

RESEARCH ARTICLE



Understanding gender differences in availability, accessibility and use of climate information among smallholder farmers in Malawi

Rebecka Henriksson ^a, Katharine Vincent ^{a,b,c}, Emma Archer ^d and Graham Jewitt ^{a,e}

^aCentre for Water Resources Research, University of KwaZulu-Natal, Scottsville, South Africa; ^bKulima Integrated Development Solutions, Pietermaritzburg, South Africa; ^cSchool of Architecture and Planning, University of the Witwatersrand, Wits, South Africa; ^dCentre for Environmental Studies, Department of Geography, Geoinformatics and Meteorology, University of Pretoria, Hatfield, South Africa; ^eDepartment of Water Resources and Ecosystems, IEH Delft Institute for Water Education, Delft, Netherlands

ABSTRACT

Smallholder farmers in the sub-Saharan Africa are vulnerable to climate variability and change, and are thus in need of adaptation. Access to climate information, such as weather forecasts, has been identified as a potential enabler for improved adaptation, but such access tends to be strongly gendered. This study uses qualitative and quantitative data to assess the availability, accessibility and use of climate information among smallholder sugarcane farmers in southern Malawi, disaggregating data according to gender, age, education level and landholding size. We found that radio is the most common, and preferred, means of accessing forecasts for men and women, but that women farmers also prefer to access forecasts through a knowledge broker. Those farmers with higher levels of education (mostly men) prefer to also obtain forecasts via internet and cell phone. Most farmers consider the forecasts reliable, timely and understandable – more so in the case of men than women. Understanding gendered preferences and barriers to climate information access is crucial for benefits of adaptation to be accessed equitably.

ARTICLE HISTORY

Received 4 February 2020
Accepted 31 July 2020

KEYWORDS

Weather forecasts; adaptation; vulnerability; climate change; sugarcane farmers; Chikwawa district



1. Introduction

Access to, and use of, climate information can contribute significantly to adaptation to climate change for the population of sub-Saharan Africa (Singh et al., 2018; Vaughan et al., 2019). Dependency on rain fed agriculture, low water availability, low adaptive capacity, combined with inadequate policies, makes large parts of sub-Saharan Africa particularly vulnerable to climate change (IPCC, 2007; World Bank, 2016). Countries with high levels of poverty, and which are frequently affected by climate extremes are further acutely in need of adaptation (Adger et al., 2003). Here, we focus on Malawi as an example of a country among the least developed in the world, and among the most vulnerable to climate change (World Bank, 2010, 2016). Agriculture is the dominant source of Malawi's export earnings and an important source of employment (Chinsinga, 2017). Smallholder farmers in Malawi produce three quarters of the country's total agricultural output through predominantly rainfed, subsistence agriculture (Asfaw & Maggio, 2018). Particularly in semi-arid areas, food insecurity remains a significant challenge to the population and is likely to be exacerbated in the context of a changing climate (Coulibaly et al., 2015; Kakota et al., 2015).

At local levels in Malawi, women are often more vulnerable to climate change and variability (e.g. Asfaw & Maggio, 2018; Coulibaly et al., 2015; Kakota et al., 2015). Malawian society is highly patriarchal, and gender inequalities are persistent (Asfaw & Maggio, 2018). Kakota et al. (2015), show that,

amongst other determinants, income, land size and access to climate information positively influence households' food security – and thus their potential to adapt to climate change.

The understanding of access to, and use of, weather and climate information in African contexts are emerging, but studies in Malawi are few, scattered, and data is rarely disaggregated on the basis of gender (e.g. Gumucio et al., 2019; Mulwa et al., 2017). The availability, present and preferred means of accessing climate information, as well as how the information is used and perceived among smallholder farmers, remains largely underexplored in Malawi (Gumucio et al., 2019; Vaughan et al., 2019). We aim here to address this gap with empirical data, disaggregated by gender, age, education level and land holding size, from a group of smallholder farmers in southern Malawi. The study uses the example of sugarcane outgrowers, who have a significant part of their land tied up in an outgrower scheme. For smallholder farmers with limited access to land, or reduced agency over the land they possess, it is arguably particularly important to make use of climate information for improved management of the land they have agency over. Climate information can refer to processed data and evidence-based knowledge about the weather and climate generated scientifically at various time scales (hours, days, seasons and longer) and presented as information (as opposed to data) in order to be relevant to the given context (e.g. Singh et al., 2018). Climate information can also be generated through 'the accumulation of experiences over generations, society–

CONTACT Rebecka Henriksson  henrikssonr@ukzn.ac.za  Centre for Water Resources Research, University of KwaZulu-Natal, Private Bag X01, Scottsville 3209, South Africa

 Supplemental data for this article can be accessed at <https://doi.org/10.1080/17565529.2020.1806777>.

© 2020 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group

This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

nature relationships, and community practices and institutions' (Kniveton et al., 2014), referred to as traditional knowledge. We use climate information in broad terms, without specifying the source of this information (e.g. scientific projections or local traditional knowledge) when referring to its potential to improve adaptation. While our focus is the availability and accessibility of scientifically generated climate information at short term (short term and seasonal weather forecast) we acknowledge that smallholder farmers in Malawi may use both scientifically and traditionally generated knowledge about the climate (e.g. Joshua et al., 2017; Nkomwa et al., 2014). Section 2 reviews the literature on climate information and its role in adaptation. Section 3 presents our methodology, outlining the case study context of a sugar outgrower scheme in southern Malawi, and the mixed qualitative and quantitative methods used. Section 4 presents the results, highlighting how gender, age, education level and landholding size influence availability, accessibility and use of climate information (in the form of weather forecasts). Sections 5 and 6 provide a discussion and conclusion, in particular highlighting how the accessibility and comprehensibility of the forecasts may be made more gender-sensitive and equitable, for improved adaptation to climate change among users.

2. Background

2.1. Gender and social differentiation of climate change impacts and adaptation

Climate and environmental change are coupled with a range of social, economic, cultural, political, historical and institutional factors that may enable, or constitute barriers to the adaptive capacity of e.g. individuals, households or communities (Lemos et al., 2012; Shackleton et al., 2015; Smit & Wandel, 2006). Scholars argue that current inequalities and vulnerabilities risk being reinforced in adaptation actions if power imbalances, underlying poverty and unequal access to resources are not considered and addressed (Adger et al., 2005; Jerneck, 2018). It is often shown that women are at a relatively greater risk of experiencing negative impacts of, and face greater barriers to adapt to, climate change (Vincent et al., 2014). Attributed to lower access to e.g. land, farm equipment and finances, and assessed through indices of the components exposure, sensitivity and adaptive capacity, Coulibaly et al. (2015) found that women in Malawi, particularly in the district of Chikwawa where this study is located, are more susceptible to climate impacts than men.

Gender differentiated vulnerabilities are typically due to socially-constructed gender norms that mean women have larger household responsibilities, greater labour burdens on agricultural lands, less access to land and resources and less decision-making power due to power imbalances arising from patriarchal structures (FAO, 2010-11; Jerneck, 2018; Jost et al., 2016; World Health Organization [WHO], 2014). Furthermore, women in Malawi typically have lower levels of education and, thus, fewer employment opportunities than men, and therefore depend more directly on smallholder agriculture for their livelihoods and food security (FAO, 2011; Van den Broeck & Kilic, 2019; Yeboah & Jayne, 2018). Women farmers

in Malawi have been shown to have lower capacity than men to adopt climate-smart agricultural practices, with reasons attributed to education, civil status, agency to land and household decisions as well as access to financial assets (e.g. Khoza et al., 2019; Murray et al., 2016). Shackleton et al. (2015) review the barriers to socially-just climate change adaptation and identify, amongst other gaps, that the understanding of how different social categories (e.g. gender, age, class, ethnicity and ability) intersect remains limited.

Intersectionality as an approach to address multiple dimensions of power, is applied to identify and analyse how combinations of injustices may impact individuals and institutions and alter systems of power and oppression (Djouidi et al., 2016; Kaijser & Kronsell, 2014). Increasing the understanding of these intersecting factors is required to address the range of resulting differential vulnerability to climate change (Djouidi et al., 2016; Kaijser & Kronsell, 2014). In particular, intersectionality challenges the assumption that all people falling in any social group, whether gender, age or ethnicity have uniform levels of vulnerability. We thus argue that an intersectional approach enables context-specific unpacking of the ways in which the relative levels of power intersecting with particular facets of social identity gives rise to multiple dimensions of vulnerability. This adds nuance to a former reliance on assumptions of homogeneity. It enables recognition, for example, that a young adult woman may be less vulnerable than an elderly man, problematizing the overly simplistic assumption that women are universally more vulnerable than men.

