



GENDER RESPONSIVE RURAL CLIMATE SERVICES: A REVIEW OF THE LITERATURE



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Gender-Responsive Rural Climate Services: A Review of the Literature

A Learning Agenda for Climate Information Services in sub-Saharan Africa

DISCLAIMER

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ACRONYMS AND ABBREVIATIONS

CCAFS	CGIAR Research Program on Climate Change, Agriculture and Food Security
GFCS	Global Framework for Climate Services
ICT	Information and Communication Technology
IPCC	Intergovernmental Panel on Climate Change
LIG	Livelihood as Intimate Government
NMS	National Meteorological Services
PAR	Participatory Action Research
PICSA	Participatory Integrated Climate Services for Agriculture
WCC-3	World Climate Conference-3

EXECUTIVE SUMMARY

Gender considerations can critically influence smallholder farmers' access and capacity to act on weather and climate information, as well as subsequent livelihood benefits. The present paper reviews the existing knowledge base on gender equality challenges in climate services to assess these gender-based differences and identify promising pathways for making climate services more responsive to the needs of rural women. Findings from the review highlight that existing research is limited; nonetheless, studies indicate that differential access to peer groups and networks and to ICTs can be significant factors limiting women's access to weather and climate information. Socio-cultural norms that define women's and men's labor roles can also influence the resources and decisions under women's and men's control, affecting their differing climate information needs and demand, also. Potential ways forward suggested by the literature are: (1) including women's groups and networks in climate information delivery; (2) developing ICTs that respond to women's preferences; meeting women's climate information needs; and pursuing cross-sectoral collaboration. Research opportunities include analysis of the potential for women's and mixed-gender groups to enhance women's access to climate information; evaluation of what combinations of communication processes improve women's understanding of and action on climate information; and further connection with the body of knowledge on intra-household decision-making processes.

INTRODUCTION

The use of weather and climate information to understand and manage risk is well-established within agricultural research and practice. Growing concern about the impacts of climate change has increased attention to the role of climate information for building resilience to risk and adapting to change. Because increases in atmospheric greenhouse gas concentrations and resulting changes in the Earth's heat balance interact with natural climate variability, climate change is experienced largely as shifts in the frequency and severity of extreme events. Evidence points to increasing risk from extreme events – including drought, flooding from extreme precipitation and coastal storm surge, and heat waves – in much of the developing world (IPCC, 2012; IPCC, 2014). Extreme events erode livelihoods through loss of productive assets, while the uncertainty associated with climate variability is a disincentive to investing in agricultural innovation (Carter & Barrett, 2006; Maccini & Yang, 2009; Morduch, 1994; Dercon, 1996; Simtowe, 2006). Within farming communities, the impacts are borne disproportionately by the relatively poor (Rosenzweig & Binswanger, 1993; Zimmerman & Carter, 2003).

“Climate services” refers to the “production, translation, transfer, and use of climate knowledge and information in climate-informed decision making and climate-smart policy and planning” (Climate Services Partnership, <http://www.climate-services.org/about-us/what-are-climate-services/>). Although there is a rich body of research on use of climate information for agriculture, the term became widely used only after the World Climate Conference-3 (WCC-3), held in Geneva in 2009, formalized the concept and endorsed the creation of the UN Global Framework for Climate Services (GFCS) (http://www.wmo.int/gfcs/wcc_3; Zebiak et al., 2014). Within an enabling environment, climate information and advisories allow farmers to understand risks, anticipate and manage extreme events, take advantage of favorable climate conditions, and adapt to change. Increasing investment in the quality and relevance of climate-related information is expanding the range of options available for making smallholder agriculture more resilient and prosperous in the face of climate risk.

Recognizing that farmers are not homogeneous, climate service funders, implementers and researchers are raising concerns about the distribution of benefits – to rural women, and socially- or economically-disadvantaged groups. While climate services can be a promising means of empowerment and resilience building for rural women, they risk reinforcing the gender-based inequalities that are prevalent in other institutional structures (Perez et al., 2015; Carr & Owusu-Daaku, 2016; Carr & Onzere, 2017) if they fail to understand and effectively target the needs of women.

The paper reviews and assesses the existing knowledge base on gender equality challenges in climate services. Specific objectives are to: i) assess the evidence about gender-based differences in access, use and benefits from climate services for farmers in the developing world; and ii) identify promising pathways for making climate services more responsive to the needs of rural women. Although prioritizing gender responsiveness as the most feasible goal, the paper also seeks to suggest potential for gender transformation where possible.¹

The following section presents the methods used for the literature review. The paper then explains the results from the review, according to gender dynamics surrounding climate services access, use and benefits. It is important to highlight that, while the review recognizes that gender is manifested as a continuum, existing research on gender and rural climate services tend to approach gender as a binary. Consequently, there is a lack of research that takes into account challenges experienced by users according to sexual orientation and gender identity and constitutes a blatant knowledge gap to be addressed. Due to limitations within the current body of literature, the present paper assesses gender-based challenges in climate services as these concern the differing limitations and restrictions that women and men may experience, without differentiation along dimensions of sexual orientation or gender identity. Following the presentation of results, potential pathways for achieving gender-responsive climate services are

¹ A gender-responsive approach seeks to address the different needs and priorities of women and men; while a gender-transformative approach goes a step further and aims to influence the social norms and systems undergirding gender inequalities (Kabeer & Subrahmanian, 1996; Hillenbrand, Karim, Mohanraj & Wu, 2015).

discussed, according to gender-based challenges found in the literature. The paper then identifies knowledge gaps and opportunities for future research on gender and climate services.

