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Short Communication

Harnessing diverse knowledge and belief systems to adapt to climate change in semi-arid rural Africa

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A B S T R A C T

Farmers in semi-arid regions have historically coped using long established practices such as place-based climate forecasting using observations. However, this is becoming less reliable with climatic changes. Meteorological forecasting based on numerical prediction provides an alternative that is also now widely available to enable adaptation. However, this climate information has constraints including uncertainty and a broad spatial and temporal scale. The use of these two sources of forecast information is also affected by farmer perceptions of its advantages and disadvantages as well as beliefs and social norms. This study uses the case of Bobirwa subdistrict in Botswana to investigate the role of traditional norms and religious beliefs in the use of place-based and national meteorological forecast information to inform adaptation. Semi-structured interviews were conducted with 82 farmers from 8 different communities. We found that whilst some farmers use national meteorological information, others use place-based forecast information only and some combine the two. We also found that certain religious beliefs and traditional norms prevent the use of national meteorological forecast information by some farmers. An integrated climate information system that is credible and accessible to farmers from different belief systems will provide opportunity for farmers to use this climate information to adapt better to climate variability and change.

Practical implications.

To enable adaptation to climate change, it has previously been suggested that meteorological forecasting based on numerical prediction and place-based forecasting based on observations should be integrated into a more relevant and useful communication product. We agree with this, however we add that this climate information should be integrated and communicated in a way that will enable the uptake of this information by people with different belief systems. In this study, we find that the use of place-based and national meteorological forecast information is affected by traditional norms and religious beliefs. Some farmers disregard climate information because they prefer to farm as they always have done, or they must wait for the chief's permission before starting planting. Other farmers believe that God controls the rain and it is not possible for humans to predict the future. They also have faith that God will provide therefore they do not have to change their farming practices. To enable successful adaptation, such diverse perspectives require that climate information integrating place-based and national meteorological forecast information as well as recommendations on appropriate agricultural practices, needs to be developed together with, and disseminated through traditional and religious leaders. This could include the incorporation of religious and traditional narratives and relevant methods of climate information sharing e.g. at *kgotla* (community meeting place) or church. Without this consideration particular traditional and religious groups of people will not use this climate information, they will not adopt adaptation practices and they will remain particularly vulnerable to climate change.

1. Introduction

In semi-arid rural environments, low rainfall and high climatic variability have a fundamental influence on people's livelihoods which are often based on rain-fed agriculture (Reynolds et al., 2007). Historically, such communities have employed a number of coping mechanisms to deal with these uncertain conditions. However, farmers are increasingly struggling to secure livelihoods in many arid countries where drought conditions are becoming more prevalent and the trend of more frequent and intense droughts is expected to continue (Nkemelang et al., 2018). Therefore, any tools that can be used to help predict, plan for and adapt to these conditions are particularly important. One of the traditional farming approaches practiced locally has been the use of local observations to forecast weather and seasonal conditions. This place-based weather and seasonal climate forecasting employs a number of biological, astrological and atmospheric

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indicators such as the flowering of plants, behaviour of certain wild insects, appearance of the moon and cloud formations to predict upcoming weather conditions (Mogotsi et al., 2011a; Kolawole et al., 2014). These indicators are then used to make decisions such as when to plant, which crops to concentrate on and which ones to leave out, and when to undertake weeding cycles (Kolawole, 2015; Mapfumo et al., 2016).

Meteorological forecasts based on numerical weather prediction are another tool that can be useful for agricultural planning and adaptation (Hansen, 2002; Roudier et al., 2014; Winsemius et al., 2014). They generally provide information on whether above or below average rainfall is expected over a rainfall season (Ingram et al., 2002; Johnston et al., 2004; Ziervogel, 2004). However, some climate information users and disseminators also erroneously interpret the national meteorological forecast information as being deterministic and not probabilistic (Patt and Gwata, 2002; Ziervogel, 2004; Winsemius et al., 2014). Many a time, farmers also find that the climate information is inaccurate, in part because of the geographic scale at which it is produced as well as the limited temporal detail (Patt and Gwata, 2002; Ziervogel, 2004; Hansen et al., 2011; Mogotsi et al., 2011a; Fitt, 2012). In contrast to the poor spatial resolution of seasonal climate forecasts, place-based forecasting provides locally relevant information that is more time bound and geographically specific (Dube and Sekhwela, 2007; Mogotsi et al., 2011a). However, in some places farmers are finding these forecasts less reliable as the climate becomes more variable (Ziervogel and Opere, 2010; Mogotsi et al., 2011a). So while some farmers have access to and use national meteorological forecasts, other farmers use place-based forecasts, some farmers use both and others use neither to inform their farming decisions to adapt to climate change (Mogotsi et al., 2011a; Mosime, 2018).