2.2. Climate information for adaptation

A range of adaptation strategies related to agricultural practices have been recommended across the developing world, including diversifying crop types and varieties, managing water through soil moisture conservation, rainwater harvesting, and irrigation strategies and altering timing of agricultural activities (Adger et al., 2007; Howden et al., 2007; Vincent et al., 2013). In order for farmers to make informed decisions regarding such agricultural adaptation strategies, access to, and ability to use, weather and climate information is important (Howden et al., 2007; Vincent et al., 2013). Climate information, in the form of seasonal forecasts, helps in planning for strategies to adapt to seasonal variability and to reduce risks; while the short term, daily to weekly forecasts, can be particularly useful in supporting farmers in deciding what farming activities to conduct the very same day or week (Archer, 2003; Singh et al., 2018; Stone & Meinke, 2006; Vincent et al., 2013; Vogel & O'Brien, 2006). For effective use of climate information for adaptation, it needs to be *available* (i.e. supplied) and *accessible* to the farmers (i.e. the farmers need to be able to receive and understand it). Furthermore, the climate information needs to be *useable* for it to be successfully used and taken up (Singh et al., 2018). As in the case of vulnerability and adaptation in general, the accessibility and use of climate information tends to be gendered (e.g. McOmber et al., 2013; Tall et al., 2014), and research is required to understand such gendered effects, as well as ways of amending these imbalances (Gumucio et al., 2019). The following section first outlines the availability of climate information in Malawi, followed by

a discussion on accessibility, and what is required for the information to be equitably accessible and used.

2.3. Availability, accessibility and use of climate information in Malawi

In Malawi, the Department of Climate Change and Meteorological Services (DCCMS) is the national meteorological and hydrological service, and produces daily, 2-day and 5-day weather forecasts (including temperature, rainfall and early warnings if applicable) that are made available on DCCMS's webpage (<https://metmalawi.com/forecasts/forecasts.php>) and disseminated to the public through TV, radio and social media (Masangano et al., 2016). Seasonal forecasts are produced annually in August/September at the Southern African Climate Outlook Forum (and updated mid-season in January), then contextualized first to produce a national seasonal forecast that is made available horizontally to national and vertically to district level government departments, after a national political approval process. The seasonal forecast then disseminates down from District Development Committees, via Area Development Committees, to the Village Development Committees, which in turn is meant to reach out to individual farmers (Masangano et al., 2016; Tembo-Nhlema et al., 2019). While structures are in place for the seasonal forecasts to be filtered down from government departments to the rural farmers, the efforts to downscale the national seasonal forecast to district level, and to provide sector-relevant interpretations and advisories, are often project-based, due to inadequate domestic resources. This means that availability of information is not uniform across the country (Kalanda-Joshua et al., 2011; Masangano et al., 2016; Tembo-Nhlema et al., 2019). Furthermore, since the seasonal forecasts are contingent upon a political process, the seasonal forecasts have been reported to be released late, and are therefore found to be not useful for the farmers (Tembo-Nhlema et al., 2019).

As indicated earlier, the availability of climate information does not guarantee that the information is accessible, useable and successfully used (Archer, 2003; Hewitt et al., 2017; Vaughan et al., 2019). A number of studies have identified factors that influence the accessibility and usability of climate information and weather forecasts by farmers in different contexts (Archer, 2003; Mulwa et al., 2017; Singh et al., 2018). Factors that have been shown to lead to successful use and uptake of forecasts – other than access to land, credit and infrastructure – include language and technical proficiency of the user, and access to a medium through which the information is disseminated (Archer, 2003; Cooper et al., 2008; Patt & Gwata, 2002; Stone & Meinke, 2006; Valdivia et al., 2000; Vogel, 2000). Furthermore, aspects such as belief systems and perceptions have been identified as barriers to uptake of climate science generated information (Osbahr et al., 2011; Singh et al., 2018; Spear et al., 2015). Resonating with many studies globally, studies in Malawi found that combining local traditional knowledge of climate and weather information with that disseminated from the authorities, could be helpful in ensuring locally relevant adaptation strategies and its uptake (Joshua et al., 2017; Nkomwa et al., 2014). Heterogeneity of the potential users of climate information requires efforts to

disseminate the information in such way that it does not overlook or marginalize certain categories of users (e.g. women and elders) (Archer, 2003). If the users of climate information are addressed as undifferentiated, the potential benefits of the information may not be realized by some categories of users and existing inequalities may be exacerbated (Archer, 2003; Carr et al., 2019; Gumucio et al., 2019).

Due to the extent to which factors such as education, literacy and access to assets in general may be gendered, women as a user group are likely to have limited access to climate information and ability to use it in such way that may help support adaptation (Archer, 2003; Gumucio et al., 2019; Jerneck, 2018; Jost et al., 2016; WHO, 2014). Certain user groups may require the information to be visualized, interpreted and communicated in such a way that it is understandable for them, which in turn requires a deeper understanding of those users (Hewitt et al., 2017; Lemos et al., 2012; Vaughan & Dessai, 2014). Boundary agents and knowledge networks, or knowledge brokers, thus play an important role as intermediaries in addressing the gaps in understanding who the users are, what their specific preferences are, and to facilitate the dissemination of climate information and weather forecasts for improved uptake (Cvitanovic et al., 2015; Guido et al., 2016; Tembo-Nhlema et al., 2019). Such an approach may be particularly beneficial at the local scale, as well as in a developing and resource-poor context, where the users are considerably, and increasingly, vulnerable to climate variability, and where deep inequalities persist, such as in the Malawian context (Archer, 2003; Vincent et al., 2014; Vogel & O'Brien, 2006).

In some districts in Malawi, efforts have been made by NGOs and extension services to improve seasonal forecast accessibility and usability by translating them into local languages, and disseminating them to rural farmer communities (Kalanda-Joshua et al., 2011; Masangano et al., 2016; Tembo-Nhlema et al., 2019). Such efforts have also focused on seasonal forecasts through the use of participatory scenario planning in some districts, which has been useful for assisting users in forecast interpretation and use, while also providing an opportunity to integrate the local traditional knowledge relevant to the user group (Tembo-Nhlema et al., 2019). However, as mentioned previously, these efforts tend to be disjointed and ad hoc, and do not benefit all who need them. It should be noted that while scholars call for gendered analysis of climate change effects and responses in general (Alston, 2013; Pearse, 2017), we acknowledge that gender is not the only determinant of differentiated access to climate information. In the next section we describe the case study area and motivate the inclusion of an intersectional approach to gender and age, as well as education level and size of landholdings as factors that may influence the accessibility and use of climate information among the smallholder farmers in this study.

3. Methodology

3.1. Case study area – smallholder sugarcane producers in southern Malawi

This study uses the Kasinthula sugarcane outgrower scheme in Southern Malawi, located in the Chikwawa district in Southern

Malawi, to obtain comprehensive information regarding the contexts of these smallholder farmers relevant to using climate information for adaptation. The farmers (in total 762 farmers, of which one third are women) have signed off 1–3 hectares of their land in lease agreements with the scheme, through which sugarcane is being produced collectively on almost 1500 hectares of irrigated fields. The scheme was established in four phases, during the years 1997, 1998, 2010 and 2012, and involves farmers located in several villages within a few kilometres from the location of the fields. The land leases are administered by a trust (Shire Valley Cane Growers Trust), that established a management company (Kasinthula Cane Growers Limited) responsible for the scheme's agricultural, financial and human resources operations. These two bodies of administration are referred to as 'outgrower management' in this study. Most farmers have additional plots of land outside of the scheme that is not under sugarcane production, and for which they make their own decisions (as opposed to decisions made by the scheme management). We acknowledge that there may be dynamics of intra-household decision making, which means that access to land does not necessarily mean that the person (particularly women) who farms on it makes the decisions on what to farm or what to use the produce for (e.g. Kathewera-Banda et al., 2011). We nevertheless consider this land relevant for this assessment, as it is an asset that provides the farmer (and their household) with some flexibility in choice of livelihood strategies, which could potentially be improved by the use of climate information. We use land size as a proxy for access to land in order to test if land access influences the use of climate information, assuming that the larger the field, the larger the flexibility to use the climate information for improved adaptation.

Henriksson et al., [under review](#), which used the same representative sample group as this study, showed that in general, the farmers have low levels of education, high levels of illiteracy, and only 12.5% of the participants have any form of income (employments, piece jobs or run an independent business). As we mentioned previously, language skills and technical proficiency are important factors for successful use and uptake of forecasts (e.g. Archer, 2003) and our assumption is that those with higher level of education have better language skills and technical proficiency. We therefore test in this study if the use of climate information differ with education level.

The age of the participants in this study range between 17 and 97. Informed by Tembo-Nhlema et al. (2019), who found that the younger participants in participatory scenario planning for dissemination of climate information in Malawi (incl. the Chikwawa district) were better able to use the information for improved adaptation, we further include age as a potential determinant of the use of climate information.