METHODS

In addition to making use of online search engines such as Web of Knowledge, Science Direct, and Google Scholar, documents were identified via the authors' professional networks. The search limited itself to peer-reviewed publications and grey literature published from 2000-2018 that included empirical results from sectors related to agriculture, food security, and rural development. The grey literature included was limited to organizations that are known to have expertise in climate services, gender and evaluation, including the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

Evidence from the publications was categorized and analyzed according to whether gender-related factors influenced i) access, ii) use, or iii) benefit from climate services. Climate services benefit a farm or pastoral household when the information is accessed and used to modify climate-sensitive agricultural or livelihood decisions in a manner that improves livelihoods, food security or some other objective of the household. Climate services can also benefit women and men farmers at an individual level, for example, by helping to increase confidence in decision-making and to enhance ability to cope. Access to relevant information is a prerequisite for its use in decision-making, which is a prerequisite for benefit. It is important to recognize, as well, that the degree to which climate-sensitive decisions are under rural women's and men's control can influence their capacity to put climate information to use. However, the extent of their role in climate-sensitive decision-making can also condition their demand for the information, and hence the likelihood that they will exercise agency to access it. In this way, an important feedback loop exists between use and access. Gender-related factors have the potential to influence the value of climate services by enabling or constraining the degree of benefit from improved management decisions, capacity to use information to improve management, or access to climate-related information.

RESULTS

In total, 43 publications were included in the review. Almost all of the studies, 37, address sub-Saharan Africa. Eight treat countries from South Asia. Oceania and Northeast Africa are addressed minimally, in multi-country studies only.² From the countries of the Sub-Saharan African region, Uganda is addressed most frequently in the literature, eight times, followed by Tanzania with six publications (See Figure 1). Senegal, Ghana and Kenya follow as frequent foci of research, each addressed five times.

Most (30) of the publications address access, while 18 studies explore use. Benefits perceived from climate services is an area much understudied in the literature, addressed by just six publications.

It is important to highlight the variation of data collection methods used across studies, as they can have important implications for the gender results reported by the publications. While the methods are not always made explicit in all of the publications, the source of data collection tends to vary, thereby determining the gender analysis possible.

In particular, gender analysis can be limited for those studies that collect information from the household head only. This is due to the tendency for women to play the role of spouse or partner to the household head rather than household head themselves; consequently, research focused on the household head effectively excludes assessment of the situation of a significant group of women (Doss & Kieran, 2014; Doss, 2001). Furthermore, women household heads can often face a decision-making and bargaining context distinct from that of women non-household heads; the household and farm labor roles they carry out and the time poverty they experience can differ, as well. These distinctions can have important implications for women farmers' capacity to access, use and benefit from climate services. In this review, a small group of studies notes the unit of analysis as the household head

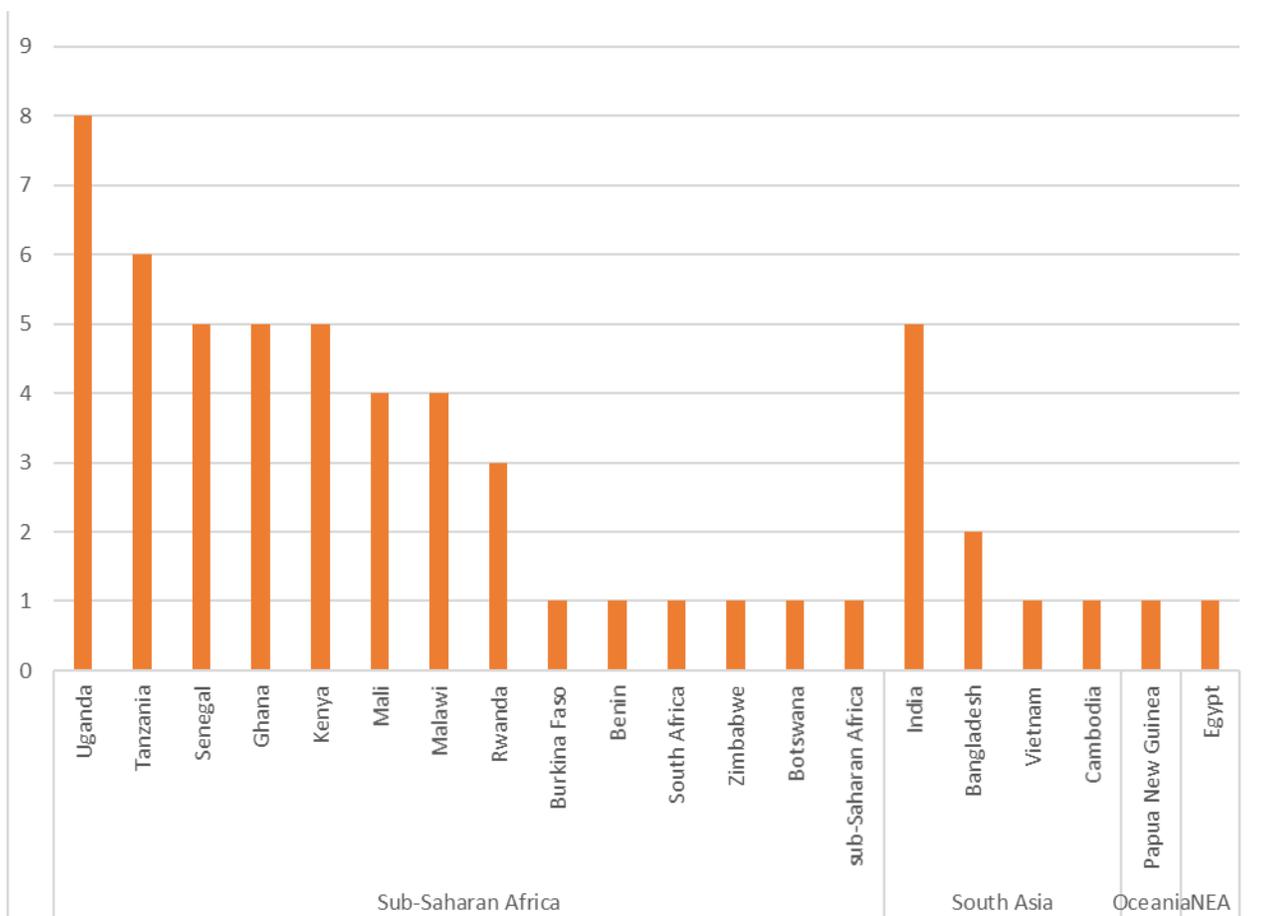
² Several of the publications were multi-country studies, including countries from different regions.

