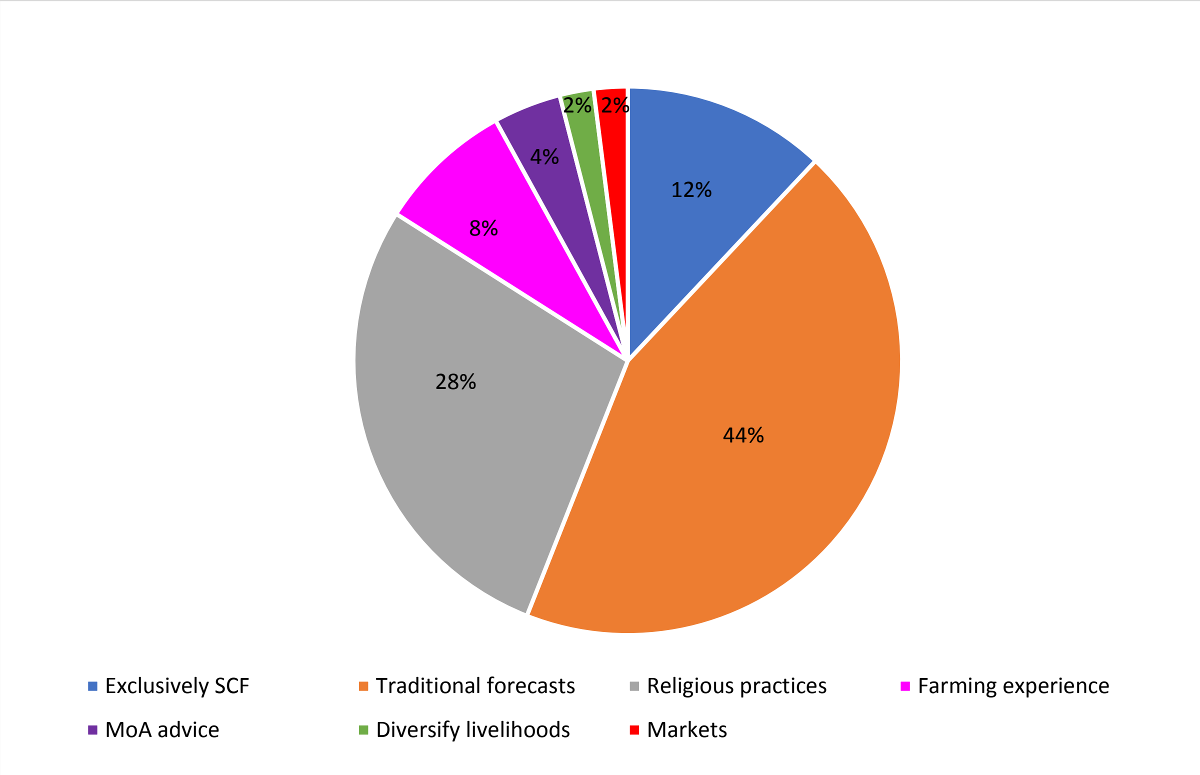

Figure 11. Percentage of exclusive use of seasonal climate forecasts and other methods used by farmers to overcome seasonal climate forecasts limitations

Men (63.6%) outnumber women (32%) in using traditional forecasts and other alternative methods to SCF (Table 10). This tallies with an earlier analysis (section 5.4) that a higher proportion of female farmers use seasonal forecast than their male counterparts. Hence men could be closing the gap of SCF limitations with alternative methods. The reasons for using traditional forecasts stated by both men and women was: “I complement the seasonal forecasts with traditional forecast” or “As I prepare my farm and start planting, I also look at the trees to see how the season is going to be like”. On the other hand, those who exclusively use SCF (12%) said the traditional method no longer works or they are not acquainted with using it. One female farmer stated, “I don’t use traditional forecasts because the changes in the atmosphere have disrupted them, hence the traditional forecasts are invalid”.

Farmers also mentioned that they use their knowledge acquired from long farming experience to overcome the limitations of SCF. Some said they do traditional farm and seeds preparation as standard practice. The religious practice of regular prayer sessions and trusting in God for rain was another method used by farmers (28%) (Figure 11). The practice is applied by both genders, reasoning that rain is made by God, so they pray and plant hoping for God's mercy to change the atmospheric condition to supersede the SCF. One of them said, "We usually gather at the *kgotla* every morning and pray for rain, trusting that maybe God will be merciful to us and give us rain".

From the results, more than three quarters of the time (80%), farmers in Bobirwa sub-district incorporate beliefs and local practices in their farming decision-making. Extension officers' advice is used by 4% of farmers. Male farmers also highlighted that they incorporate economic ventures (4%) in decision-making by considering what the markets dictate and also diversify livelihoods.

Table 10. Other methods used by farmers for decision-making

Theme Category	**Theme**	**MALES**		**FEMALES**	
		n	**Illustrative Quotation**	**n**	**Illustrative Quotation**
Local knowledge	Traditional forecasts	14	"As I prepare my farm I also look at the flowering trees and stars to determine what the season is going to be like." "I complement the seasonal forecast with traditional forecasts which I have been taught by elders how to observe it." "I sometimes observe the two stars but due to changes in patterns these indicators are confused and no longer trustworthy."	8	"As I prepare my farm and start planting I also look at the trees to see how the season is going to be like." "I also do my observations from traditional forecasts to compare with the seasonal forecast." "I also do some traditional forecasts (trees like *Mophane* and stars) and I combine the two forecasts."
	Religious practices	7	"We usually gather at the *kgotla* every morning and pray for rain trusting that may be God will be merciful to us and give us rain." "I trust in God because rain is from God."	7	"All things are created by God, I trust God because he made all things including rain." "I trust in God for rain as I plant because He can override the forecast and change the situation."
	Farming experience	3	"Use the skills I learnt as I practice farming." "I rely on what works for me and don't follow the forecast all the time. "	1	"We also end up making preparations for seeds and equipment as is the norm."