There are a number of factors that appear pertinent in determining whether a farmer will use climate forecast information to make decisions or not. These include perceptions of risk, perceptions of ability to avert loss, perceptions of barriers to their utility, social norms, personal beliefs and financial, technical and informational resources that affect the ability to respond (O'Brien et al., 2000; Lemos et al., 2002; Grothmann and Patt, 2005; Hu et al., 2006; Singh et al., 2016). Traditional norms and religious beliefs are potentially important contributing factors to decision making by farmers, to adapt to climate variability and change, as they can have an important influence on the perception of risk and ability to respond (Schipper, 2010; Thomalla et al., 2015). This means that even when useful climate information is available and resources are sufficient to enable adaptation of agricultural practice these practices are not adopted.

The importance of different value systems in achieving adaptation has previously been highlighted by O'Brien and Wolf (2010) who acknowledge that different value systems mean that climate change cannot be responded to in only one way and that there may be conflicts between the responses of different actors because of their different value systems. Indeed, different ethnic groups respond differently e.g. some communities have much better social safety nets than others and mobility patterns differ between different cultures (Adger et al., 2012; Jones and Boyd, 2011). It has also been recognized that traditional norms may limit the uptake of adaptation options (Adger et al., 2009) e.g. in Burkina Faso cultural norms limit the uptake of adaptation responses such as labour migration, working for development projects, gardening and the engagement of women in economic activities (Nielsen and Reenberg, 2010) and likewise in Nepal different cultures have access to different adaptation opportunities (Jones and Boyd, 2011). In Zimbabwe farmers opt to use traditional planting by planting a variety of crops annually to avert the risks instead of using national meteorological forecasts to maximise harvests (Patt and Gwata, 2002). In addition, in Botswana (Mogotsi et al., 2011b), Namibia (Davies et al., 2018) and South Africa (Hudson and Vogel, 2003) some farmers don't sell their cattle when drought is predicted because of cultural attachment to their animals.

Religion has also been found to be important in farming decisions. There are farmers across the globe that believe that rain is the work of God and that it cannot be predicted e.g. in Tanzania (Slegers, 2008), Uganda (Orlove et al., 2010), Nigeria (Ebhuoma and Simatele, 2017), Brazil (Lemos et al., 2002; Pennesi, 2007), Senegal (Ndiaye et al., 2013) and Namibia (O'Brien et al., 2000; Spear and Chappel, 2018). There are also traditional leaders that discourage the communication and use of climate predictions for religious reasons e.g. sheiks in Burkina Faso (Roncoli et al., 2002). Many farmers also believe that they should take the risk and plant their crops as they have always done because they have faith that God will provide e.g. in Georgia (Crane et al., 2008), Uganda (Orlove et al., 2010), Kenya (Maseno, 2017), Brazil (Pennesi, 2007) and Namibia (O'Brien et al., 2000; Spear and Chappel, 2018). Some farmers who have a strong belief in acts of God also do not respond because of a perceived inability to change their situation e.g. in India (Singh et al., 2016). As such religious beliefs could make these farmers more vulnerable to climate change. Although this issue of the important role of religious beliefs and traditional norms for making farming decisions for some farmers has been mentioned in the literature there hasn't been a focus on the importance of this for potentially making these farmers more vulnerable to climate change as has been highlighted by Schipper (2010) and Thomalla et al. (2015).