Section 2 outlined that opportunities for adaptation, including accessibility and use of climate information tend to be gendered (e.g. Tall et al., 2014). The study by Henriksson et al., ([under review](#)) identified significant differences between women and men – identifying gendered disadvantages affecting women. These include women having lower education levels, higher levels of illiteracy, being more often divorced or widowed, and having larger family responsibilities. Further, women have considerably fewer opportunities to partake in

decision-making processes compared to men in the Kasinthula outgrower scheme. Reasons for this include underlying power imbalances pertinent in a patriarchal society, inequalities as outlined above, as well as preconceived perceptions of women being less suitable for leadership positions and women being perceived (by both men and women) as inferior and/or incapable of contributing to decision-making (reducing women's participation) (Henriksson et al., [under review](#)).

3.2. Methods and data collection

We address the aim of the study, i.e. to investigate the availability, accessibility, and use of climate information among smallholder sugarcane farmers, by using a mixed-methods approach, combining qualitative and quantitative data collected through in-depth interviews, and a questionnaire survey with farmers within the Kasinthula outgrower scheme ('farmers' and 'outgrowers' are used interchangeably from here on).

A range of methods were applied during two field visits in June and November 2017. In order to understand specifics regarding climate information access and use, initial one hour long in-depth interviews were conducted (June 2017) with four women and four men outgrowers, using an interview questionnaire (Appendix 1). The respondents were selected purposively, and stratified in terms of sex. The respondents (from various phases and villages) were approached by committee representatives, and determined by their availability over the following days. The insights gained from the in-depth interviews were also used in order to develop a questionnaire survey for the second field visit. In November 2017, this questionnaire survey (30 minutes, Appendix 2) was conducted with 136 outgrowers (78 women and 58 men). The respondents were selected randomly from a complete list of the 762 outgrowers, with 20 women and 20 men randomly selected from each of the four phases of scheme establishment (in order to include newer and older members). Assuring participation from the four phases also meant representation from a variety of villages. Not all agreed or were available – an additional 10 women and 10 men were thus randomly selected. Logistical and time constraints limited the total number of participants to 136. The intention was to have equal numbers of men and women, but the final selection largely depended on availability. The in-depth interviews were facilitated by a Malawian research assistant, who provided simultaneous interpretation between English and Chichewa. The questionnaire survey was conducted using the same research assistant, and three other interpreters, who translated between English and Chichewa. The questionnaires were written in English, but simultaneously translated to Chichewa by the interpreter, and the answers given in Chichewa, were transcribed in English onto the questionnaires in the field. Ethical approval from the researchers' host University was obtained for the research, and all data collection was conducted under relevant principles, in terms of informed consent, voluntary withdrawal and confidentiality.

3.3. Data analysis

The responses from the in-depth interviews were analysed using inductive thematic content analysis (Neuendorf, 2019).

After familiarization with the entire data set (both the qualitative and quantitative data), the information was coded according to themes such as gender and equity, adaptation, land agency and climate information availability, access and use. Quotes that confirmed or contradicted the results of the quantitative data were chosen to provide context to the results of the quantitative analysis. The responses from the questionnaire survey were entered, in full or condensed, into a MS Excel spreadsheet. The data was categorized according to the themes of the analysis. Qualitative information from the questionnaire survey was used in the same way as the in-depth interviews. Unpaired t-tests were used to compare gender differences of means where applicable. The chi-square test and/or Fisher's exact test (Bewick et al., 2003), were used to analyse gender differences in regards to occupation (other than farmer), crop field size (other than sugarcane), irrigation, crop types, and number of different crops planted. The chi-square test was further used to establish if the use of daily, 2–10 days and seasonal forecasts (yes or no to any of the forecasts), and current and preferred means of obtaining forecasts, were determined by gender, age, education levels or size of crop fields. The categories with insufficient replies for statistical testing were ignored in the further analysis. The sample size was too small to statistically test if combinations of the factors influenced the responses.

To test if gender, age, education levels and size of crop fields determined if the outgrowers perceived the forecasts as reliable, understandable and timely, we first assured that the categories were large enough for the statistical testing by combining all three types of forecasts, giving scores to the answers (yes = 2, sometimes = 1, no = 0), and then summed the answers for each respondent, for reliability, comprehensibility and timeliness, separately. If the sum of each forecast for one respondent was 0–3 the answer was set to 'no', and if the sum was 4–6, the answer was set to 'yes'. Specific examples include: One respondent perceived daily and seasonal forecasts as reliable and 2–10 days forecasts as reliable sometimes, the answer was summed up to 5, and the combined perception was set to 'yes'. Another respondent perceived seasonal forecasts as not timely, but observed that daily and 2–10 days forecasts were timely sometimes – the combined score was 2, and the perception set to 'no'. To enable chi-square analysis of association, the means of obtaining forecasts were grouped to three categories. Radio, TV and cars with speakers were grouped, as these are forms of broadcast which are delivered at a specific time or schedule, and cannot be revisited once they have been disseminated. Community leaders, NGOs, extensionists and the outgrower management were grouped together, since they provide opportunities to engage with those delivering the forecasts, and assistance in interpreting them can take place. The last group consisted of newspaper, sms, WhatsApp or internet; since these means enable revisiting the information at any preferred time.

4. Results

The farmers have on average 1.3 ha (0–98 ha range) of land in addition to the land farmed through the outgrower scheme. On this land they grow on an average 2.3 different crop types,

including cotton, maize, millet, sorghum, beans, rice and various vegetables. More men than women irrigate their crop fields (25.5% and 8.1% respectively, $p < 0.01$).

While both short term and seasonal forecasts are technically available for all in the Chikwawa district, in that they are produced by the DCCMS and the Southern African Climate Outlook Forum respectively, and made available through public channels, the reality is that they are not accessible to all for a range of reasons. Radio is the most frequently used means of accessing climate information amongst the outgrowers – 83.3% of women and 86.2% of men use radio to obtain daily forecasts (Figure 1(a)). For the 2–10 days and seasonal forecasts, the numbers are 76.9% of women and 82.8% of men, and 71.8% of women and 82.8% of men respectively (Figure 1(b–c)). 9.0% of the women and 10.3% of the men indicate they do not use any of the three forecasts. 14.1% of the women and 6.9% of the men do not use the seasonal forecasts (Figure 1(c)). Gender, age, land size or education level did not explain the means of obtaining daily, 2–10 days or seasonal forecasts, since the respondents were strikingly unanimous, with radio being the dominant response. In contrast to the means through which the forecasts are actually obtained, the preferred means of obtaining forecasts is more diverse, with radio being the most preferred (58.1% of all farmers), followed by community leaders (32.4%), sms (18.4%), outgrower management (9.6%), and extensionists (8.8%) (Figure 1(d)).

Gender, age, land size or education level did not explain the preferred means when calculated per individual means. When the preferred means were grouped into categories, however, there were associations found with gender and education level. Men are more likely than women to prefer obtaining forecasts through the category 'newspaper, SMS, WhatsApp or internet' ($X^2(2, N = 197) = 11.68, p < .001$) (Figure 2(a)). Farmers with the highest education category (10–14 years of education) are more likely to prefer obtaining forecasts through 'newspaper, SMS, WhatsApp or internet' and less likely to prefer 'radio, TV or cars with speakers' ($X^2(4, N = 194) = 15.89, p < .001$) (Figure 2(b)).

Women and men outgrowers indicated that they use the daily, 2–10 days and seasonal forecasts for a number of decisions (Figure 3). The daily forecasts are used to plan and prepare agricultural activities in general, but respondents also indicate that they help to inform specific activities such as land and soil preparation, buying or preparing seeds, as well as deciding whether to plant. The use of 2–10 days forecasts differed to some extent from the daily forecasts, being used more diversely – to decide when over the next coming days to plant, prepare the land and soil, and to buy or prepare seeds. Both women and men outgrowers used seasonal forecasts predominantly for deciding which crops or seed varieties (e.g. drought tolerant or early maturing varieties) to plant, to prepare the land, and to plan for the agricultural activities in general. An additional category of activity for which seasonal forecasts were used (but not the daily or 2–10 days) was to decide whether to extend or reduce the extent of cultivated land. This category was indicated by 10 farmers only (7.7% of the women and 6.9% of the men) – the statistical difference between these groups and the rest thus cannot be established. The sizes of their crop fields are, however, on average higher than those who do not indicate extension or reduction of fields as an activity (women's average 2.1 ha, men's average 1.9 ha).