Scientific Information	MoA Advice	2	"I use the advice given by extension officers like keeping drought resistant livestock like Tswana breed instead, by storing the wilted crops for livestock."	0	-
	Exclusively SCF	2	"I don't use traditional forecasts because the changes in the atmosphere have disrupted them hence the traditional forecasts are invalid."	4	I don't use any traditional forecast or anything else because I was never exposed to them at an early age as I was working.
Economic ventures	Diversify livelihoods	1	"When my crops are wilting I find other ways making livelihood and finding other forms to survive on."	0	-
	Markets	1	"I also look at what the market dictates and use that information."	0	-

This study reveals that a majority of farmers in Bobirwa incorporate local knowledge in their farming decisions to overcome the limitation of credibility and scale encountered when using SCF. This is consistent with findings of Mogotsi et al. (2011b), that few households (36%) in Bobirwa use only traditional forecasts, but most of them use it simultaneously with SCF. The authors further explained that traditional indicators are used because of their availability and ability to cater for local scale whereas SCF fail to capture variations in rainfall within localities. Furthermore, traditional forecasts are deemed easy to use, farmers are accustomed to them and few perceive SCF as unreliable (Mogotsi et al., 2011b). Similarly, other studies across parts of Africa show that farmers combine SCF with traditional forecasts which they regard to be of high relevance to local scale (Roncoli et al., 2002; Luseno et al., 2003; Orlove et al., 2010; Dube et al., 2016). However, like Bobirwa farmers, in Burkina Faso a decline of confidence in local indicators due to climate variability was mentioned (Roncoli et al., 2002). This is the opposite of the Horn of Africa and Brazil where local forecasts are still given high credence because of their perceived accuracy and wider dissemination than SCF (Lemos et al., 2002; Luseno et al., 2003).

The religious practices of prayer sessions at public gatherings and trusting God is also one of ways used in Bobirwa to overcome the limitation of SCF. Strikingly, present-day prayers for rain as the dry season ends and the time for planting begins are almost unanimously adopted and have a long history of use as part of traditional religious beliefs in Botswana (Denbow & Thebe, 2006). Moreover, as discussed in section 5.4.2, the practice has been institutionalised in Botswana from national to local scales and even inspired by the President. Denbow and Phenyo (2006) explain that incantations for rain – "*Pula*", meaning "let it rain" – are usually made at the beginning and end of national and local *kgotla* assemblies. The practice is similar to what happens in Brazil, Uganda, Burkina Faso, and Namibia where farmers trust in God for rain (Lemos et al., 2002; Roncoli et al., 2002; Orlove et al., 2010; O'Brien et al., 2000). However, in Bobirwa the difference is that an intervention of prayer is made.

Farmers using extension officers' advice in Bobirwa is also mentioned in several parts of Africa where farmers use it together with local or scientific knowledge (O'Brien et al., 2000; Patt & Gwata, 2002; Roncoli et at., 2002; Davis, 2008). O'Brien et al. (2000) stated that in Tanzania a composite of meteorological forecasts and advice to farmers is often disseminated to reduce risks and make gains from forecast reports. Embarking on economic ventures entailing diversified livelihoods and market assessment by Bobirwa farmers as input information for decision-making agrees with several studies in Africa (Ingram et al., 2002; Ziervogel et al., 2006; Roncoli et al., 2009). In South Africa farmers pursue market priorities rather than relying solely on SCF, while some engage in alternative livelihoods to augment their farming income and have a food source in case crops fail (Ziervogel et al., 2006).

Overall, farmers in Bobirwa engage in various approaches, particularly local knowledge, to complement SCF and overcome its limitations to reduce risk of associated losses. Despite the large indication of the influence of local knowledge as climate information in farmers' decision-making in Bobirwa, its full analysis is out of the scope of this study and will require further research.

5.6.1 Comparison of seasonal climate forecasts and other methods

Upon enquiring which method is better for making farming decisions as compared to the SCF, 31 farmers made comparisons between SCF and traditional forecasts as two prominent methods. It is found that 29% of them thought SCF and traditional forecasts were comparable and both useful for making decisions as they complement each other and are frequently in agreement. The majority of farmers who thought so made similar statements to this: "I use both the seasonal and traditional forecasts, and the two forecasts are normally in agreement." The reasons given by those who perceived SCF as better (25%) were that advanced equipment is used to forecast and that government is leading the process and guiding the nation. They explained further that traditional indicators are not reliable because they appear when the season has already started. For example, one farmer said, "Traditional forecasts no longer work because they are also confusing elders who observe them due to excessive heat and changed rainfall seasons affecting the flowering of plants." The farmers who perceived traditional forecasts as a superior method (16.1%) reasoned that they looked at indicators in their localities, unlike the seasonal report that gives broad areas but when rain comes it misses their areas. However, they stated that they used traditional forecasts in combination with SCF and some acknowledged that traditional indicators had changed over the years making them less accurate than in the past.

The use of SCF and traditional forecasts as complementary methods for decision-making in Bobirwa is also noted by several authors from studies across Africa (Vogel, 2000; Luseno et al., 2003; Orlove et al., 2010; Mogotsi et al., 2011b; Roudier et al., 2014; Dube et al., 2016). Mogotsi et al. (2011b) found that even though a few farmers use both forecasts for decision-making, given the opportunity to select one they preferred SCF reasoning, that it is reliable and uses modern technology. This contradicts with the Brazil case study portraying that the majority of farmers favour traditional forecasts over SCF because traditional forecasts are considered more credible than SCF (Lemos et al., 2002). In the Horn of Africa and Uganda, although farmers largely use traditional forecasts because of their accessibility, they view SCF as vital additional information that can be used together with traditional indicators (Luseno et al., 2003; Orlove et al., 2010), whereas in Burkina Faso farmers welcome the use of SCF because of loss of credibility in traditional forecasts caused by climate variabilities (Roncoli et al., 2002). It can therefore be seen that even though some farmers in Bobirwa still use traditional forecasts they consider SCF more credible and could be using traditional forecasts as additional information to close the scale gap and as a form of confirmation of SCF to build confidence in decision-making.

5.7 Recommendations made by farmers to improve seasonal climate forecasts

According to the farmers in Bobirwa, several improvements should be made to SCF for these to be more useful to them (Table 11). The frequently made suggestions for improvement ranged from specifying the areas (25%), distribution of rainfall (16.1%), dry spells within the season (10.7%) and disseminating SCF updates (10.7%) to providing adverse weather information (1.8%). Other suggested improvements were rarely mentioned (< 6%). It is worth noting that scale improvement (53.6%) was the most recommended by farmers while credibility (3.6%) was one of the least recommended for improvement. Gender comparisons show that more responses from men (57.1%) advanced scale as an area of improvement than those from women (47.6%). One man stated: "Our villages are never depicted by the forecast and it would be good to see our areas mentioned to show that indeed it will rain in our areas as we end up making assumptions". One woman made a general suggestion that "… the forecast should elaborate how the month will be in each season for me to take advantage of the rain that will come." Credibility improvement had no distinct disparities between the two genders.