The diversity of traditional, religious and modern perspectives along with numerous other contributing factors such as access to knowledge, assets and finance as well as an ability to decide on appropriate action means that the use of climate information is differentiated in society, potentially making some groups more vulnerable than others. Although there is an increasing number of authors suggesting integrating place-based and national climate forecasting information and making this knowledge more accessible to, and useful for, communities to enable adaptation (e.g. Ziervogel and Opere, 2010; Mogotsi et al., 2011a; Dube et al., 2016), we argue that traditional norms and religious beliefs need to be considered in this process. Without this consideration, certain groups of traditional and religious people will not use climate information, will not adopt adaptation practices and will remain particularly vulnerable to climate change. This study therefore uses the case of Bobirwa subdistrict in Botswana to investigate the role of traditional norms and religious beliefs in the use of place-based and national climate forecast information to enable adaptation to climate change.

Following this introduction section, the paper is organised around three main sections. The next section is the methodology section. This is followed by the results and discussion section and lastly there is the conclusions section.

2. Methodology

Fieldwork for this study was conducted in July 2016 as part of a broader investigation of barriers and enablers to the use of place-based and national meteorological weather and forecast information for decision making in Bobirwa subdistrict (see Selato, 2017; Mosime, 2018). The study used semi-structured interviews conducted by the authors JS (n = 47) and BM (N = 35) with purposively selected farmers in 8 villages of Bobirwa subdistrict: Bobonong (n = 23), Gobojango (n = 5), Moletemane (n = 7), Molalatau (n = 12), Motlhabaneng (n = 6), Mathathane (n = 6), Semolale (n = 10) and Tsetsebjwe (n = 13). Agricultural extension officers invited a range of farmers to attend interviews through the help of farmers committee chairpersons at the 8 villages. Interviewees were selected from those farmers that made themselves present on interview days while trying to obtain a representative sample including men, women and different age groups. There were slightly more females (54%) than males interviewed which is consistent with majority of households in Bobirwa being female-headed. Only 2 young adults in the age group 21–35 were interviewed, while the majority (61%) of farmers interviewed were categorised as elderly rather than middle-aged (37%). This is consistent with the finding in the 2014 agricultural survey that 64% of subsistence farmers

in Botswana are aged 60 and above where as 4% are between 15 and 39 years of age (Statistics Botswana, 2016) with young people not being interested in farming (Mogotsi et al., 2011c). It is also important to note that men are predominantly engaged in livestock keeping where as women are responsible for crop farming, with equal proportions of both groups using forecast information.

Bobirwa subdistrict is located in the eastern side of Botswana. The subdistrict is situated along the borders with Zimbabwe and South Africa. Questions for respondents revolved around their use of place-based and national meteorological forecasting information for making decisions as well as limitations to utilising and accessing this knowledge. All data were analysed using thematic analysis. Thematic analysis proceeds by grouping data into specific identifiable themes and patterns then analysing it as such towards addressing study objectives.

3. Results and discussion

3.1. Place-based and national meteorological forecasts

The Department of Meteorological Services provides seasonal climate forecasts for 4 regions in Botswana. These are communicated to the Ministry of Agricultural Development and Food Security and reach farmers through radio (77%) and television (64%) but also through extension officers (38%) (Selato, 2017). Other sources include the *kgotla* (community meeting place), friends, newspaper and the internet. These forecasts mention whether normal or above or below normal rainfall is expected. Although all the farmers reported that they have access to forecast information more men (86%) had access to radio than women (68%) which relates to radio ownership (Selato, 2017). Also, the *kgotla* was only mentioned as a source of forecast information for men. The majority of farmers (80% of women and 73% of men) interviewed in Bobirwa subdistrict said that they use this information to make farming decisions (Selato, 2017). There were similar numbers of men and women who trusted or didn't trust information and who gave a similar range of perspectives about this. However more women (n = 7) than men (n = 2) mentioned trust in God as a reason for not trusting forecasts where as men mentioned other factors such as shifts in season in addition to incorrect forecasts that were also indicated by women (Selato, 2017). Farmers who use this type of information attributed their decision to use it to having experienced and seen it being correct in the past. As one elderly man in Semolale village noted:

> "I trust the [national] forecast because last season it predicted there would be low rainfall and indeed there was no rainfall".

However, similarly, other farmers do not trust national meteorological forecasts based also on previous experiences:

> "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" (middle-aged man from Molalatau).

The credibility of national meteorological forecasts being related to their performance in the past is well documented in the literature (Patt and Gwata, 2002; Ziervogel, 2004; Crane et al., 2008).