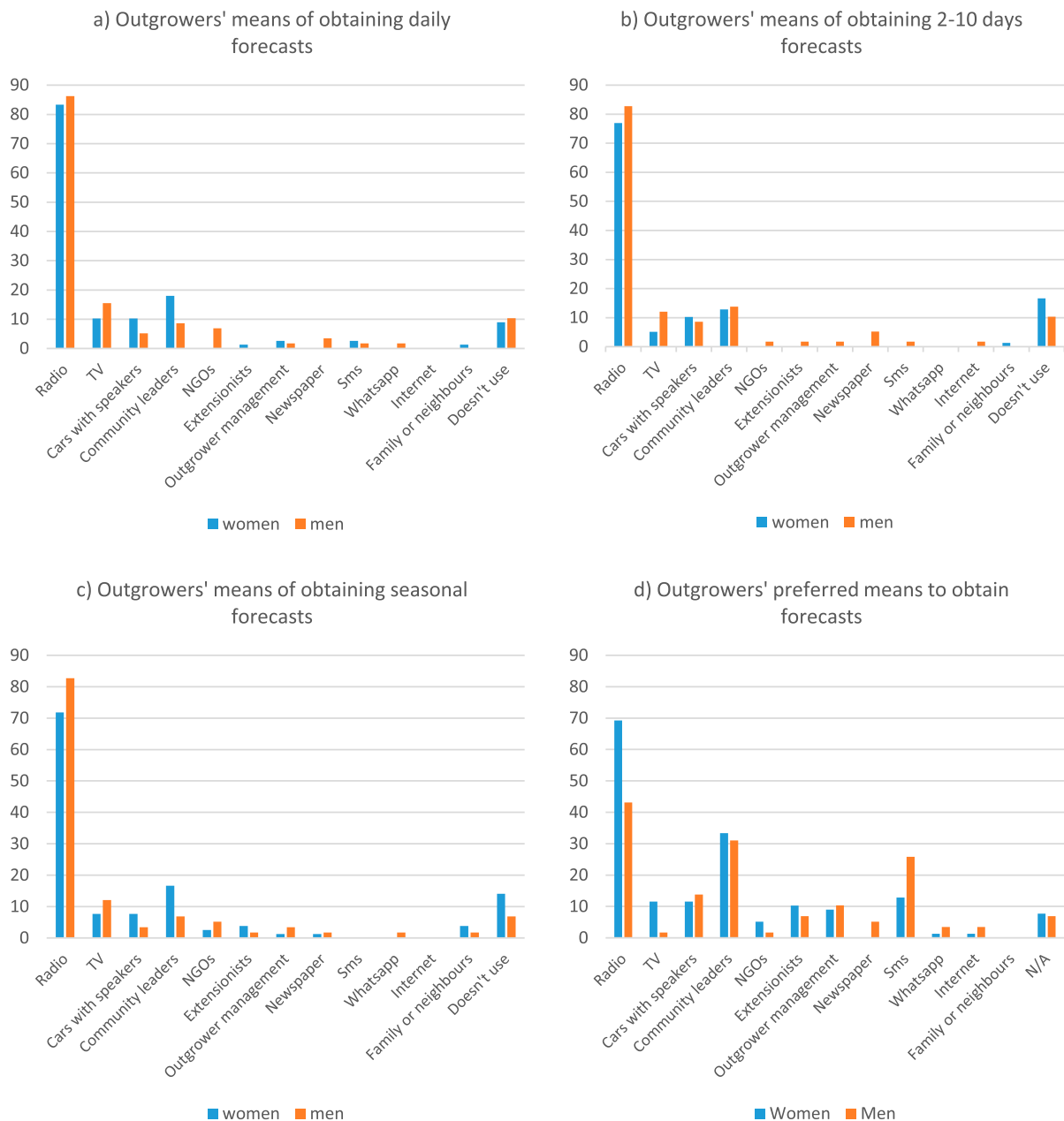


Figure 1. The outgrowers' means of obtaining daily (a), 2–10 days (b) and seasonal (c) forecasts, as well as their preferred means (d).

The outgrowers generally perceive the forecasts as reliable, comprehensible and timely – more so in the case of men than women (Figure 4). The reliability of the forecasts is questioned to a greater degree than in the case of comprehensibility and the timeliness – by women more than men. The daily and the seasonal forecasts are better understood than the 2–10 days forecasts. These results cannot be fully explained statistically by neither gender, age, education level nor land size, as the categories 'no' and 'sometimes' are too small and thus, excluded from the chi-square test.

5. Discussion

Aiming at investigating the availability, accessibility and use of climate information amongst the farmers in Kasinthula sugarcane outgrower scheme, we found that women and men

farmers use mostly radio to obtain daily, 2–10 days and seasonal forecasts. These forecasts are utilized to make decisions for agricultural activities on a day-to-day or weekly basis, or to adapt to next seasons forecasts by planning crop types and varieties, sourcing seeds, preparing the land for irrigation and altering the size of the land under cultivation. While statistical differences could not be established in many of the analyses (often due to categories being too small), the findings nevertheless indicate that the farmers manifest a variety in terms of the use, and perceptions of climate information – and, critically, that women are disadvantaged in several aspects. These findings add to existing literature from other locations in sub-Saharan Africa that show that men had better access to climate information than women (Carr et al., 2016; Carr & Onzere, 2018; Diouf et al., 2019). Among the Kasinthula outgrowers, more than twice as many women (14.1%) as men

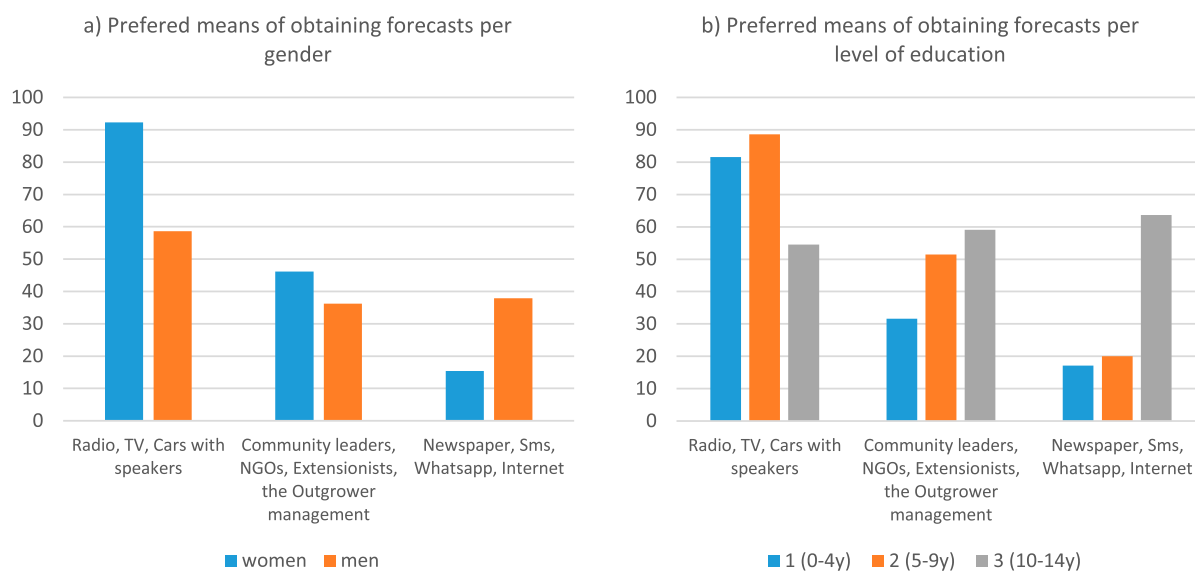


Figure 2. The outgrowers' preferred means of obtaining forecasts per gender (a) and per level of education (b).

(6.9%) do not use, or have no access to, seasonal forecasts at all. In order to better support adaptation, it is necessary to assess, acknowledge and account for this diversity of users.

Understanding the preconditions for the farmers' uptake of climate information is required to tailor the dissemination, as recommended by Archer (2003) and Carr et al. (2016). The heterogeneity of this group is apparent in aspects such as gender, age, education level, civil status and socio-economic capacities. Nuances of such differences, that entail disadvantages for women, were established through in depth-interviews with the farmers. One of the woman farmers who stated she does not use forecasts said: 'My son bought me a radio, but it got stolen and he doesn't have the money to buy a new one. I can no longer get the forecasts like I used to'. Another woman farmer referred to lack of batteries or electricity as a barrier to use her radio. Resonating with the findings by Archer (2003) and Tall et al. (2014), the restriction of time was mentioned by a number of, especially, women, including one who stated: 'I am busy working in the household or out in the field, and not always where my radio is or where the car with the speaker drives around', indicating that she would miss regularly scheduled forecasts due to other commitments. Such statements show that although the forecasts may be available, they are not equitably accessible among women and men farmers. Considerably more women than men are divorced or widowed (Henriksson et al., *under review*), which potentially also reduces the opportunities to obtain forecasts, compared to men – where all but 3% are married and can share the information between spouses.