Table 11. Recommendations made by farmers to improve seasonal climate forecasts for increased uptake and usability

Theme Category	Theme	MALES		FEMALES	
		n	Illustrative Quotation	n	Illustrative Quotation
Scale	Specify area	9	"The forecasts should specify exactly where in Bobirwa rain is expected, elaborate on specific areas the rain will cover." "Our villages are never depicted by the forecast, it would be good to see our areas mentioned to show that indeed it will rain in our areas as we end up making assumptions." "The forecasts should specify areas and even mention Bobirwa because when our areas are not specified we become confused and end up making assumptions."	5	"It needs to specify the areas." "Forecasts should specify our areas so we don't waste our time and energy planting large areas when it won't rain in our area."
	Specify rainfall distribution	5	"We want the forecasts to specify which month it will rain. As farmers, we are used to have rainfall in November but if it will not rain the forecasts should clearly state that November will be dry and it will rain in January so that we don't become confused." "The forecasts should show when it will rain in the season, like this year the rain came late in the season which wasn't explained." "The forecast should specify the months when there will be rain and the months that will be dry to avoid farmers making losses."	5	"The forecasts should elaborate how the month will be in each season for me to take advantage of the rain that will come." "The forecasts should tell us when it will rain e.g. in December or towards the end of the season."
Rainfall parameters	Specify dry spells	5	"The forecast should specify periods of dryness during the season which is important because certain crops are not tolerant to dry conditions, even for livestock this information is	1	"The forecasts need to also specify which month it will not rain."

			important." "The dry months/period should also be explained when they will occur by the forecasts."		
	Indicate onset	2	"The forecast should specify the exact month it will start raining."	0	-
	Specify amounts	1	"The forecast should also specify how much it will rain in a season and in a month so that we are not surprised by 100mm of rain at a go."	1	"Forecasts should elaborate when it will rain and the amount every month so that it benefits us more."
	Indicate adverse weather	1	"We need the forecasts to include adverse weather like strong damaging winds as sometimes they destroy plants."	0	-
Accessibility	Issue SCF updates	3	"Update forecasts at least every month to cater for changes that could have occurred within the season."	1	**"**DMS can do monthly updates and disseminate it monthly."
	Regular dissemination	1	"Some people may miss the once-off dissemination because of other engagements or couldn't watch the television so there is need to repeat the dissemination so that it reaches as many people as possible."	2	"DMS can disseminate SCF updates monthly."
	Improve accessibility	1	"If there are any changes in the season they should be communicated well in time as the only forecast we hear and cling to is the initial September forecast."	1	"There should be a public display of the forecast in each village where any farmer can go and see what the seasonal forecast is for the season."
Institutional capacity	Improve equipment	1	"There is need to improve the technology used to avoid the forecasts being wrong so that the forecasts become at par with other advanced countries."	2	"There is need to improve the equipment for forecasts to show specific sides of Bobirwa (North south, east west) where it will rain."
	Train forecasters	1	"The forecasters need to be trained to operate the equipment, also the human resource training avoids these problems of forecasts being wrong."	1	"Forecasters could just go to school to increase their knowledge."
Awareness and education	Conduct SCF education	2	"Intensify educating farmers on SCF but in the process also encourage farmers not to lose their traditional practices." "Mistrust is also caused by the fact that sometimes we don't understand the information so there is need to conduct educational campaigns to reinforce understanding."	0	-
Credibility	Improve SCF quality	1	"The quality of the forecasts should also be improved as they are sometimes incorrect."	1	"The forecasts accuracy or quality should improve so that we don't base our planting on God's mercies."
Local knowledge	Include traditional practices	2	"The forecast should also incorporate traditional forecasts."	0	-
MoA advice	Advice farming methods	0	-	1	"The forecasts should also give us through extension officers advice on what crops to plant and better ways of planting. They should also take us for courses/trainings and encourage us to plant so we don't give up on farming despite the low rainfall, to improve crop production."

The farmers' call to improve scale is consistent with section 5.3, that scale is a major constraint in SCF use and uptake, hence a top priority area for improvement in the SCF. It can therefore be expected that improving the SCF scale could result in a higher percentage of farmers using SCF. The literature also mentions that the spatial and temporal scale of SCF need to be improved without compromising the credibility of SCF (Johnston et al., 2004; Marshall et al., 2011). The second recommendation, of providing information on dry spells, is also suggested in literature (Johnston et al., 2004; Ingram et al., 2002; Vincent et al., 2017). It is stated that SCF should provide rainfall variations within the season including onset and cessation (Johnston et al., 2004; Ingram et al., 2002). Production and dissemination of updates are also reflected as key to farmers (O'Brien et al., 2000; Johnston et al., 2004; Batisani & Yarnal, 2010; Vincent et al., 2017). As suggested by farmers, a bulk of literature recommended continuous awareness and education activities to improve understanding SCF (O'Brien et al., 2000; Johnston et al., 2004; Ingram et al., 2002; Mogotsi et al., 2011b; Singh et al., 2017). It is also important to form strong networks between producers and users of SCF as well as relevant sectors to understand the decision context of users, better tailor SCF and overcome barriers of SCF at farm level (Johnston et al., 2004; Ingram et al., 2002; Crane et al., 2010; Singh et al., 2017). Furthermore, there is a need for co-production of knowledge by exploring integration of local knowledge and other information like economic information into the SCF.

CHAPTER 6: CONCLUSION

The main aim of the study was to assess how credibility and scale affect farmers' use of SCF in decision-making in Bobirwa sub-district of Botswana. Credibility is the perceived trustworthiness, reliability and quality of SCF, whereas scale is the perceived relevance of SCF in geographical range and in timing and distribution of rainfall for the season. To achieve this, the study sought to explore the credibility and relevance of SCF reaching communities in the area; how the credibility and relevance of these SCF influence the decision-making of farmers; and, lastly, how farmers deal with the limitations of credibility and relevance in scale of SCF in their decision-making. The study sampled 47 farmers to seek answers to research questions. All the sampled farmers had access to SCF primarily through radio and television (see section 5.2). The following outcomes addressing each research question, were obtained from study.