(Coulibaly et al., 2015a; Coulibaly, Kundhlande, Tall, Kaur, & Hansen, 2015b; Rao et al., 2015; Tall, Kaur, Hansen, & Halperin, 2015a; Tall A., Kaur, H., Hansen, J., & Halperin, 2015b).

Recognizing the importance of intra-household gender dynamics, a few studies collect data from both women and men primary decision-makers or spouses from within each household (Twyman et al., 2014; Ngigi, Mueller, & Birner, 2017). While the present review paper does not assess further the significance of data collection methods for research findings reported, it can be important to consider how varying data collection methods can make it difficult to compare studies directly, when observing results across studies in the sections that follow.

The next sections discuss trends found in the literature concerning gendered access, use and benefits from climate services. Each section begins with a review of women’s and men’s rates of access, use or benefits, as reported by those studies that do not include analysis of the possible explanatory factors; followed by discussion of influences on gendered access and use,³ as identified in other publications.

Figure 1. Countries represented in the literature per # of publications



³ No studies address possible factors influencing gender differences in benefits.

Gender differences in access

Whether farmers access particular climate-related information products is determined by the types of information products that the national meteorological service and other providers make available, by access to the communication channels used to disseminate them, and by demand for the information. While a subset of publications provides information related to gendered rates of access with limited explanation of related factors, a significant portion of the research on gendered access focuses on gender factors that influence access to several types of communication channels that are or could be used for climate services. In this way, the existing literature on gendered access tends to address primarily the second aspect of access mentioned above, concerning accessibility. Much less is analyzed concerning the demand aspect of access. It is important to highlight that each of the different communication channels discussed should not be considered as substitutes for each other; rather, each is appropriate for certain situations and types of climate information.

Gendered rates of access

Table 1 summarizes sex-disaggregated rates of access to particular types of weather and climate information found in publications included in the review. As many comprise baseline survey reports, they tend to not include significant analysis of the factors that might account for differences and similarities in rates of access by women and men. Additionally, it is important to note that all studies referenced in Table 1 concern climate information commonly available; they were not carried out in the context of interventions designed to enhance smallholder access to weather and climate information.

Although the data may suggest in some instances that men access weather and climate information more than women, the range of studies may be too narrow to support this as a generalization. For example, men may tend to access weather and climate information more than women across CCAFS Climate-Smart Villages⁴ in Uganda, Kenya and Senegal, and in several instances the difference is significant (Twyman et al., 2014). In several other research sites in Rwanda, men tend to access different types of weather and climate information more than women, as well (Coulibaly, Birachi, Kagabo, & Mutua, 2017). In contrast, studies in Tanzania and Malawi found that the rates of access between women and men are often similar, although in a few cases men may access information more (Coulibaly et al., 2015a; Coulibaly et al., 2015b).

With respect to type of climate information, men significantly access information on droughts more than women across Climate-Smart Village sites in Kenya and Uganda (Twyman et al., 2014). Similarly, research across three agro-ecological zones in Kenya involving husbands and wives of the same household found that men tend to have more access to early warning information for events such as droughts and floods; however, women tend to have more access to weather forecasts (Ngigi et al., 2017).

While the studies presented in Table 1 do not assess explanatory factors, other studies included in the review highlight factors related to differences in access to particular communication channels, primarily involving group processes and ICTs, as influences on gendered access to weather and climate information. The following sections analyze these findings.

⁴ Climate Smart Villages are territories distinguished by high-climatic risk and wherein CCAFS partners have established strong links with local communities. Community representatives and researchers together decide upon climate smart agricultural options best-suited to put into practice in the Village, in an ongoing participatory process of piloting, discussion and evaluation (<https://ccaafs.cgiar.org/climate-smart-villages#.WyO5cUxFxXI>).

Table 2. Types of climate information received by women (W) and men (M)

Statistically significant: More men than women access information

Statistically significant: More women than men access information

Study	Location	Sample size		Weather forecast		Seasonal forecast		Onset forecast		Pest, disease early warning		Extreme event forecast		Drought early warning		Historical data	
		W	M	W	M	W	M	W	M	W	M	W	M	W	M	W	M
Twyman et al., 2014	Nyando, Kenya	200	200	45%	75%	40%	80%	91%	91%					70%	85%		
	Wote, Kenya	175	176	36%	41%	92%	88%	98%	97%					43%	92%		
	Rakai, Uganda	187	155	37%	91%	80%	81%	73%	83%					64%	78%		
	Kaffrine, Senegal	323	200	55%	61%	64%	67%	65%	83%					20%	23%		
Coulibaly et al., 2017	Eastern province, Rwanda	396	318	23%	28%	32%	38%	30%	38%	7%	9%	15%	24%	20%	26%	5%	2%
	Kigali province, Rwanda	161	144	7%	17%	20%	28%	4%	14%	2%	6%	2%	11%	3%	7%	0%	0%
	Northern province, Rwanda	235	274	9%	14%	16%	22%	15%	21%	5%	5%	9%	14%	9%	5%	3%	4%
	Southern province, Rwanda	410	398	5%	9%	16%	27%	16%	25%	6%	10%	12%	20%	9%	9%	0%	2%
	Western province, Rwanda	390	320	9%	18%	13%	24%	16%	26%	6%	11%	13%	21%	6%	12%	2%	4%
Coulibaly et al., 2015a	Kiteto district, Tanzania	NA	NA	9%	14%	9%	15%	38%	42%	9%	10%	38%	43%				
	Longido district, Tanzania	NA	NA	0%	10%	5%	8%	48%	27%	5%	7%	36%	23%				
Coulibaly et al., 2015b	Lilongue district, Malawi	NA	NA	57%	66%	29%	49%	57%	74%	29%	24%	71%	81%				
	Nsanje district, Malawi	NA	NA	52%	59%	44%	47%	76%	76%	28%	53%	80%	79%				
	Zomba district, Malawi	NA	NA	28%	59%	26%	48%	61%	83%	26%	40%	54%	70%				
Ngigi et al., 2017	6 districts, Kenya	156	156	63%	45%	30%	26%							26%	38%		

Biased institutions and differences in group participation and networks

Peer groups and networks can serve as important means for the flow of useful climate knowledge (Meinke et al., 2006). Furthermore, group-based approaches can help farmers share knowledge and build resilience to climate risk (Ngigi et al., 2017). Notwithstanding the utility of group-based approaches, it is important to recognize that culturally-entrenched normative beliefs about women's and men's roles can limit who is able to meaningfully access certain groups and networks. Additionally, it often occurs that strong male biases can undergird the structures of external and local organizations targeting agricultural production and food security in climate-challenged regions, such that women are restricted from participating in the group processes these institutions promote (Perez et al., 2015; Cramer, Forch, Mutie, & Thornton, 2016).