When assessing the preferred means of obtaining forecasts, the preferences were more diverse than those means which were actually used. While radio was still the most preferred means by women and men, the respondents, especially women, also expressed the wish to obtain forecasts through community leaders, sms, the outgrower management and extensionists. There is thus a clear need to offer a range of choices to access forecasts that allows for flexibility, and which will provide alternatives to radio forecasts that are broadcast at specific times of the day, and cars with speakers

which might not be regular and scheduled (as also found in Tall et al., 2014). Men preferred the category 'newspaper, sms, WhatsApp or internet' more than women. This may be explained by men's higher education and literacy levels, as shown in Henriksson et al. (*under review*), which is confirmed in the analysis, showing that the farmers with the highest education level (10-14 years) also prefer this category. The category 'community leaders, NGOs, extensionists and the outgrower management' is the second most preferred means of obtaining forecasts among farmers. This is likely to reflect the trust that the community members have in their leaders (Dionne, 2012), and could also be attributed to the previously mentioned benefits in getting assistance in interpreting the information (Archer, 2003; Valdivia et al., 2001). These results confirm findings elsewhere that knowledge brokers are particularly important to communicate to women (e.g. Archer, 2003), but highlight that the broker in question varies according to context.

As previously mentioned, Malawi has systems in place for seasonal forecasts to be made available by DCCMS, through local departments and NGOs – but that not all who might make use of the information are currently reached and/or benefiting (Kalanda-Joshua et al., 2011; Masangano et al., 2016; Tembo-Nhlema et al., 2019). Our findings support this observation – women have more limited access to these forecasts than men, and interventions are needed to meet the requirements of the variety of users in the rural communities, especially elders, women and those less educated (who to a greater degree are women). Efforts to provide a wider range of alternative means of accessing forecasts would help address the issue of farmers' lack of ability or time, and allow flexibility amongst the users. Short-term radio forecasts (i.e. daily and 2–10 days), if translated into local languages, as highlighted as a priority also by Kalanda-Joshua et al. (2011), and if broadcast regularly throughout the day, could complement sms and WhatsApp services for those who are able to interpret such information (predominantly men). Having access to such technologies or electronic devices is, however, not a matter of

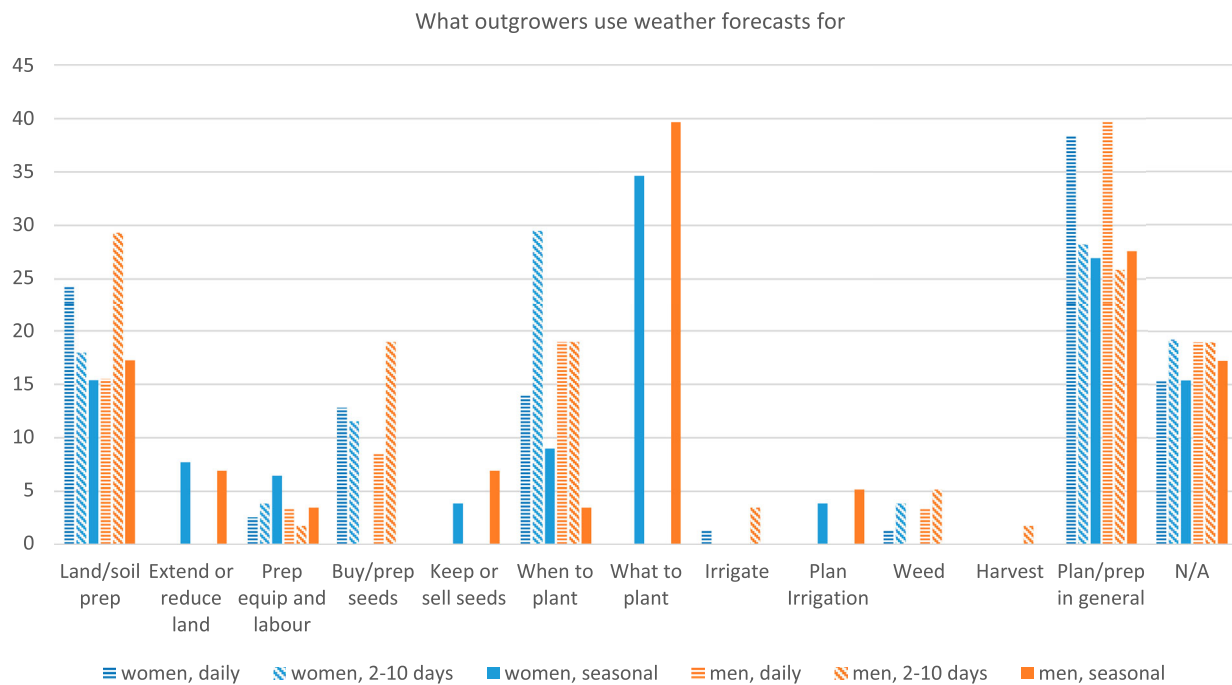


Figure 3. The outgrowers' use of daily, 2–10 days, and seasonal forecasts for decisions of agricultural activities.

course for all, and cannot be uniformly assumed. Access to solar powered and portable radios could overcome certain of these barriers.

For increased use and efficient uptake of the climate information, it is crucial that users find the information reliable, that they understand it, and that it is received on time (Kalanda-Joshua et al., 2011; Tembo-Nhlema et al., 2019). This study found that a majority of the farmers perceive the forecasts as such. For each type of forecast (daily, 2–10 days and seasonal) and each of the characteristics (reliable, comprehensible and timely), it is critical to note, however, that men were more positive than women. This may, as mentioned earlier, also reflect the lower levels of education and literacy among women. In general, the forecasts were deemed reliable less often than they were considered comprehensible and timely. The daily and the seasonal forecasts were better understood than the 2–10 days forecasts, which is not straight-forward to explain.

Fewer women than men (around 80% and 90% for each forecast type, respectively, see Figure 4) state that they understand the forecasts. As highlighted by a number of scholars (e.g. Kalanda-Joshua et al., 2011; Tembo-Nhlema et al., 2019; Vogel & O'Brien, 2006), the gaps in comprehensibility may be explained by the technical terms and concepts used in forecasts, indicating that smallholder farmers, especially those with lower level of education and literacy, would greatly benefit from obtaining training and assistance in interpreting the information. Boundary agents and knowledge networks or brokers can play a significant role in the dissemination of climate information to make it more accessible and comprehensible for end users, as previously discussed and highlighted by other scholars (Cvitanovic et al., 2015; Guido et al., 2016). These organizations have the opportunity to develop a deeper understanding in terms of who the users are and what their specific needs and

preferences are, in order to accommodate disadvantaged groups such as women, those who are less educated, those who are resource poor and elders (Archer, 2003; Kakota et al., 2015). Our results confirm this – the farmers identified the category 'community leaders, NGOs, extensionists and the outgrower management' as the second most preferred means of obtaining forecasts. This reflects the need to provide a platform that can facilitate assistance with interpretation and, likewise, with strategies to use the forecasts for successful adaptation through altering agricultural activities, as also discussed by Mulwa et al. (2017). As mentioned previously (and found also by Cherotich et al., 2012), integrating local traditional knowledge with scientifically generated forecasts may increase the accessibility and uptake by some users. Tembo-Nhlema et al. (2019) found that by receiving training in interpretation of the forecasts and combined with traditional knowledge through participatory scenario planning exercises, both men and women farmers in rural Malawi were able to adapt their agricultural activities in response to the advice they were given.

NGOs or extensionists might in many contexts be the most obvious choice of bodies for an intermediary who is able to support gender-sensitive availability and accessibility of climate information. This particular case study identifies the outgrower management as an additional option. The outgrower management regularly interacts with the farmers, in some cases having done so for decades, and would therefore constitute a potential organization to function as a knowledge broker for the farmers in obtaining forecasts (daily, 2–10 days and seasonal). The outgrower management has access to detailed user profile information of this diverse group of members (and can further assess it in-depth) and, by accommodating the diversity of needs that this group comprises, they can use gendered access preferences to support more equitable access to climate information, and to foster adaptation.