Farmers in Bobirwa also recognize the limitations of national meteorological forecasts in terms of their broad spatial scale. As highlighted by a middle-aged woman in Tsetsebjwe:

> "It covers broad areas but it should explain where it will rain exactly so that we are informed of where the rain will cover".

Farmers also noted that the national meteorological forecasts are weak on information around temporal distribution of rain including onset and timing of rainfall:

> "It doesn't explain when it will rain exactly, like last year it rained very late" (elderly man, Motlhabaneng).

However, it was notable that a small number of interviewed farmers do not use national meteorological forecasts because they simply do not understand them:

> "I am not familiar and I don't understand this seasonal climate forecast because what I do traditionally, is that at the start of the season when the cloud thunders we go to plant" (elderly woman, Semolale).

Even though there is limited detail in the climate information provided in national meteorological forecasts, the indication of either more or less rain being expected can inform decisions, for example, on which crops to plant and how much to invest. These decisions can be beneficial to people's livelihoods as has been experienced by local farmers in the study area. Almost half of the farmers mentioned having benefited from information in national meteorological forecasts (Selato, 2017). Benefits were gained from planting sorghum and melons and not maize in dry years and not over investing in planting big areas of land in dry years. As a middle-aged man in Molalatau noted:

> "*I once followed the [national] forecast and at the time 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.*"

There is limited empirical evidence demonstrating the benefits of using national meteorological forecasts in Africa and it has been mentioned that although farmers can perceive benefits from climate forecasts changes in management practices such as changing crops and planting dates can also bear neutral or negative outcomes (Roudier et al., 2014).

As previously mentioned, in contrast to the large scale and low resolution of national meteorological forecasts place-based forecasts based on observations are specific to the local area. In Bobirwa subdistrict, indicators such as plant flowering are used to indicate the onset of rain and whether or not there will be a good rainy season (Mogotsi et al., 2011a; Mosime, 2018). Local forecast knowledge is held by community members who have the ability to interpret the different indicators. This information is shared with others. Some farmers use local indicators in combination with national meteorological forecasts, as highlighted by some farmers across the sub district: "*I use the forecast together with the traditional forecast*" (young man, Molalatau). Local indicators give a small number of farmers more confidence in the national meteorological forecast:

> "I trust it because when the forecast is released and I observe the clouds also I see that indeed from my observations confirm [national] meteorological forecast" (elderly man, Semolale).

However, those who do not know how to use traditional indicators get information from other community members about the place-based forecast:

> "I usually confirm it [the national meteorological forecast] with traditional forecasts observed by parents and mostly the two forecasts are in agreement" (middle-aged woman, North Bobonong).

While the techniques of place-based forecasting could be beneficial to farmers in complementing national meteorological forecasts (Ambani and Percy, 2014; Singh et al., 2017) these are generally being lost in communities in recent years. For example, one interviewed farmer noted the negative influence of western education:

> "Western education has led to increased doubts in the myths and beliefs about local weather and seasonal forecasting." (elderly woman, Moletemane)

There is also limited transfer of traditional knowledge because of such factors as migration as one young man in Bobonong noted:

> "Migration, changes in beliefs and changes in lifestyles are a reason why we lack experience in traditional forecasting. We don't have time to observe or learn from our elders."

3.2. The role of traditional norms and religious beliefs in the use of forecast information

Different farmers that are influenced by traditional norms and religious beliefs have different perspectives on the salience and credibility of place-based and national meteorological forecast information (also see O'Brien et al., 2000; Orlove et al., 2010; Spear and Chappel, 2018). This affects whether they will take on board either local or national meteorological information and use it in their decision making. In addition, there are differences in the ability of different social groups to access and use the different types of knowledge. As previously indicated, national meteorological forecast information is not understood by some farmers, but local forecasts are also not accessible to all farmers. This is because interpreting observations of indicators to produce local forecasts require specialised knowledge or access to someone with the knowledge (Mosime, 2018).