Several studies included in the review show that socio-cultural norms that define women's and men's proper spaces and responsibilities can limit women's access to important dissemination locations of agro-climatic information. For instance, research in Tanzania and Burkina Faso demonstrate that women are often restricted from participating in agro-advisory services trainings and meetings due to norms that associate public meeting participation with men and restrict cross-gender interaction in public spaces (CICERO, 2018; Roncoli et al., 2009; Roncoli, Ingram, Kirshen, & Jost, 2003). Ethnicity can play a significant role as well, with gender-differentiated access to public meetings varying among ethnic groups. Socio-culturally embedded norms can also influence mobility; for example, in India and Zimbabwe, greater mobility restrictions on women inhibit their capacity to access agro-advisory and extension services at far distances from farmers' villages (Venkatasubramanian, Tall, Hansen, & Aggarwal, 2014; Zamasiya, Nyikahadzo, & Mukamuri, 2017). In contrast, when extension agents are able to travel to local communities and when sources of information and services are located within the village, women's capacity to access weather and climate information is enhanced (Venkatasubramanian et al., 2014; Rengalakshmi, Manjula & Devaraj, 2018). Due to socio-culturally defined beliefs surrounding women's and men's proper places and activities, women can prefer to receive weather and climate information from sources familiar to them (like Village Knowledge Centers in India as discussed by Rengalakshmi et al. (2018)) and at places they frequent (e.g., prayer meetings and water boreholes, as discussed by Roncoli et al. (2009) and Tall, Kristjanson, Chaudhury, McKune, and Zougmore (2014c)).

Moreover, the literature reviewed suggests that farmers' group requirements that disadvantage women can limit women's access to agro-climatic information. This resonates with other agricultural research (Mudege, Chevo, Nyekanyeka, Kapalasa, & Demo, 2015; Mudege, Mdege, Abidin, & Bhatasara, 2017; Manfre et al., 2013) demonstrating that, while extension services may seek to enhance reach via coordination with local groups, women may be underserved via this channel due to land ownership and fee-based criteria that may tend to exclude them from membership-based groups such as producer associations or cooperatives. Coulibaly et al.'s (2017) study in Rwanda notes that men's greater access to climate information products can be due in part to their increased group membership and social capital. Venkatasubramanian et al.'s (2014) research in India suggests that participation in farmers' clubs can facilitate enhanced knowledge and awareness of agro-advisory services; however, male-biased membership can limit women's participation. Moreover, while men may share agro-climatic information learned from the groups in which they participate with women, the information can be incomplete and inadequate for women's decision-making context (Rengalakshmi et al., 2018).

Despite the challenges of accessing farmers' groups, community-based and female-dominated groups can allow women to access group processes important for climate information dissemination. Venkatasubramanian et al.'s (2014) research highlights that community and women's self-help groups can be an important means for disseminating knowledge of agro-meteorological advisory services to women. Rengalakshmi et al. (2018) similarly note that a women-managed Village Knowledge Center and the incorporation of gender-sensitive group processes in communication channels has helped to stimulate women's confidence to seek weather and climate information in Tamil Nadu, India. Similarly, Coulier's (2016) study in Vietnam emphasizes already-formed women's groups as important networks for farmer-to-farmer information exchange. Studies in India also note that women "communicators" have played an important role in disseminating and enhancing the utility of agro-climatic information for women (Venkatasubramanian et al., 2014; Rengalakshmi et al., 2018).

While women's groups may serve as useful communication channels, studies suggest that the type and scope of men's networks can be more advantageous for sharing and accessing agro-climatic information. Ngigi et al.'s (2017) study in Kenya demonstrates that men's membership in social groups tends to be longer-lasting and the groups they belong to have a greater tendency to be mixed-gender in comparison to women, earning men a higher score on the study's social capital index. Moreover, women have access to less sources of information than men. Manfre and Nordehn's (2013) study in Kenya similarly notes that men's networks tend to be more expansive than women's. Correspondingly, Martin and Abbott's (2011) study in Uganda suggests that the utility men associate with mobile phone technologies for making new contacts has helped men to develop new agricultural uses for the mobile phone, including those related to accessing agro-advisory information. Additionally, Ngigi et al.'s (2017) research in Kenya indicates that while belonging to social groups might help facilitate enhanced access to early warning information and more sources of information for both husbands and wives, a greater proportion of husbands acquire climate information through social groups. The greater effectiveness and reach of men's networks, as suggested by the above studies, for sharing agricultural information aligns with another trend identified in other publications: while both women and men farmers share agro-climatic information received through trainings and additional means with others, men might tend to share information beyond the family (i.e., with peers) slightly more (Clarkson, Dorward, Kagabo, & Nsengiyumva, 2017; Coulier, 2016; Coulier & Wilderspin, 2016).

Access to information through media and ICT

Interactive radio programming and ICTs are increasingly being used to communicate agriculture and climate information to smallholder farmers, with promising opportunities to reach farmers at expanding scales (Tall, Davis & Gutunku, 2014a; Mittal, 2016; Hampson et al., 2014; Tall et al., 2014b). ICTs may be particularly useful for communicating information at a short time-scale, like weather forecasts. Despite this potential, women may face gender-specific limitations to access and control ICTs and communication assets, related to cost barriers and education constraints. Further, research on ICT-use in agriculture emphasizes that for services to be useful to women, they must be aligned with their livelihood goals and incorporate time-saving mechanisms (USAID, 2012). Understanding of gendered content preferences can be critical in designing interventions that are equally beneficial to women and men, as well (Huyer, 2006; Nath, 2006).