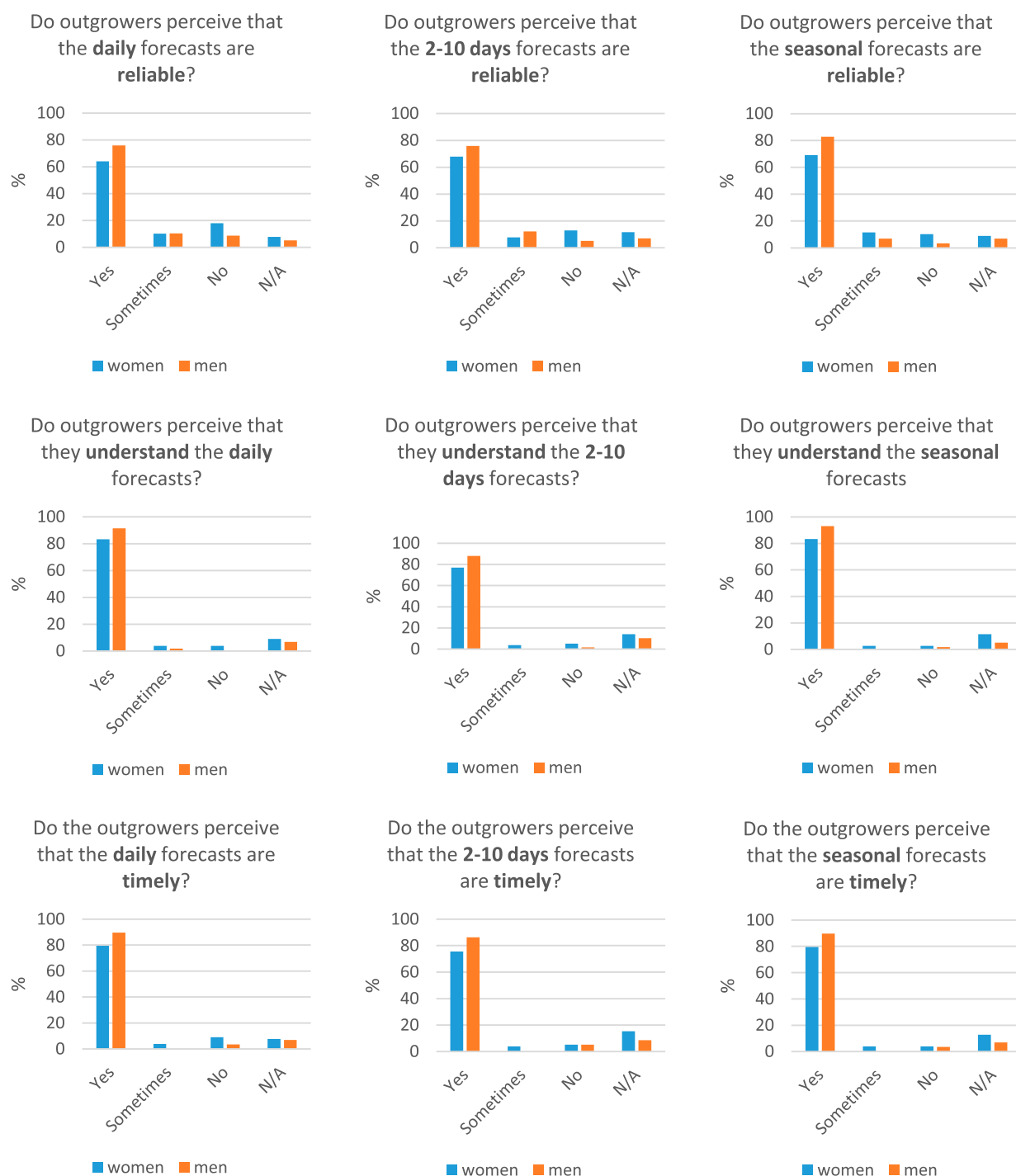


Figure 4. The outgrowers' perceptions of the daily, 2–10 days and seasonal forecasts being reliable, understandable and timely.

Having access to this extra, gender-sensitive, support would be valuable for the outgrowers, particularly the women who, as our results show, are often inadvertently disadvantaged by gender-blind processes. This is likely to be additionally important during years when the sugarcane productivity is low, and the financial benefits from producing sugar are reduced. Ideally, for seasonal forecast dissemination, alongside training in the interpretation and assistance in developing adaptation strategies, should happen in collaboration between the outgrower management, extensionists, NGOs and community leaders, as well as interacting with those structures already in place in

the district that disseminate climate information through participatory scenario planning (Tembo-Nhlema et al., 2019). This corresponds with recommendations by Vogel and O'Brien (2006), who suggest that existing platforms should be used to 'piggy-back' information.

This study provides useful insights into gendered preferences for accessing climate information that is applicable to small-holder farmers in general, particularly in other sub-Saharan African countries with similar contextual vulnerabilities and inequalities, and not exclusively sugarcane outgrowers in Malawi. By further addressing the diversity of needs among

smallholder farmers as a heterogeneous user group, gender inequalities, and disadvantages determined by other factors, can be reduced. We argue that the government, who have the greater responsibility to increase the adaptive capacity of the farmers through equitable access to land, credit, education and information, must address the current institutional and financial constraints that hamper a successful cascade of climate information from the DCCMS to the end users, as discussed by Masangano et al. (2016) and Tembo-Nhlema et al. (2019). NGOs, extensionists or other potential knowledge brokers such as outgrower management bodies, as identified in this study, require governmental support to reach the broad range of potential beneficiaries. Such support includes obtaining sufficient training and facilities to further disseminate information and assist farmers to adapt in response to the information, in order to assure consistent and useful information that is received and used also by the less advantaged users. While the study described here has largely focused on availability and accessibility of the weather forecasts, further research is needed to investigate the usability and utility of the information, as well as detailed assessments on how farmers use the forecasts to improve their adaptation and livelihood strategies.

6. Conclusion

This study shows that the ways in which climate information availability, accessibility and use differ among sugarcane outgrowers in relations to gender, age, education level and land holding size. The findings contribute to an emerging literature that highlights how the diversity of needs and preferences needs to be taken into account in order to ensure equitable access and of climate information to improve adaptation, in a developing country context such as Sub-Saharan Africa and countries similar to Malawi. We found that both access and preferences regarded climate information are gendered, and a more diverse range of options for accessing the forecasts is required to accommodate the specific needs of women. Following radio, men farmers would prefer to obtain forecasts through newspaper, whatsapp, sms or internet. Women's second preference, however, is to obtain forecasts through an organization that can function as a knowledge broker, such as NGOs, extensionists, community leaders or the outgrower management, which is likely attributed to the fact that such interaction enables training and assistance in interpreting the forecasts, as well as guidance in how the forecasts can be used for improved adaptation. Insights from this study can guide governments, NGOs, extensionists and other local organizations such as the outgrower scheme, to further develop existing platforms for gender-sensitive dissemination of climate information to a wide range of beneficiaries. By deepening the understanding of gender preferences and inequitable barriers to access, forecasts can thus be tailored to be successfully used by women, less educated, resource poor and elders, and not only benefit those already advantaged.

Acknowledgements

This work was conducted under the Future Climate For Africa UMFULA project, with financial support from the UK Natural Environment

Research Council (NERC), grant references: NE/M020010/1 (Kulima), NE/M02007X/1 (CSIR), NE/M020134/1 (UKZN), and the UK Government's Department for International Development (DfID). We thank two anonymous reviewers for valuable input. We further thank Stefanie Schütte for performance of statistical data analyses, Dorothy Tembo-Nhlema and Hawa Munganya for support and assistance with field work, and the Kasinthula sugarcane outgrower scheme members for participating in interviews and conversations.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by Natural Environment Research Council (NERC) [grant numbers NE/M020010/1 (Kulima), NE/M02007X/1 (CSIR), NE/M020134/1 (UKZN)], and the Department for International Development UK Government.

Notes on contributors

Rebecka Henriksson is a sustainability scientist with experience in research on gender and equity issues within agricultural landscapes in Southern Africa, specifically smallholder farming systems. Her current focus is decision-making at various levels and factors shaping and influencing the sustainability of land, water and natural resources management.


Katharine Vincent is interested in adaptation to climate change, disaster risk reduction, climate services, and gender. As well as conducting research, Katharine works at the interface between science and policy/practice, ensuring that research findings enable effective and equitable adaptation to climate change, particularly in Africa.

Emma Archer is a geographer, working on sustainable agriculture, managed ecosystems and climate change/variability in southern Africa, as well as on the continent more broadly. She has particular interests in early warning and preparedness, including applied forecasting.

Graham Jewitt is a hydrologist working on integrated resource management solutions, especially in developing countries. He has a particular interest in the effective use of science to better inform land and water resources policy development and developing tools to support the effective implementation of these.