Some young people in rural Botswana may be moving away from traditional ways but traditional norms still influence the way people farm and the use of national meteorological forecast information. Many prefer to continue to farm as they always have: "*We plant the way parents taught us.*" (middle-aged woman, Semolale) Some farmers continue to plant the way they always have even when a dry season is expected. As indicated by a middle-aged man in North Bobonong:

> "*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.*"

Some traditional approaches to farming include planting when it rains:

> "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" (elderly man, Motlhabaneng).

Due to the uncertainty of forecasts this could still be a good option sometimes. However, some crops also fail due to intra-seasonal variation not reflected by place-based forecasts, which can be said to be a limitation in both national and local forecasts:

> "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" (elderly woman, Gobojango).

Some farmers are also constrained because planting cannot be started until the chief gives permission for planting and this can be a restriction for farmers:

> "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" (elderly woman, Semolale).

Some farmers do not use local or national meteorological forecasts. Like in other countries globally (Orlove et al., 2010; Slegers, 2008; Lemos et al., 2002; O'Brien et al., 2000) they believe rather that God, as the creator of all things, controls the rain. Such statements as "*rain is controlled by God*" (middle-aged man, Tsetsebjwe), "*I don't use the [national] forecast I just trust in God because he knows everything and is creator of everything*" (middle-aged woman, Semolale) were common during interviews across the 8 villages. Those who expressed such sentiment believe that humans cannot predict the rain as "*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*" (middle-aged woman, Tsetsebjwe).

In some instance, faith in God meant that people will plant their crops regardless of what the forecast says with faith that God will provide rain. As a middle-aged man in North Bobonong indicated:

> "when I plant, I trust in God even when the [national] forecast says there is no rain I tell myself only God knows and may bless us with rain".

In this case, it is understood that faith in God will make rain fall regardless of forecasts: "*he can override the forecast and change the situation*" (elderly woman, Gobojango) and that praying will lead to the provision of rain by God: "*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*" (Elderly man, Semolale). There is a belief therefore that God will solve the problem and no individual interventions need to be made. Most of the farmers who have converted to Christianity disregard traditional practices as expressly stated by a middle-aged woman in Molalatau village:

> "one cannot go to church and believe in traditional practices. These practices are demonic and are not recognised by our church".

Orlove et al. (2010) have also found that as farmers become more involved in Christianity, the use of traditional knowledge is reduced.

As place-based and national meteorological information is discredited for religious reasons, some people do not adequately prepare for fluctuations in rains and they go along as usual. In some cases they also do not think that they can change anything. Singh et al. (2016) refer to farmers who do not respond because of a perceived inability to change one's situation as "fatalistic farmers". These farmers hold a strong value of accepting their lot in life and often have a strong belief in external stressors as an 'act of God'. In Singh's study these farmers often had a meagre asset base, were socially marginalised and were unable to see improvements in future. The situation in this study is slightly different but importantly finds that a reliance on faith in God without taking appropriate action and a lack of willingness to adopt new practices and heed forecast information can lead to increased vulnerability to climate change as there could be loss of investment in crops and loss of livestock when rains fail. Likewise, traditional norms that prevent the adoption of practices that will assist farmers to adapt to climate change could make communities more vulnerable to climate change.

3.3. Towards an integrated and accessible knowledge system for adaptation

Whereas in the past traditional norms prevailed and local farming approaches and traditional knowledge were used, there is now a diversity of belief and knowledge systems that are present (Kolawole et al., 2014). Along with traditional beliefs there are now Christian and other beliefs in communities and in addition to place-based observations, national meteorological information is also now available. For farmers in Bobirwa subdistrict to be better prepared for the more variable and extreme climatic conditions that they may face in the future, forecasting information needs to be more useful. Farmers expressed the need for information at a better spatial and temporal resolution, specifying when and where the rain will fall, specific dry spells and onset of rainfall as well as more regular updates and dissemination of forecast information (Selato, 2017). In addition to this advice on what crops to plant and when is very useful to farmers. Information also needs to be more credible and it needs to be made more accessible and reliable to farmers. One way of doing this is through the development of an integrated knowledge system.