How credible and scale-relevant are seasonal climate forecasts that reach communities in Bobirwa sub-district?

The study shows the majority of farmers perceiving the SCF they received as credible. On the other hand, while the SCF were largely viewed as relevant in terms of dissemination procedure and cognition of SCF, this relevance seems to be blighted by the problem of scale. The problem of scale *vis-à-vis* relevance has to do with the broad geographical range covered by the information, without taking local-level dynamics into account. Furthermore, the lack of detail in rainfall distribution and duration within the season adds to the problem of scale.

How does the credibility and scale relevance of these seasonal climate forecasts influence decision-making and livelihoods in Bobirwa sub-district?

SCF are widely used by farmers in Bobirwa. However, even among farmers who find SCF less credible, many still use them for decision-making in crop and livestock production. This could be because SCF are readily available and some traditional indicators are perceived to be less reliable, due to climate variability and therefore need validation through SCF. The study found that the very few non-users of SCF attributed non-use of SCF to their low credibility. Although scale is an issue for farmers in Bobirwa, as noted earlier, it did not hinder the uptake and the use of SCF. This is because farmers used other methods such as local knowledge and economic information to complement SCF. Therefore, credibility was found to be a more important determining factor for uptake of SCF than scale.

On examining the value of SCF, almost half of the users of SCF sampled indicated having benefited from using SCF, while a quarter had been disadvantaged by using SCF due to scale. The reviewed literature mentions that there has been minimal empirical research to assess tangible SCF benefits to farmers (O'Brien et al., 2000; Ziervogel et al., 2006; Hansen, 2002 Roudier et al., 2014). There is therefore a research need to focus on assessment of benefits resulting from the use of SCF by the farmers over a continuous period.

How have the farmers in Bobirwa sub-district dealt with limitations of credibility and scale relevance of seasonal climate forecasts in their decision-making?

Firstly, to respond to this research question, constraints to uptake and use of SCF were identified. The farmers provided numerous constraints to effective use of SCF in their farming practices. The study shows that the constraints of using SCF were either limitations of SCF or barriers preventing effective use. Among the limitations of SCF, scale due to lack of spatial and temporal distribution of SCF was popularly mentioned, while credibility did not emerge as a major issue. Other limitations mentioned were limited human and technological capacities to predict precisely the atmosphere, which contributed to the limitation of credibility and scale. Lack of provision of information on climate variations in SCF was also mentioned as a limitation. Barriers to effective use of SCF largely emanated from local beliefs and practices, agricultural services, economic and environmental factors. The barrier of local beliefs and practices was caused by farmers' non-responsiveness to SCF because farmers perceive rainfall to be an Act of God. Furthermore, farmers' value to uphold the Chief's declaration of *letsema* resulted in a lack of timeliness to respond to SCF. Limited provision of tractors as an agricultural service by MoA was also a hindrance to effective use of SCF. The lack of a market to sell agricultural produce and insufficient capital to secure farm labour, buy farm equipment and ICT equipment for direct access of SCF are other barriers limiting response to SCF. In addition, environmental barriers such as FMD, *quelea* birds and clay soil environment were found to preclude the response to SCF. Therefore, interventions to improve use of SCF should not be done in isolation but a multi-sectoral approach should be used to address other barriers inhibiting the effective use of SCF.

The study revealed that credibility was a constraint for non-users of SCF while the scale limitation was a barrier for users of SCF. The farmers applied different ways of coping with SCF limitations. Non-users of SCF dealt with the limitation of credibility by resorting to planting traditionally, using the ISPAAD government programme and applying local knowledge. In this regard, it is proposed that government programmes be designed in such a way so as to take SCF into account in order to reduce farmers' vulnerability to climate variabilities. Conversely, the users of SCF largely applied local knowledge, which is relevant to local scales to complement SCF limitations. MoA advice and economic information such as markets for selling agricultural produce are used mostly by male farmers to overcome scale limitations. Thus, it can be said that farmers overcome the limitation of scale in SCF by using local knowledge. This calls for further research and strengthened networks between scientists and farmers to explore incorporating local knowledge in SCF and possibly closing spatial and temporal scale gaps.

While it is important to improve SCF to overcome their limitations, there is a need for co-production of knowledge using local and scientific knowledge as well as inclusion of socio-economic information. In Malawi, farmers' use of local knowledge in planning farming activities has resulted in research and training institutions, non-governmental organisations and government, embracing its vital role and the need for its integration into production and dissemination of climate information services (Hampson et al., 2014). Dube et al. (2016) noted that the processes of generating SCF from indigenous and scientific knowledge are different, hence the two forecasts can be generated in parallel to allow for each approach to develop without invading each other. In the end, a consolidation of the forecasts resulting from the two approaches through interaction and discussion by the actors would make up one SCF (Dube et al., 2016). Providing such an array of information to farmers could help them to make better crop and livestock management decisions that would subsequently improve their livelihoods.

Outcome of gendered assessment of the study

Analysis by gender differentiation showed that both men and women had equal access to

SCF. The study also found that a slightly higher percentage of women used SCF than men. Women in Botswana traditionally practise arable farming more than men, who are agro-pastoralists. However, from this study, these gendered differences were found to be statistically insignificant. Nonetheless, Luseno et al. (2003) mention that large-scale resolution of SCF is more directed to crop production than livestock. Additionally, most livestock management practices are done in response to the rainfall impacts than its forecast (Roncoli et al., 2009). As dynamics in the case study area show, SCF should therefore not only focus on crop production but also include livestock management strategies.

It is worth noting that while women also use SCF, the study shows that they have been the most disadvantaged in using SCF and benefit the least from using SCF as compared to men. This makes women more vulnerable than men, which is attributed to their focus on arable farming being more sensitive to climate variability, scale and temporal limitations than the male-dominated livestock production. Women were found to fill the SCF scale limitation with local knowledge and MoA advice while men also add economic information to avert risks. This seems to suggest that less credible SCF can make women more vulnerable than men. Inaccurate SCF could result in a loss of resources, exacerbate poverty and put life at risk (Ingram et al. 2002).