Findings from the review demonstrate that there can be pronounced gendered patterns of ownership when it comes to ICT assets. In general, men tend to own communication assets like radios and mobile phones more than women (Coulibaly et al., 2017; Kyazze, Owoyesigire, Kristjanson, & Chaudhury, 2012; Hampson et al., 2014; Owusu, Yankson & Frimpong, 2017; Tall et al., 2015a; Tall et al., 2015b; Stats4D, 2017; Partey et al., in review; CICERO, 2018), thereby potentially limiting women's access to climate information products (Tall et al., 2015a; Coulibaly et al., 2017; Partey et al., in review). Additionally, a few studies analyze ownership and use trends related to age and indicate that younger individuals access ICTs more than older women and men (Cherotich, Saidu, & Omedo Bebe, 2012; Chaudhury, Kristjanson, Kyagazze, Naab, & Neelormi, 2012).

Gender-based differences in time availability can influence that women are less able to listen to radio programs than men. Although radio may give more opportunity for shared ownership among the family, men still tend to listen to the radio more often than women in research in Malawi and Tanzania (Hampson et al., 2014). This may be due to time limitations women experience as a result of their role in household work and childcare; for instance, time poverty in India, Senegal, Malawi, South Africa and Tanzania inhibit women from listening to TV or radio as freely as men do (Venkatasubramanian et al., 2014; Poulsen, Sakho, McKune, Russo, & Ndiaye, 2015; Tall et al. 2015a; Archer, 2003; CICERO, 2018). In addition, a study in Rwanda shows that men access educational radio programs more (Coulibaly et al., 2017). Exceptions to this trend are found in Cambodia (Coulier and Wilderspin, 2016) and in pastoralist communities in Tanzania (Coulibaly et al., 2015a; Tall et al., 2015b); concerning the latter, women spend more time in the home and have greater opportunity to listen to the radio in comparison to men. In recognition of the obstacles women confront to listen to the radio freely, an evaluation of an intervention in Tanzania recommends that weather and climate forecasts and advisories be transmitted several times during the day to facilitate more opportunities for women to access them (CICERO, 2018).

Several publications highlight the barriers that can inhibit rural women from accessing mobile phone technologies and radio for agricultural and livelihood planning. Lack of financial resources can limit women's ownership and use of mobile phones (Wong, 2012; GSMA, 2012; Scott, McKemyey & Batchelor, 2004; Hampson et al., 2014; Blumenstock & Eagle, 2012). When women do access mobile technologies and radio programmes, they are more likely than men to confront challenges to use devices and understand information transmitted, due to gender inequalities in literacy, formal education and technical literacy (CICERO, 2018; GSMA, 2012; Caine et al., 2015; Owusu et al., 2017; Scott et al., 2004). Additionally, a four-country study of women's mobile phone ownership and use finds that spousal disapproval can be a deterrent to women's mobile phone ownership (GSMA, 2012). Despite women's limited ownership, some studies demonstrate that women tend to share phones more than men (Blumenstock & Eagle, 2012) and that they often access phones through friends and family (GSMA, 2012; Stats4SD, 2017; Hampson et al., 2014).

The daily activities that women and men carry out can influence how they access and use mobile phone advisories for agricultural and household management as well. Caine et al.'s (2015) review of mobile applications for climate information finds that mobile phones can be a convenient means of accessing information for women, who are often limited from other channels due to mobility and time constraints mentioned above. In addition, women's free time may be at different times of the day than men's due to differences in their daily household activities; consequently, their call patterns can vary (GSMA, 2012). While men in Uganda may use mobile phones more for agricultural purposes, women are more likely to use mobile phones for both kinship maintenance and agriculture (Martin & Abbott, 2011).⁵ Martin and Abbott (2011) and Owusu et al. (2017) also note that men may be more likely to use mobile phones for reaching and coordinating with contacts such as agricultural input dealers and financial institutions. However, women in Ghana, compared to their male counterparts, are more likely to use mobile phones to contact market women for market prices, most likely due to the former's significant role in marketing in the country (Owusu et al., 2017).

Gender differences in use and benefit

Once farmers have access to weather and climate information, various factors and processes condition the extent to which they use the information to make changes in their approaches to agricultural management and their livelihood strategies. If acted upon, the information can potentially benefit farmers on both individual and household levels. While the studies included in the review minimally address the gender factors that influence benefits from climate services, a significant portion of the studies do analyze those factors that condition women's and men's use of weather and climate information. In particular, these publications tend to emphasize how socio-cultural norms concerning gender labor roles and responsibilities can influence the productive resources and decision-making processes under women's and men's control; correspondingly, this dynamic affects the types of climate information that will be most useful to women and men. The studies also illustrate how the gender division of labor, resource control and decision-making power can influence women's and men's differential capacities to act on information. It is important to emphasize that factors related to socio-cultural norms, access to resources and the household decision-making context can also condition women's and men's differing access to weather and climate information; however, the research addressing challenges to put climate information to use particularly highlights these intersecting factors.

Gendered rates of use and benefit

There is a subset of studies that reports rates of women's and men's use of different types of weather and climate information, in the absence and in the context of climate services interventions. While limited in number, the studies suggest that it is difficult to discern particular gender patterns in use. Among four CCAFS Climate-Smart Villages, women and men in Kaffrine, Senegal, show similar rates of use of types of weather and climate information, except for drought early warning, for which a greater proportion of men than women report using it

⁵ Women in Uganda were also more likely to use mobile phones for emergency veterinarian assistance for their livestock, due to their role and decision-making authority in livestock production (Martin & Abbott, 2011).

for making agricultural changes (Twyman et al., 2014). Additionally, across the four sites, almost all women and men report use of onset of rainfall forecast information; only in Nyando, Kenya, did women report using the information slightly more than men. Coulibaly et al.'s (2017) baseline study in Rwanda suggests that women and men tend to act on weather and climate information at similar rates across all provinces except for the Northern Province, wherein men show the tendency to report greater use. Clarkson et al.'s (2017) monitoring and evaluation study in Rwanda demonstrates that almost all women and men report use of information learned through the Participatory Integrated Climate Services for Agriculture (PICSA) method in their agricultural and livelihood decision-making, with no significant gender differences. For all of the above studies, in order to analyze the extent of use of information accessed, the sample size is limited to those men and women who had access to the climate or weather information or who had participated in the intervention.