The idea of integrating place-based and national meteorological forecast information has recently been suggested for Botswana (e.g. see Dube et al., 2016). It has been advocated by internationally funded programmes such as the Climate Change Adaptation in Africa programme (Ziervogel and Opere, 2010) and put into practice by programmes such as the Adaptation Learning Programme for Africa (Ambani and Percy, 2014) that brought together staff from meteorological services and local forecasters to develop tailored forecast information (Ambani and Percy, 2014). Such initiatives have shown that

participatory and collaborative approaches can be critical in enhancing understanding and building trust (Singh et al., 2017). They have also demonstrated that local and national meteorological forecast information can be integrated to develop more useful forecast information that is tailored to local contexts including information on what to plant and when to plant as well as socio-economic benefits (Ambani and Percy, 2014). These programmes have also shown that existing structures can then be used for the dissemination of climate information to enable adaptation (Ambani and Percy, 2014; Singh et al., 2017).

In as far as the case study area is concerned, integration of place-based and national meteorological information can be done through three main ways. Firstly, this can be done through creating clear and structured platforms for shared dialogue, such as workshops involving representatives of local communities, government meteorologists and local agricultural extension officers scheduled at strategically timed and agreed intervals to produce seasonal forecasts and other useful adaptation information such as what crops to plant (see Ambani and Percy, 2014; Singh et al., 2017). For example, these workshops could be convened before the start of every farming season to come up with joint forecasts which local community representatives, traditional leaders, and agricultural extension officers relaying back information to local communities. This method has been successfully employed in western Kenya where government meteorologists and traditional Nganyi weathermen meet at the beginning of the rainy season to come up with agreed forecasts that are acceptable to local communities; an initiative which has led to increased uptake and use of forecasts (IPMGSD, n.d).

Secondly, relevant government departments and scientists from research institutions, such as the University of Botswana, working on climate change and other related issues in different rural communities, may create a transdisciplinary climate research network which should also include representatives from local communities. One of this network's main responsibilities will be to systematically document different aspects of indigenous knowledge used to cope with weather hazards in rural Botswana. This is in light of the widely noted drawback in knowledge systems integration efforts; that indigenous knowledge is not well documented which raises concerns about its preservation. As noted in the previous section, the loss of indigenous knowledge in recent years due to various factors was one of the issues raised by respondents in the case study area.

Thirdly, how weather and climate information is communicated is important. This includes what information is communicated, how it is communicated, the narratives that are used and who communicates it. As we have illustrated values are important in determining the uptake of information. Therefore, it follows that the messages communicated need to be: i) contextualised in a manner that reflects the audience's identity and respects their values; ii) presented in familiar language and narratives; and iii) cognisant that any proposed actions support the audience's values and identity (Marshall et al., 2016). Working with people that local communities trust in communicating national weather and climate forecasts is important as credibility of information is also determined by the trustworthiness of the communicator (Ingram et al., 2002; Patt and Gwata, 2002; Ziervogel, 2004). In the case of the study area, agricultural extension officers and representatives of local communities may be incorporated in actively conveying national meteorological forecasts. This is a method that has been effectively used in other parts of the world. In Tikopia Island, Solomon Islands for example, effective dissemination of climate information has been achieved through integrating Radio Australia's transmission of cyclone warning (scientific method) with local runners taking the message out to the wider community in the local language (indigenous method) (McAdoo et al., 2008). Furthermore, given the deeply religious nature of local communities in Bobirwa district, religious leaders may also have to be incorporated in communicating forecasts, and this could then involve the use of religious narratives to communicate climate information to enable adaptation. Religious narratives are already used to promote the uptake of conservation farming practices by movements such as Foundations for Farming (Kassam et al., 2014).

4. Conclusions

For farmers to be better equipped for future climatic conditions they need to be more forward looking in their decisions. To enable this there is need to harness the knowledge and climate information from different groups and have conversations between the developers and holders of place-based and national meteorological forecast information to develop climate information tailored to the local context. This climate information would then need to be translated, disseminated and made accessible using different entry points and narratives to cater for different social groups. The climate information that is communicated also needs to include recommendations of the farming approaches that can be applied in response to predicted climatic conditions to further enable adaptation. Further work is required on how to make climate information credible and useful to different groups of farmers so that they will use it for adapting to climate change. Without this effort some groups of farmers with strong traditional and religious beliefs will not use climate information to adopt new farming approaches and they will remain particularly vulnerable to climate change.

Declaration of Competing Interest

None declared.

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Appendix A. Supplementary data

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