ORCID

Rebecka Henriksson  <http://orcid.org/0000-0002-9949-8851>

Katharine Vincent  <http://orcid.org/0000-0003-3152-1522>

Emma Archer  <http://orcid.org/0000-0002-5374-3866>

Graham Jewitt  <http://orcid.org/0000-0002-7444-7855>

References

- Adger, N. W., Arnell, N. W., & Tompkins, E. L. (2005). Successful adaptation to climate change across scales. *Global Environmental Change*, 15, 77–86. <https://doi.org/10.1016/j.gloenvcha.2004.12.005>
- Adger, W. N., Agrawala, S., Mirza, M. M. Q., Conde, C., O'Brien, K., Pulhin, J., Pulwarty, R., Smit, B., & Takahashi, K. (2007). Assessment of adaptation practices, options, constraints and capacity. *Climate Change 2007: Impacts, Adaptation and Vulnerability*. In M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden & C.E. Hanson (Eds.), *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 717–743), Cambridge University Press.
- Adger, W. N., Huq, S., Brown, K., Conway, D., & Hulme, M. (2003). Adaptation to climate change in the developing world. *Progress in Development Studies*, 3, 179–195. <https://doi.org/10.1191/1464993403ps060oa>

- Alston, M. (2013). Introducing gender and climate change: Research, policy and action. In M. Alston, & K. Whittenbury (Eds.), *Research, action and policy: Addressing the gendered impacts of climate change* (pp. 3–14). Springer. <https://doi.org/10.1007/978-94-007-5518-5>
- Archer, E. R. M. (2003). Identifying underserved end-user groups in the provision of climate information. *Bulletin of the American Meteorological Society*, 84(11), 1525–1532. <https://doi.org/10.1175/BAMS-84-11-1525>
- Asfaw, S., & Maggio, G. (2018). Gender, weather shocks and welfare: Evidence from Malawi. *The Journal of Development Studies*, 54(2), 271–291. <https://doi.org/10.1080/00220388.2017.1283016>
- Bewick, V., Cheek, L., & Ball, J. (2003). Statistics review 8: Qualitative data – tests of association. *Critical Care*, 8(1), 46. <https://doi.org/10.1186/cc2428>
- Carr, E. R., Fleming, G., & Kalala, T. (2016). Understanding women's needs for weather and climate information in agrarian settings: The case of Ngetou Maleck, Senegal. *Weather, Climate, and Society*, 8(3), 247–264. <https://doi.org/10.1175/WCAS-D-15-0075.1>
- Carr, E. R., Goble, R., Rosko, H. M., Vaughan, C., & Hansen, J. (2019). Identifying climate information services users and their needs in Sub-Saharan Africa: A review and learning agenda. *Climate and Development*, 1–19. <https://doi.org/10.1080/17565529.2019.1596061>
- Carr, E. R., & Onzere, S. N. (2018). Really effective (for 15% of the men): Lessons in understanding and addressing user needs in climate services from Mali. *Climate Risk Management*, 22, 82–95. <https://doi.org/10.1016/j.crm.2017.03.002>
- Cherotich, V. K., Saidu, O., & Bebe, O. (2012). Access to climate change information and support services by the vulnerable groups in semi-arid Kenya for adaptive capacity development. *African Crop Science Journal*, 20(Suppl. 2), <https://www.ajol.info/index.php/acsj/article/view/81711>
- Chinsinga, B. (2017). The Green Belt initiative, politics and sugar production in Malawi. *Journal of Southern African Studies*, 43(3), 501–515. <https://doi.org/10.1080/03057070.2016.1211401>
- Cooper, P. J. M., Dimes, J., Rao, K. P. C., Shapiro, B., Shiferaw, B., & Twomlow, S. (2008). Coping better with current climatic variability in the rain-fed farming systems of sub-Saharan Africa: An essential first step in adapting to future climate change? *Agriculture, Ecosystems & Environment*, 126, 24–35. <https://doi.org/10.1016/j.agee.2008.01.007>
- Coulibaly, J. Y., Mbow, C., Weldesemayat Sileshi, G., Beedy, T., Kundhlande, G., & Musau, J. (2015). Mapping vulnerability to climate change in Malawi: Spatial and social differentiation in the Shire River Basin. *American Journal of Climate Change*, 4, 282–294. <https://doi.org/10.4236/ajcc.2015.43023>
- Cvitanovic, C., Hobday, A. J., van Kerkhoff, L., Wilson, S. K., Marshall, N. A., & Dobbs, K. (2015). Improving knowledge exchange among scientists and decision-makers to facilitate the adaptive governance of marine resources: Review of knowledge and research needs. *Ocean and Coastal Management*, 112, 25–35. <https://doi.org/10.1016/j.ocecoaman.2015.05.002>
- Dionne, K. Y. (2012). Local demand for a global intervention: Policy priorities in the time of AIDS. *World Development*, 40(12), 2468–2477. <https://doi.org/10.1016/j.worlddev.2012.05.016>
- Diouf, N. S., Ouedraogo, I., Zougmore, R. B., Ouedraogo, M., Partey, S. T., & Gumucio, T. (2019). Factors influencing gendered access to climate information services for farming in Senegal. *Gender, Technology and Development*, 23(2), 93–110. <https://doi.org/10.1080/09718524.2019.1649790>
- Djoudi, H., Locatelli, B., Vaast, C., Asher, K., Brockhaus, M., & Basnett Sijapati, B. (2016). Beyond dichotomies: Gender and intersecting inequalities in climate change studies. *Ambio*, 45(Suppl. 3), S248–S262. <https://doi.org/10.1007/s13280-016-0825-2>
- FAO. (2010–11). *Women in agriculture – closing the gender gap*. FAO SOFA. <http://www.fao.org/publications/sofa/2010-11/en/>
- FAO. (2011). Gender inequalities in rural employment in Malawi: An overview. Malawi country brief.
- Guido, Z., Rountree, V., Greene, C., Gerlak, A., & Trotman, A. (2016). Connecting climate information producers and users: Boundary organization, knowledge networks, and information brokers at Caribbean climate outlook forums. *Weather, Climate, and Society*, 8, 285–298. <https://doi.org/10.1175/WCAS-D-15-0076.1>
- Gumucio, T., Hansen, J., Huyer, S., & van Huysen, T. (2019). Gender-responsive rural climate services: A review of the literature. *Climate and Development*, 1–14. <https://doi.org/10.1080/17565529.2019.1613216>
- Henriksson, R., Vincent, K., Archer, E., & Schütte, S. (Under Review). Ensuring gender equity for social-ecological resilience and sustainability of smallholder sugarcane production.
- Hewitt, C. D., Stone, R. C., & Tait, A. B. (2017). Improving the use of climate information in decision-making. *Nature Climate Change*, 7, 614–616. <https://doi.org/10.1038/nclimate3378>
- Howden, S. M., Soussana, J., Tubiello, F. N., Chhetri, N., Dunlop, M., & Meinke, H. (2007). Adapting agriculture to climate change. *Proceedings of the National Academy of Sciences of the United States of America (PNAS)*, 104, 19691–19696. <https://doi.org/10.1073/pnas.0701890104>
- IPCC (Intergovernmental Panel on Climate Change). (2007). *Climate change 2007: Synthesis report: A report of the intergovernmental panel on climate change. Contribution of working groups I, II, and III to the fourth assessment report of the intergovernmental panel on climate change*. IPCC.
- Jerneck, A. (2018). Taking gender seriously in climate change adaptation and sustainability science research: Views from feminist debates and sub-Saharan small-scale agriculture. *Sustainability Science*, 13, 403–416. <https://doi.org/10.1007/s11625-017-0464-y>
- Joshua, M., Ngongondo, C., Monjerezi, M., Chipungu, F., & Malidadi, C. (2017). Relevance of indigenous knowledge in weather and climate forecasts for agricultural adaptation to climate variability and change in Malawi. In P. L. Mafongoya, & O. C. Ajayi (Eds.), *Indigenous knowledge systems and climate change management in Africa* (pp. 316). CTA.
- Jost, C., Kyazze, F., Naab, J., Neelormi, S., Kinyangi, J., Zougmore, R., Aggarwal, P., Bhatta, G., Chaudhury, M., Tapio-Bistrom, M. L., Nelson, S., & Kristjanson, P. (2016). Understanding gender dimensions of agriculture and climate change in smallholder farming communities. *Climate and Development*, 8(2), 133–144. <https://doi.org/10.1080/17565529.2015.1050978>
- Kaijser, A., & Kronsell, A. (2014). Climate change through the lens of intersectionality. *Environmental Politics*, 23(3), 417–433. <https://doi.org/10.1080/09644016.2013.835203>
- Kakota, T., Nyariki, D., Mkwambisi, D., & Kogi-Makau, W. (2015). Determinants of household vulnerability to food insecurity: A case study of semi-arid districts in Malawi. *Journal of International Development*, 27, 73–84. <https://doi.org/10.1002/jid.2958>
- Kalanda-Joshua, M., Ngongondo, C., Chipeta, L., & Mpem-beka, F. (2011). Integrating indigenous knowledge with conventional science: Enhancing localized climate and weather forecasts in Nessa, Mulanje, Malawi. *Physics and Chemistry of the Earth*, 36, 996–1003. <https://doi.org/10.1016/j.pce.2011.08.001>
- Kathewera-Banda, M., Kamanga-Njikho, V., Malera, G., Mauluka, G., Kamwano Mazinga, M., & Ndhlovu, S. (2011). *Women's access to land and household bargaining power: A comparative action research project in patrilineal and matrilineal societies in Malawi*. Brief project paper. Women's Legal Resources Centre.
- Khoza, S., Van Niekerk, D., & Nema-konde, L. D. (2019). Understanding gender dimensions of climate-smart agriculture adoption in disaster-prone smallholder farming communities in Malawi and Zambia. *Disaster Prevention and Management*, 28(5), 530–547. <https://doi.org/10.1108/DPM-10-2018-0347>
- Kniveton, D., Visman, E., Tall, A., Diop, M., Ewbank, R., Njoroge, E., & Pearson, L. (2014). Dealing with uncertainty: Integrating local and scientific knowledge of the climate and weather. *Disasters*, 39(1), 35–53. <https://doi.org/10.1111/disa.12108>
- Lemos, M. C., Kirchhoff, C. J., & Ramprasad, V. (2012). Narrowing the climate information usability gap. *Nature Climate Change*, 2(11), 789. <https://doi.org/10.1038/NCLIMATE1614>
- Masangano, C. M., Kakota, T., Tostensen, A., & Mkwaila, W. (2016). *Institutional landscape for climate services development and delivery in Malawi*. Report. Lilongwe University of Agriculture and Natural