Additional PICSA monitoring and evaluation studies in other countries show heterogeneity in gender trends concerning use of information, as well. Research in Tanzania finds that women household heads tend to report using information from PICSA trainings in their decision-making slightly more than men household heads (Stats4SD, 2017). In particular, while women and men made similar numbers of average changes to livestock and crop enterprises, women made slightly more changes to livelihood activities. In contrast, while both women and men in Rwanda demonstrate high rates of putting information learned to use, significantly larger proportions of men report making changes in crop and livelihood enterprises than women; similar proportions make changes in livestock enterprises (Clarkson et al., 2017). In Malawi, the average number of changes made across types of activities due to participation in similar trainings were comparable among female and male household heads (Stats4SD, 2017).

Few of the publications reviewed address benefits to women and men farmers from use of climate services, and those that do tend to address perceived benefits. As occurs with the information from studies on use, results concerning gendered benefits vary across studies. Research in Eastern Kenya (Rao et al., 2015) and in Benin (Amegnaglo, Asomanin, & Mensah-bonsu, 2017) find that both women and men report willingness to pay for climate services, thus indicating similar benefits perceived, although the sample size of women in comparison to men is small for the Benin study. However, the research in Eastern Kenya suggests that where both women and men receive training concerning climate information, women are not willing to pay as much as men (Rao et al., 2015). Along the same lines, an evaluation of climate services interventions in Malawi and Tanzania demonstrates that male household heads in Malawi perceive more household benefits from climate services trainings, particularly concerning improved income and health care (Stats4SD, 2017); in contrast, in Tanzania there are no significant differences in rates of perceived household benefits reported among men and women household heads. In Malawi, men also report improved social standing in the household more frequently than women, although this difference is not as large. Baseline information from Rwanda shows that less than 45% of respondents report perceived changes to their livelihoods due to the use of climate information, although men report changes more than women; the difference is statistically significant in two of the five provinces (Coulibaly et al., 2017). Subsequent monitoring and evaluation information from PICSA trainings notes that both women and men report substantial changes in attitudes and perceived benefits as a result of the trainings, with no significant gender differences (Clarkson et al., 2017). For example, high proportions of both women and men report greater confidence in planning farming and livelihood enterprises and in discussing farming or livelihood with fellow farmers. Furthermore, women and men both report thinking of farming as a business more than they had previously. Although the data is limited, studies in India suggest that climate services benefit women farmers through increased capacity to make informed decisions and more active participation in agricultural decision-making processes, also (Mittal, 2016; Rengalakshmi et al., 2018).

The variations in gender patterns in use of and benefits from climate services point to the need to understand underlying factors that influence how and when women and men act upon information received. The literature included in the review provides some insights into how factors such as socio-cultural norms, access to and control over resources and decision-making power can influence women's and men's proclivity to use climate services.

Influences on differing climate service needs

Norms that define women's and men's roles and responsibilities according to gender and seniority and that critically condition resource access can influence the type of information that women and men find useful, as demonstrated by research in Senegal and Mali. For example, Tall, Kristjanson, Chaudhury, McKune, and Zougmore's (2014c) study in Kaffrine, Senegal, shows that women farmers are more interested in information on droughts and rain cessation in that region than men because social norms dictate that they labor on men's plots before their own and must also wait to use men's farming equipment; consequently, women can tend to plant later. Similarly, precipitation information may be minimally relevant to women groundnut producers in research in Mali, due to gender norms that limit women's production and drive them to plant later (Carr, Onzere, Kalala, Rosko, & Davis, 2016b). Carr et al. (2016b) highlight that the women may feel inhibited from using the precipitation data to its fullest extent due to repercussions they could experience if their increased production were to be seen as a threat to their husbands' authority, as well. Additional research (Carr, Fleming & Kalala, 2016a) in Ngetou Maleck, Senegal, suggests that varying access to farming equipment, secondary income and farm animals influences the type of climate information that is most useful for junior and senior women farmers. Moreover, because they have fewer domestic obligations, senior women in Senegal can often cultivate sooner than their junior counterparts; correspondingly, climate information can be more relevant for the former. Another study in Mali suggests that junior and senior women and men can have differing interests in the information that advisory services can provide due to their varying prioritization of subsistence or market production (Carr & Owusu-Daaku, 2016).

Other research shows the influence of gendered household and farm labor roles on implementation of weather and climate information. For example, Jost et al.'s (2016) pilot study suggests that men in Ghana and in Bangladesh may use daily and seasonal weather information in agricultural decision-making; in comparison, women in Ghana use it primarily for planning household chores and in Bangladesh, women tend to use it for decision-making on mobility. Research in India suggests that the extent of women's roles in agriculture can positively influence their degree of use of agro-advisories (Mittal, 2016; Venkatasubramanian et al., 2014).

Constraints on use of information

Several studies demonstrate that differences in access to resources can limit women's abilities to use climatic information relative to men. A study by Sandstrom and Strapasson (2017) suggests that access and utilization of productive assets and inputs can be important preconditions for the use of climate information, for women just as much as they are for men. In this way, the analysis highlights the significance of inequalities in meaningful access to inputs for gender-equitable action on climate information. Other studies find that women have less access to the financial capital and productive assets (e.g., farming equipment and seeds) needed to be able to act on climate-based advisories (Carr, 2014; Carr et al., 2016b, Poulsen et al., 2015, Coulibaly et al., 2015a, Tall et al., 2015b). Carr et al. (2016b) notes that in Mali even women household heads, who have greater decision-making power over rain-fed crops than women in male-headed households, are often constrained from acting on precipitation information due to lack of access to resources. Similarly, research in Malawi shows that women household heads report more frequently than men that lack of money is an obstacle to incorporating climate services training into decision-making on crop enterprises (Stats4SD, 2017).⁶