CHAPTER 7: RECOMMENDATIONS

The following recommendations are made after conducting the study:

The study revealed that Bobirwa sub-district farmers perceive SCF that they receive to be credible but not relevant to their local scale and in detailing parameters needed by farmers. Therefore, the recommendation is to improve the resolution of SCF to local scale relevant to farmers' decision-making. This can be done through capacity development on the use of modelling techniques, investment on computing infrastructure and collaborating with other research centres in the region and abroad. The study indicated that a bulk of farmers incorporate SCF into their decision-making; however, they also indicated a need for detailed information on issues such as dry spells, onset, distribution and duration of rainfall within the season. There is a need to conduct research to explore ways of improving SCF to include parameters needed by farmers in SCF with the aim to improve spatial and temporal scales as much as science permits. This is also articulated by Hansen et al. (2011), that the use of RCM in Africa to provide detail and parameters relevant to agriculture is a research area to explore. A pilot study that provides high spatial and temporal resolution forecasts to farmers in a particular district could be conducted while considering the need to communicate uncertainties associated with forecasts at that fine scale. Such studies provide room for continual improvement and if successful, they can be rolled out nationwide. Furthermore, in the period between 2003 and 2006, DMS used to do trials on sector-focused forecasts such as the water and health sectors by applying Canonical Correlation Analysis (CCA) using the Climate Predictability Tool (CPT). Although such forecasts were associated with high uncertainties which needed to be communicated to users, they promoted user-tailored SCF, an opportunity for use of new approaches to advance SCF production and strong collaboration between SCF producers and users. Therefore, it is recommended that such studies for sector-based forecasts could be continued and the capacity required be developed. This requires the production of user-driven forecasts and translation to usable information in the context of various users including farmers.

It was apparent that the benefits of use of SCF are still difficult to gauge. Hence, the following research areas are recommended:

- Conduct research on benefits of SCF to farmers over time to assess actual benefits of the use of SCF by farmers.
- Expedite research on production and dissemination of long-term climate information to reduce vulnerability of the farmers to climate variabilities.

The farmers complement SCF with local knowledge, MoA advice and economic information to cope with SCF limitations. Therefore, it is recommended that there should be co-production of knowledge of indigenous and scientific knowledge, socio-economic information for better crop and livestock management decisions. Currently traditional forecasts are generated at local scale relevant to the farmers, therefore they could improve the geographical scale of SCF. However, it is proposed that the forecasts from the two knowledge systems be developed separately as the two approaches are different, and then the two can be synergised at the result level to produce a single forecast.

It is important that SCF be integrated into government programmes, planning and all agricultural production sectors to build resilience to climate variability. This will also cushion the most vulnerable groups to climate variability, such as non-users of SCF and women, who are mostly arable farmers, as arable farming is most affected by climate variability.

It has been noted that besides SCF limitations, there are a number of barriers impeding effective use of SCF. Thus, it is essential to strengthen collaboration between forecast producers, agronomists, extension officers at all levels, tribal authorities, and farmers to enhance understanding, interpretation, and effective use of SCF and to understand the end-user decision-making context. It is also recommended that such collaboration be used to collectively address barriers to effective use of SCF which are not only related to SCF production but also socio-economic in nature. Furthermore, such strong networks could also be used for generating co-produced SCF information and widen its understanding and application.

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APPENDICES

Appendix 1: Interview Questions for Farmers

Adaptation at Scale in Semi-Arid Regions (ASSAR)

Credibility and Scale as Barriers to uptake and Use of Seasonal Climate Forecasts in Bobirwa Sub-District, Botswana

Guideline questions for farmers

A. Basic information

	Farmer's information (Tick)			
Location				
AGE	**18 - 21**	**22-35**	**36-55**	**56 and above**
Years of Farming experience				
GENDER	**M**		**F**	
Farming Category	**Subsistence**		**Commercial**	
What is farmed				

Objective 1: Understanding the credibility and relevance of availed seasonal forecast

1. Do you receive or have access to seasonal forecasts? [Yes_______NO______go to Quest. 6]

2. If yes, where do you get it from? (Information source)
   Radio_______TV_____MoA Extension Officer________Newspaper_____Friend/Family___
   Others_______

3. Do your trust the information you receive [Yes/No]_______

4. Why do you trust or not trust the seasonal forecasts?
   ____

5. If you have access but you don't use the availed seasonal forecasts, why is it so? (Probing in terms of reliability/credibility and relevance at desired time- and spatial scales)____

6. How about the daily forecasts broadcast on radio or BTV, do you trust them [Yes/No]_______

7. Give reasons why you trust or don't trust daily weather forecasts?
   ____

8. Do the above reasons also contribute to why you trust or don’t trust the seasonal forecasts (explain)____

9. If you do not have access, what source(s) of information do you use to decide on/plan your farming activities (i.e. crop/livestock practices) at the seasonal time-scale?____

Objective 2: Understanding how credibility and relevance of seasonal forecasts influence decision-making and livelihoods

10. Do you use availed seasonal forecasts for your farming practices or decision making in agriculture? [YES/NO]______________

11. If yes, how do you use the information specifically? Probe in terms of:

    (a) change of planting dates

    (b) change of varieties

    (c) destock/ restock/ buy feed

    (d) diversifying of livelihoods

12. What have been the (a) advantages and (b) disadvantages of using the availed seasonal forecasts? (Probe in terms of what they have benefited and/or lost after using the information vis-a-vis changing cropping and/or livestock practices based on the information received?)

Objective 3: Exploring how have farmers have dealt with limitations of credibility and relevance of seasonal forecasts in decision making

13. What specific problems have you had with the availed forecasts? (Probe in terms of how the seasonal forecasts have failed to meet specific farmer needs and/or expectations)
    (i) late
    (ii) unreliable
    (iii) inaccurate
    (iv) not understandable
    (v) spatial scale large
    (vi) Insufficient information

14. What alternatives do you use in your crop/livestock practices to overcome these challenges?

15. How have the alternatives compared with availed seasonal forecasts? (Probing in terms of whether they have been better or worse)

Objective 4: Examining how seasonal forecasts can be made more credible and relevant for farmers

16. What more information do you need to help you in your crop/livestock farming? (probing in terms of onsets, dry spells, spatial and temporal scales).

17. How do you want the information to be presented for better understanding (Probing in terms of (a) format (b) language (c) means of dissemination)?