- Resources (LUANAR) and the Chr. Michelsen Institute (CMI). Global Framework for Climate Services Adaptation Programme in Africa.
- McOmber, C., Panikowski, A., McKune, S., Bartels, W., & Russo, S. (2013). *Investigating climate information services through a gendered lens*. CCAFS Working Paper no. 42. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). www.ccafs.cgiar.org
- Mulwa, C., Marenya, P., Bahadur Rahut, D., & Kassie, M. (2017). Response to climate risks among smallholder farmers in Malawi: A multivariate probit assessment of the role of information, household demographics, and farm characteristics. *Climate Risk Management*, 16, 208–221. <https://doi.org/10.1016/j.crm.2017.01.002>
- Murray, U., Gebremedhin, Z., Brychkova, G., & Spillane, C. (2016). Smallholder farmers and climate smart agriculture: Technology and labor-productivity constraints amongst women smallholders in Malawi. *Gender, Technology and Development*, 20(2), 117–148. <https://doi.org/10.1177/0971852416640639>
- Neuendorf, K. A. (2019). Content analysis and thematic analysis. In P. Brough (Ed.), *Research methods for applied psychologists: Design, analysis and reporting* (pp. 211–223). Routledge.
- Nkomwa, E. C., Joshua, M. K., Ngongondo, C., Monjerezi, M., & Chipungu, F. (2014). Assessing indigenous knowledge systems and climate change adaptation strategies in agriculture: A case study of Chagaka Village, Chikhwawa, Southern Malawi. *Physics and Chemistry of the Earth, Parts A/B/C*, 67–69, 164–172. <https://doi.org/10.1016/j.pce.2013.10.002>
- Osbahr, H., Dorward, P., Stern, R., & Cooper, S. (2011). Supporting agricultural innovation in Uganda to respond to climate risk: Linking climate change and variability with farmer perceptions. *Experimental Agriculture*, 47(02), 293–316. <https://doi.org/10.1017/S0014479710000785>
- Patt, A., & Gwata, C. (2002). Effective seasonal climate forecast applications: Examining constraints for subsistence farmers in Zimbabwe. *Global Environmental Change*, 12, 185–195. [https://doi.org/10.1016/S0959-3780\(02\)00013-4](https://doi.org/10.1016/S0959-3780(02)00013-4)
- Pearse, R. (2017). Gender and climate change. *WIREs Climate Change*, 8, e451. <https://doi.org/10.1002/wcc.451>
- Shackleton, S., Ziervogel, G., Sallu, S., Gill, T., & Tschakert, P. (2015). Why is socially-just climate change adaptation in sub-Saharan Africa so challenging? A review of barriers identified from empirical cases. *WIREs Climate Change*, <https://doi.org/10.1002/wcc.335>
- Singh, C., Daron, J., Bazaz, A., Ziervogel, G., Spear, D., Krishnaswamy, J., Zaroug, M., & Kituyi, E. (2018). The utility of weather and climate information for adaptation decision-making: Current uses and future prospects in Africa and India. *Climate and Development*, 10(5), 389–405. <https://doi.org/10.1080/17565529.2017.1318744>
- Smit, B., & Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. *Global Environmental Change*, 16(3), 282–292. <https://doi.org/10.1016/j.gloenvcha.2006.03.008>
- Spear, D., Baudoin, M.-A., Hegga, S., Zaroug, M., Okeyo, A., & Haimbili, E. (2015). *Vulnerability and adaptation to climate change in semi-arid areas in Southern Africa. Adaptation at scale in semi-arid regions (ASSAR), ASSAR working paper*. University of Cape Town.
- Stone, R. C., & Meinke, H. (2006). Weather, climate and farmers: And overview. *Meteorological Applications*, 13, 7–20. <https://doi.org/10.1017/S1350482706002519>
- Tall, A., Kristjanson, P., Chaudhury, M., McKune, S., & Zougmore, R. (2014). *Who gets the information? Gender, power and equity considerations in the design of climate services for farmers*. CCAFS Working Paper No. 89. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). www.ccafs.cgiar.org
- Tembo-Nhlema, D., Vincent, K., & Henriksson Malinga, R. (2019). *Creating useful and usable weather and climate information – Insights from Participatory Scenario Planning in Malawi*. Working Paper No. 357, Centre for Climate Change Economics and Policy/ Working Paper No. 325, Grantham Research Institute on Climate Change and the Environment, London School of Economics and Political Sciences.
- Valdivia, C., Gilles, J., Espejo, R., & Carrillo, R. (2001). Current users and diffusion nodes of local climate forecasts in the Andes of Bolivia: Lessons on potential users, timing, and content for climate forecast communications. In *Proc. communication of climate forecast information workshop* (pp. 44–45). International Research Institute for Climate Prediction.
- Valdivia, C., Gilles, J. L., & Materer, S. (2000). Climate variability, a producer of typology and the use of forecasts: Experience from Andean semi-arid smallholder producers. In *Proc. int. forum on climate prediction, agriculture and development* (pp. 227–239). International Research Institute for Climate Prediction.
- Van den Broeck, G., & Kilic, T. (2019). Dynamics of off-farm employment in Sub-Saharan Africa: A gender perspective. *World Development*, 119, 81–99. <https://doi.org/10.1016/j.worlddev.2019.03.008>
- Vaughan, C., & Dessai, S. (2014). Climate services for society: Origins, institutional arrangements, and design elements for an evaluation framework. *WIREs Climate Change*, 5, 587–603. <https://doi.org/10.1002/wcc.290>
- Vaughan, C., Hansen, J., Roudier, P., Watkiss, P., & Carr, E. (2019). Evaluating agricultural weather and climate services in Africa: Evidence, methods, and a ‘learning agenda’. *Wiley Interdisciplinary Reviews: Climate Change*, <https://doi.org/10.1002/wcc.586>
- Vincent, K., Cull, T., Chanika, D., Hamazakaza, P., Joubert, A., Macome, E., & Mutohodza-Davies, C. (2013). Farmers’ responses to climate variability and change in Southern Africa – is it coping or adaptation? *Climate and Development*, 5(3), 194–205. <https://doi.org/10.1080/17565529.2013.821052>
- Vincent, K., Tschakert, P., Barnett, J., Rivera-Ferre, M. G., & Woodward, A. (2014). Cross-chapter box on gender and climate change. In C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, M. Chatterjee, K. L. Ebi, Y. O. Estrada, R. C. Genove, B. Girma, E. S. Kissel, A. N. Levy, S. MacCracken, P. R. Mastrandrea, & L. L. White (Eds.), *Climate change 2014: Impacts, adaptation, and vulnerability. Part A: Global and sectoral aspects. Contribution of working group II to the fifth assessment report of the intergovernmental panel on climate change* (pp. 105–107). Cambridge University Press.
- Vogel, C. (2000). Usable science: An assessment of long-term seasonal forecasts amongst farmers in rural areas of South Africa. *South African Geographical Journal*, 82(2), 107–116. <https://doi.org/10.1080/03736245.2000.9713700>
- Vogel, C., & O’Brien, K. (2006). Who can eat information? Examining the effectiveness of seasonal climate forecasts and regional climate-risk management strategies. *Climate Research*, 33, 111–122. <https://doi.org/10.3354/cr033111>
- World Bank. (2010). *Social dimensions of climate change: Equity and vulnerability in a warming world*.
- World Bank. (2016). *Absorbing shocks, building resilience*. Malawi Economic Monitor, 38 p.
- World Health Organization (WHO). (2014). *Gender, climate change and health*.
- Yeboah, F. K., & Jayne, T. S. (2018). Africa’s evolving employment trends. *The Journal of Development Studies*, 54(5), 803–832. <https://doi.org/10.1080/00220388.2018.1430767>