Gender norms, control of productive resources and the decision-making context can interact significantly to condition differences in women's and men's use of climate information. Intersecting influences of gender, seniority and ethnicity can be important to take into account, as well. In particular, several studies highlight that women's limited control of land and limited involvement in decision-making over rain-fed crops (or agriculture in general) can make climate information irrelevant for women (Carr & Onzere, 2017; Carr et al., 2016b; Roncoli et al., 2009; Poulsen et al., 2015; Serra & McKune, 2016; Carr, 2014; Carr & Owusu-Daaku, 2016). Additionally, Carr and Onzere's (2017) research in Mali shows that junior men's ability to put climate information into use depends on their accessing land and farming equipment controlled by senior men. In general, the study suggests that households

⁶ Men reported unfavorable season more frequently than women as a barrier to implementing information (Stats4SD, 2017).

of junior adults are less able to act on information. However, other research in Mali (Carr 2014) adds a gendered intra-household dimension that complicates the finding regarding seniority, observing that even when women may have their own plots of land, they have limited decision-making power regarding crop selection, often deferring to male household members' authority; consequently, climate information can be less actionable for them. Furthermore, Carr and Onzere (2017) highlight that agricultural decision-making can be more inclusive among partners in Malinke households in Mali, in contrast to trends in Bambara and Senoufo communities; for this reason, Malinke women may wield greater decision-making power than those in other ethnic groups and have more opportunity to put climate information to use. However, as Malinke households grow wealthier and men acquire more wives, women's degree of participation in decision-making decreases. Another consideration highlighted from the research in Mali is that in more asset-rich households, women may not be held so strictly to gender roles and responsibilities because their participation in rain-fed agriculture and in traditionally masculine productive activities does not threaten male authority; consequently, they may have greater opportunity to contribute to decision-making on rain-fed crops (Carr et al., 2016b).

DISCUSSION

Pathways for making climate services more gender-responsive

Results from the literature review highlight that certain gendered processes and factors can condition women's and men's access to and use of climate services. Results emerging from the literature can suggest a few guideposts for developing more gender-responsive climate services (Table 2). The first three potential solutions deal with gender-based challenges to access.

Table 2. Key factors and potential ways forward for the development of gender-responsive climate services

Gender factor	Affects	Potential solution
Access to ICTs	Access to routine weather information, advisories	Develop ICT-based communication channels appropriate to women's needs
Access to group processes	Access to technical information, trainings, planning processes	Include women's groups and information-sharing mechanisms as communication channels
Context-specific norms limit participation in public activities	Access to extension services and externally-based channels	Connect with local and civil society organizations to address norms that constrain women's access
Social norms influence the resources and decisions under men's and women's control	Type of information needed	Meet women's climate information needs
Limited resource control influences women's capacity to act on climate information	Demand	Integrate climate services with rural development efforts that seek to overcome women's resource constraints

Access

Develop ICT-based communication channels appropriate to women's needs. Because differing access to ICTs due to gender-based constraints often disadvantage women, they can also have differential access to routine weather information and advisories. Correspondingly, it is critical that interventions targeting ICTs consider local household trends in accessing communication assets, seek to understand the manners and situations through which women are able to access information via ICTs and use them to enhance climate services' reach to women (Table 2). A potential example underway is the project "Climate services for agriculture: empowering farmers to manage risk and adapt to a changing climate in Rwanda," which considers baseline research on men's and women's asset control and access to communication channels to design ICT or media-based climate services communication tools that enable farmers to access climate information (Nsengiyumva, Kagabo & Gumucio, 2018).

Include women's groups and information-sharing mechanisms as communication channels.

Institutional biases and differential access to formal group processes can constrain women's access to technical information, trainings and planning processes related to agro-advisories and climate risk management. Including women's groups and networks in climate information and rural advisory delivery may help National Meteorological Services (NMS) and agricultural extension services address this challenge (Table 2). The potential for women's groups and networks to increase women's knowledge and awareness of climate information products is particularly critical, considering that some studies indicate that men may tend to have greater awareness of weather and climate information than women (Carr, 2014; Venkatasubramanian et al., 2014; Coulibaly et al., 2017); and that, when gender inequalities in awareness are minimized, there may be more equitable access to information (Coulibaly et al., 2017). Participatory Action Research (PAR) methodologies can be useful to identify group processes and information-sharing mediums suited to women's access constraints, also (Tall et al., 2014b; Tall et al., 2014c).

Connect with local and civil society organizations to address socio-cultural norms that constrain women's access.

It is important that interventions recognize that enhancing women's access to characteristically male groups and public sphere activities depends upon shifts of often deeply entrenched socio-cultural norms and institutions. Collaboration with local partners and organizations (Table 2) who are engaged in gender consciousness-building and who are cognizant of indigenous normative structures surrounding gender will be important in designing socially-relevant climate services (Cornwall, 2016).

Use

There may be less documentation of potential ways forward concerning use and incorporation of weather and climate information in agricultural and livelihood planning. However, the existing research points to a few pathways.

Meet women's climate information needs. The publications included in the review highlight how socio-cultural norms concerning labor roles can influence the resources and decisions under women's and men's control; this in turn affects the types of weather and climate information that are useful to women and men. For this reason, it is important that climate services include mechanisms to identify and meet women's climate information needs (Table 2). Additionally, it will be critical to consider how women's and men's climate information needs can vary according to seniority, ethnicity and other socio-economic aspects. Approaches like the Livelihoods as Intimate Government (LIG) (Carr, 2013) can provide a useful methodology and framework for differentiating groups of women and men farmers according to assemblages of vulnerabilities, the livelihoods strategies and decisions in which they engage and their corresponding climate information needs (Carr et al., 2016a; Carr and Onzere, 2017).

Integrate climate services with rural development efforts that seek to overcome women's resource constraints. Limited resource control and lack of opportunity to participate in agricultural decision-making can significantly restrict women's capacity to make full use of climate information. This also acts as a deterrent on women's demand for information (Table 2). While it can be difficult for climate services alone to address the extreme challenges that more marginalized groups confront to act on climate and weather information, coordination with other sectors can be a key opportunity to enhance impacts in these cases (Carr and Onzere, 2017). This also resonates with Hansen et al.'s (2013) observation that it may be necessary for climate services actors to identify opportunities to play a part in larger programs or policies for the services to be truly actionable for rural farmers.