18. Is the current timing of the release of seasonal forecasts right in terms of your crop and livestock practices?

19. If not, when do you think would be the right time for the availing of seasonal forecasts?___________

Appendix 2: Setswana Version of Interview Questions for Farmers

Adaptation at Scale in Semi-Arid Regions (ASSAR)

Credibility and Scale Barriers to uptake and Use of Seasonal Climate Forecasts in Bobirwa Sub-District, Botswana

Guideline questions for farmers

A. Basic information

	Farmer's information (Tick & fill-in as appropriate)			
Lefelo				
Dingwaga	**18 - 21**	**22-35**	**36-55**	**56 and above**
Lobaka le kafe eo le molemi-morui				
Bong	**M**		**F**	
Temo/Thuo ee ntse jang	**Go ijesa**		**Kgwebo**	
Tlhaloso ya Temo/Thuo	**Lema eng:**		**Thuo eng:**	

Objective 1: Understanding the credibility and relevance of availed seasonal forecast

1. A o e tle o utlwe pego ya paka ya pula e tlhalosang gore ngwaga o tlaa bo ntse jang? [Ee_________/Nyaa_________ (if NO then go to ques 6)]

2. Pego e o e tsaya kae/o e utlwa kae? (Information source)
   Radio_______TV_____Balemisi________Pampiri ya dikgang_____Tsala/Lesika___
   Ko Kgotleng_______Tse dingwe(Tlhalosa)__________

3. A o tshepha pego e ya paka pula? [Ee_________/Nyaa_________]

4. Ka go reng o e tshepa/ kana o sa etshephe?
   ____

5. Fa o e amogela mme o sa e dirise ke eng go ntse jalo? (Boleng ja teng bo ntse jang, a o a ikanya, a e maleba le temo/thuo kgotsa e tlhaela sengwe- nako ee begwang ka yone e thari, ga e itlhalose sentle, ga e bue gore pula ea go na jang mo pakeng, e simolola leng, kana e solofetswe leng)____

6. Pego ya tsatsi le le tsatsi ya Tepo loapi ee gasiwang go tswa mo radio, BTV a yone o a etshepha? [Ee_________/Nyaa_________]

7. Ke eng o sa e tshephe pego ya tsatsi le letsatsi kana ke eng o e tshepha? ____

8. A mabaka a ke one a dirang gore o seka wa tsepha pego ya paka ya pula kana jang (tlhalosa)?____

9. Fa o senke o utlwa pego e ya paka ya pula o dirisa eng go bona gore ngwaga o tlaabo o ntse jang? ____

Objective 2: Understanding how credibility and relevance of seasonal forecasts influence decision-making and livelihoods

10. A mme gone pego e ya pula o a e dirisa mo temong/thuong? [Ee_______/Nyaa_____]

11. Fa e gore Ee, o e dirisa mo go eng? Ke dife di tshwetso tse o di tsayang ka go e dirisa?:

    (a) Gore ke simololе go lema leng/ ke e seka ka lema

    (b) Ke reke dipeo dife

    (c) Ke jwale peo e fe mo tshimong

    (d) Ke rekise leruo/ ke reke leruo/ ke reke dijo tsa dikgomo

    (e) Ke batle metlhale e mengwe ya go itshetsa

12. Ke dife di tla morago tse o di itemogetseng tsa a) go dirisa kana b) go sa dirise pego ya paka ya pula? (E go tswetse mosola jang kana ga e a gotswela mosola jang mo temo thuong ya gago?)

Objective 3: Exploring how have farmers have dealt with limitations of credibility and relevance of seasonal forecasts in decision making

13. Mathata a o bonang tebang le pego e ya pula ke afe? (E palelwa ke go go tlamela mo temo/thuong ya gago jang, ga o kgotsofalele eng?)
    (i) E tla tlhari (ke setse ke rekile dipeo/dijo tsa dikgomo)
    (ii) Ga e ikanyege
    (iii) Ga e bue boammaruri/ ga e tshware pua sentle
    (iv) Ga ke e tlhaloganye
    (v) E bophara ja lefatshe thata e sa bue ka masimo/motse wame
    (vi) Ga e itlhalose sentle: go re pula, komelelo e a gonna leng, jang
    (vii) E abelela thata

14. Go tila one mathata a, o dira jang mo temo/thuo jaanong (aa dirisa bolepi loapi ja setso)? ____

15. Methale e mengwe (ya go lepa paka ya pula) e o dirisang yone e mosola gole kafe? (e gaisa/ e palewa go lekafe fa o e bapisa le pego ya paka ya pula ya Tepo Loapi)____

Objective 4: Examining how seasonal forecasts can be made more credible and relevant for farmers

16. O tlhokana le eng gape gore pego ya paka ya pula e go thuse mo temo/thuong? (probing in pula e simololola eng, komelelo e go nna leng, pula e a gona jang le leng mo pakeng, e fokotse phara ka go tlhalosa ka masimo/moraka wa me).

17. O batla pego e begwa jang gore e tswele mosola? (Probe in terms of: (a) methale (b) puo efe (c) e tle ko go wena jang)?

18. Aa nako e pego e ntshiwang ka yone (September/Lwetse) e go siametse go ka e dirisa go ka dira dipaakanyo tsa temo/thuo (kgotsa e fitlhela o ise/o setse o tsere di tshwetso)?

19. Fa nako ya teng e sa go siamela, o bona nako e e siameng go ntsha pego e e le leng? (kgwedi e fe)_____________

Appendix 3: Consent Form

African Climate & Development Initiative

GEOLOGICAL SCIENCE BUILDING,
UNIVERSITY OF CAPE TOWN
PRIVATE BAG
RONDEBOSCH 7701
SOUTH AFRICA

RESEARCHER
Janet Selato
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Informed Voluntary Consent to Participate in Research Study

Project Title: Credibility and Scale as Barriers to Uptake and Use of Seasonal Climate Forecasts in Bobirwa Sub-District, Botswana

Invitation to participate and benefits: You are invited to participate in a research study conducted with farmers and key stakeholders in climate risk and adaptation in Bobirwa sub-district, Botswana. The study will assess the uptake and use of seasonal forecasts and climate information in the area. I believe that your experience would be a valuable source of information, and hope that by participating you may gain useful knowledge.

Procedures: During this study, you will be asked to engage in a discussion around a set of questions around the credibility and relevance of seasonal forecasts and climate information in farmers' decision making and adaptation to climate change.

Risks: There are no potentially harmful risks related to your participation in this study.

Disclaimer/Withdrawal: Your participation is completely voluntary; you may refuse to participate, and you may withdraw at any time without having to state a reason and without any prejudice or penalty against you. Should you choose to withdraw, the researcher commits not to use any of the information you have provided without your signed consent. Note that the researcher may also withdraw you from the study at any time.

Confidentiality: All information collected in this study will be kept private in that you will not be identified by name or by affiliation to an institution. Confidentiality and anonymity will be maintained as pseudonyms will be used.

What signing this form means:

By signing this consent form, you agree to participate in this research study. The aim, procedures to be used, as well as the potential risks and benefits of your participation have been explained verbally to you in detail, using this form. Refusal to participate in or withdrawal from this study at any time will have no effect on you in any way. You are free to contact me, to ask questions or request further information, at any time during this research.

I agree to participate in this research (tick one box)

☐ Yes ☐ No _________ (Initials)

____________________________	______________________________	_______
Name of Participant	Signature of Participant	Date
____________________________	______________________________	_______
Name of Researcher	Signature of Researcher	Date

Appendix 4: *Setswana* Consent Form

African Climate & Development Initiative

GEOLOGICAL SCIENCE BUILDING,
UNIVERSITY OF CAPE TOWN
PRIVATE BAG
RONDEBOSCH 7701
SOUTH AFRICA

RESEARCHER
Janet Selato
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E-MAIL:
jselato@gmail.com

Tumalano ya Dipatisiso

Setlhogo: Tiriso ya Pego ya Tebelopele ya Paka ya Pula (Tepo Loapi), Bobirwa Sub-District,

Taleletso go tsaya karolo: Re go laletsa go ithaopa go tsaya karolo mo dipatisisong tsa tiriso ya pego ya Tepo ya Loapi.

1. Tebelopele ya paka ya pula go tswa ko Tepo Loapi
2. Go o lepa loapi ka Setso

Puisanyo: Re a go buisanya ka tiriso ya pego ya paka ya pula, boleng ja yone, a e maleba le fa o leng teng, tiriso ya go lepa loapi ka setso, le gore a e a ikanyega.

Dipuisanyo tse, ke tsa dipatisiso fela, maina a lona ga a na go tlhagelela mo mokwalong wa dipego. Jaanong re kopa gore le akgele ka kgololesego.

Go baya monwana go supa tumalano (saena):

Ke dumalana le go tsaya karolo mo Dipuisanong tse.

______________________	______________________	________
Leina la Moithaopi	Saena Moithaopi	Letsatsi
______________________	______________________	________
Leina la Mmatisisi	Saena Mmatisisi	Letsatsi

Appendix 5: Interview Questions for Ministry of Agriculture Officers

Adaptation at Scale in Semi-Arid Regions (ASSAR)

Credibility and Scale as Barriers to uptake and Use of Seasonal Forecasts and Climate Information for Adaptation in Bobirwa Sub-District, Botswana

Guideline questions for Stakeholders

A. Basic information

	Organization information (Tick)			
Location				
Organization Represented				
Position Held/Designation				
Users of Distributed information	1.	2.	3.	4.
Approx. numbers of users information is distributed to				
Information Distributed (seasonal forecast, climate information, Agromet Bulletin etc)				

Objective 1: Understanding the credibility and relevance of availed seasonal forecast

1. Do you receive or have access to seasonal forecasts? [Yes_______No_______go to Ques. 7]

2. If yes, where do you get it from? (Information source) MoA_______________Regional Office/Headquarters___________DMS________Radio_______BTV_____Newspaper_____ Others(specify)__________________________________

3. Do you use the information to make plans and/or advice farmers? [YES/NO]__________

4. Do your trust the information you receive [Yes/No]_______

5. Why do you trust or not trust the seasonal forecasts?____

6. If you have access but you don't use the availed seasonal forecasts, why is it so? (Probing in terms of reliability/credibility and relevance at desired time- and spatial scales)____

7. How about the daily forecasts broadcast on radio or BTV, do you trust them [Yes/No]_______

8. Give reasons why you trust or don't trust daily weather forecasts? ____

9. Do the above reasons also contribute to why you trust or don't trust the seasonal forecasts (explain)____

10. If you do not have access, what source(s) of information do you use to prepare for your messages for the farmers?____

Objective 2: Understanding how credibility and relevance of seasonal forecasts influence decision-making and livelihoods

11. If yes, how do you use the information? Probe in terms of:

    (a) Advice on change of planting dates

    (b) change of varieties

    (c) advice destock/ restock/ buy feed

    (d) advice on diversifying of livelihoods

12. How are agriculture practices/planning at district level and national level integrate seasonal forecasts?

13. What have been the (a) advantages and (b) disadvantages of using the availed seasonal forecasts? (Probe in terms of what farmers benefited and/or lost after using the information. How has the information facilitated or inhibited their planning/ practices?)

Objective 3: Exploring how have farmers have dealt with limitations of creditability and relevance of seasonal forecasts in decision making

14. What specific problems have you had with the availed forecasts? (Probe in terms of how the seasonal forecasts have failed to meet your expectations)
    (i) late
    (ii) unreliable
    (iii) inaccurate

(iv) not understandable
(v) spatial scale large
(vi) Insufficient information

15. What alternatives do you use in your planning and practices to overcome these challenges?

16. How have the alternatives compared with availed seasonal forecasts? (Probing in terms of whether they have been better or worse)

Objective 4: Examining how seasonal forecasts can be made more credible and relevant for farmers

17. What more information do you need to help you in your planning and practices? (probing in terms of onsets, dry spells, spatial and temporal scales).

18. How do you want the information to be presented for better understanding (Probing in terms of (a) format (b) language (c) means of dissemination)?

19. Is the current timing of the release of seasonal forecasts right your agricultural planning and preparing and delivering for messages to the farmers?