Knowledge gaps and research opportunities

Although the significance of gender to climate services is increasingly recognized as an important focus of investigation, the limited number of relevant studies identified for the review demonstrates that additional empirical research on the theme is paramount.

The review highlights four significant evidence gaps.

- **Regional.** Although the significant amount of studies on sub-Saharan Africa is important, increased research in other regions is necessary, recognizing the resiliency needs of smallholder farmers in other parts of the world. This is especially critical, considering the context-specific nature of gender dynamics.
- **Benefit and demand.** A blatant gap exists concerning how women and men benefit from their use of climate services. More studies on the demand side of access will also be important in order to develop a more complete understanding of gender-based challenges.
- **Assess the influence of climate services on women's participation in decision-making.** Mittal's (2016) and Rengalakshmi et al.'s (2018) research suggests that access to weather forecasts has helped women to make informed agricultural decisions. While useful, more in-depth impact assessment concerning changes in women's and men's roles in agricultural and livelihood decision-making due to their access to climate information products will be important to advance the knowledge on gender-transformative climate services.
- **"Success stories" of interventions that enhance women's ability to act on weather and climate information.** Little research exists that documents "success stories" of women's increased use of climate-related information in decision-making at a project level, including analysis of possible enabling factors and mechanisms. This contrasts with the existing knowledge base on gendered access, which includes studies of interventions and mechanisms that have contributed to women's enhanced access (Tall et al., 2014b; Tall et al., 2014c; Venkatasubramanian et al., 2014). An important related research question is whether or not women face more significant, gender-based structural constraints to take action on climate information, rather than to access it.

The review suggests four priority research questions and themes for enhanced learning on how to promote gender-responsive climate services.

- **Compare potentialities of mixed-gender and women's groups.** Research that evaluates the conditions under which mixed gender or female-dominated group processes are more effective for enhancing women's access to climate information will be critical to clarify potential pathways for gender-responsive climate services. This is critical, in recognition of other research on women's group participation that shows that female-dominated natural resource management groups can perform worse than mixed or male-dominated groups, due in part to gender inequalities in access to productive resources (Mwangi et al., 2011). However, in those cases where strict cultural norms limit male-female interaction in public, female-dominated natural resource management groups can be an important means to enable women's meaningful participation in information-sharing and decision-making processes.
- **Understand what combination of communication processes best enable women to understand and act on information.** Existing studies are useful in highlighting trends in and barriers to women's and men's ICT access and use; notwithstanding, research that analyzes when ICTs or face-to-face training and discussion is more useful to women will help identify more gender-responsive communication channels. While ICTs may be helpful for particular types and timescales of information, other channels might be better-suited to enable women's understanding and use of complex forms of information. This is important, considering that studies in the review suggest that women can face challenges to understand and interpret the technical information that constitutes forecasts and climate data (Venkatasubramanian et al., 2014; Kyazze et al., 2012; Carr et al., 2016b; Coulier, 2016), often due to literacy and formal education constraints.
- **Link further with body of knowledge on intra-household decision-making.** Other research demonstrates that the household decision-making context may constitute a complex arena wherein spouses contest and consult each other (Carr 2008a, 2008b; Farnworth, Stirling, Chinyophiro, Namakhoma & Morahan, 2017). While there exist a few studies in the review that recognize that livelihood management entails processes of negotiation and contestation involving different household members (Carr & Onzere, 2017; Carr et al.,

2016a), more research that analyzes the intra-household decision-making processes surrounding the use of different climate information for agricultural and livelihood planning will be important to develop interventions that enhance action on information.

- ***Understand how gender interacts with other socioeconomic attributes to shape access preferences and information needs.*** Studies show that socio-economic attributes such as life-stage, seniority and ethnicity can intersect critically with gender and influence women's and men's household decision-making roles and access to group processes, among other important factors for effective access and use of climate services. Approaches such as the LIG (Carr et al., 2016a; Carr and Onzere, 2017) can permit differentiation of types of women and men farmers and identification of their information needs and delivery preferences.

CONCLUSIONS

Despite the limited knowledge base, the review highlights key issues and factors concerning gender-related challenges to access and use climate services. Gender-based differences in access to group processes and to ICTs can limit women's access to weather and climate information. Furthermore, socio-cultural norms that define gender labor roles can influence the resources and decisions under women's and men's control; this conditions the types of climate information that are useful to women and men. Factors related to the gender division of labor, resource control and decision-making power can also influence women's and men's differing capacities to use weather and climate information to make changes in agricultural and livelihood management.

From the understanding of principal gender-based factors and processes, it is possible to suggest priority areas for improving practice and achieving gender-responsive climate services. Development of ICTs appropriate to women's needs and inclusion of women's groups in communication channels can help enhance women's access to climate and weather information. Moreover, linkages with local and civil society organizations will be important to take into account socio-cultural normative structures that restrict women's access. Meeting women's climate information needs will also be a critical pathway to enable women's use of weather and climate information in agricultural and livelihood planning. Furthermore, collaboration with robust initiatives on sustainable rural development will be key for overcoming the extreme resource and decision-making constraints faced by some women.

Notwithstanding progress of current learning, it will be important to address critical knowledge gaps and research opportunities in order to develop climate services that meet the needs of rural women. Important evidence gaps exist concerning regional variations in gender influences on climate services access and use. Additional research is also necessary regarding gender-based benefits from climate services and concerning gendered trends in demand. More documentation and analysis of interventions that enhance women's action on climate information is key, as is increased investigation of climate services' influence on women's participation in household decision-making. Critical research questions moving forward concern how women's and mixed-gender groups may differentially enable women's enhanced access to climate information, and which combination of communication processes can promote women's understanding of and action on information. Moreover, it will be important for future research to continue to connect with the knowledge base on intra-household decision-making processes and seek to understand how gender interacts with other socioeconomic attributes for better identification of gender-based climate information needs and enhanced smallholder action on information. Such combined efforts on the part of researchers and practitioners will be critical to ensure that climate services truly serve the needs and interests of women and men smallholder farmers most vulnerable to climate-related risk.

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