20. If not, when do you think would be the right time for the availing of seasonal forecasts?___________

Appendix 6: Interview Questions for Department of Meteorological Services

Adaptation at Scale in Semi-Arid Regions (ASSAR)

Credibility and Scale Barriers to uptake and Use of Seasonal Climate Forecasts in Bobirwa Sub-District, Botswana

Guideline questions for Producers of climate Information (DMS)

A. Basic information

	Organization information (Tick)			
Location				
Organization Represented				
Position held/Designation				
Users of Distributed information	1.	2.	3.	4.
Approx. numbers of users				
Information Distributed (seasonal forecast, climate information, Agromet Bulletin etc)				

Objective 1: Understanding the credibility and relevance of availed seasonal forecast

1. How do you disseminate seasonal forecasts?
MoA_________DistrictOffice________Headquarters____________ Radio_______
BTV_____Newspaper_____Website____________Social Networks____________________
Others(specify)____

2. Who are your key stakeholders?________________________
____
____

3. Do you think the farmers have access to seasonal forecasts (explain)____
____

4. How is the skill of the forecast disseminated? ____________________________________

5. How credible (quality, trustworthy, dependable, reliable) are the forecasts disseminated?
____
____

6. Has there been improvement in the credibility of the seasonal forecasts over the years? (explain)____
7. How relevant or not relevant is the scale (temporal and spatial) for farmers to use the seasonal forecasts?____
8. How do you think daily forecasts influence farmers' perceptions about the seasonal forecasts?____

Objective 2: Understanding how credibility and relevance of seasonal forecasts influence decision-making and livelihoods

9. Do farmers use seasonal forecasts [YES____________NO__________]
10. How do farmers use the information in decision making? ____
11. How do you think MoA use seasonal forecasts for agriculture practices/planning at (district level and national level)____
12. What have been the benefits/gains to farmers associated with use of seasonal forecasts in decision making? ____
13. What have been the losses to farmers associated with use of seasonal forecasts?____
14. How do you think credibility (quality, trustworthy, dependable, reliability) of seasonal forecasts has limited or boosted farmers' decision making____
15. How do you think scale (temporal and spatial) have limited or boosted farmers' decision making?____
16. What other alternatives do you think farmers use for decision making besides the information you disseminate? ____

Objective 3: Exploring how have farmers have dealt with limitations of creditability and relevance of seasonal forecasts in decision making

17. What specific challenges associated with disseminated forecasts- either by farmers or MoA
    (i) Late dissemination
    (ii) unreliable
    (iii) inaccurate

(iv) not understandable
(v) spatial scale large
(vi) unclear temporal distribution
(vii) Insufficient information
(viii) Onset unclear
(ix) Dry spells unclear

18. How do you think credibility (quality, trustworthy, dependable, reliability) inhibit the use of seasonal forecasts in decision making by farmers?____
____

19. How does scale (temporal and spatial) impede the use of seasonal forecasts?
____
____

20. What are other barriers which inhibit the use of seasonal forecasts in decision making by farmers?____
____

21. How have the alternatives methods or forecasts compared with your availed seasonal forecasts? (Probing in terms of whether they have been better or worse)
____
____

Objective 4: Examining how seasonal forecasts can be made more credible and relevant for farmers

22. What more information do you need to be included to make the forecast more usable? (probing in terms of onsets, dry spells, spatial and temporal scales)?____
____

23. Do you think the spatial resolution can be improved and how?____
____

24. Do you think the spatial resolution can be improved and how?
____
____

25. How can the forecast be made more credible?____
____

26. How can the information to be presented for better understanding (Probing in terms of (a) format (b) language (c) means of dissemination)?____
____

27. When do you think would be the right time for the availing of seasonal forecasts for farmers' decision making? ____
____

Appendix 7: Interview Questions SADC Climate Services Centre

Adaptation at Scale in Semi-Arid Regions (ASSAR)

Credibility and scale as Barriers to uptake and Use of Seasonal Forecasts and Climate Information for Adaptation in Bobirwa Sub-District, Botswana

Guideline questions for Producers of climate Information (Climate Services Centre)

A. **Basic information**

	Organization information (Tick)			
Location				
Organization Represented				
Position held/Designation				
Users of Distributed information	1.	2.	3.	4.
Approx. numbers of users				
Information Distributed (seasonal forecast, climate information, Agromet Bulletin etc)				

Objective 1: Understanding the credibility and relevance of availed seasonal forecast and climate information

1. How do you disseminate seasonal forecasts?
   MoA________________RegionalOffice/Headquarters_________DMS_________Radio________
   BTV_____Newspaper_____Website______Social networks____________________________
   Others(specify)____
2. Who are your key stakeholders?__________________________
   ____
   ____
3. Do you think the farmers have access to seasonal forecasts (explain)____
   ____
4. How is the skill of the forecast disseminated? ______________________________________
5. How credible (quality, trustworthy, dependable, reliable) are the forecasts disseminated? ____
   ____
6. Has there been improvement in the credibility of the seasonal forecasts over the years? (explain)____
   ____

7. How relevant or not relevant is the scale (temporal and spatial) for farmers to use the seasonal forecasts?____
____

8. How do you think daily forecasts influence farmers' perceptions about the seasonal forecasts?____
____

Objective 2: Understanding how credibility and relevance of seasonal forecasts and climate information influence decision-making and livelihoods

9. Do you think farmers use seasonal forecasts [YES____________NO_________]

10. How do you think farmers use the information in decision making? Probe in terms of:

    (a) Advice on change of planting dates

    (b) change of varieties

    (c) advice destock/ restock/ buy feed

    (d) advice on diversifying of livelihoods

    (e) Others (specify)_______________

11. How do you think MoA use seasonal forecasts for agriculture practices/planning at (district level and national level)____
____

12. What have been the benefits/gains to farmers associated with use of seasonal forecasts in decision making?
____
____

13. What have been the losses to farmers associated with use of seasonal forecasts?____
____

14. How do you think credibility (quality, trustworthy, dependable, reliability) of seasonal forecasts has limited or boosted farmers' decision making___________________________________
____

15. How do you think scale (temporal and spatial) have limited or boosted farmers' decision making?____
____

16. What other alternatives do you think farmers use for decision making besides the information you disseminate? ____
____

Objective 3: Exploring how have farmers have dealt with limitations of creditability and relevance of seasonal forecasts and climate information in decision making

17. What specific challenges associated with disseminated forecasts- either by farmers or MoA

(i) Late dissemination
(ii) unreliable
(iii) inaccurate
(iv) not understandable
(v) spatial scale large
(vi) unclear temporal distribution
(vii) Insufficient information
(viii) Onset unclear
(ix) Dry spells unclear

18. How do you think credibility (quality, trustworthy, dependable, reliability) inhibit the use of seasonal forecasts in decision making by farmers?____
____

19. How does scale (temporal and spatial) impede the use of seasonal forecasts? ____
____

20. What are other barriers which inhibit the use of seasonal forecasts in decision making by farmers?____
____

21. How have the alternatives methods or forecasts compared with your availed seasonal forecasts? (Probing in terms of whether they have been better or worse) ____
____