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Climate Change and Gender in Africa: A Review of Impact and Gender-Responsive Solutions

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Climate change affects livelihoods and wellbeing. Women and men may experience the impacts of climate change differently. But climate change and its associated impacts affect women negatively. A review was done on peer-reviewed literature related to the impact of climate change on gender in Africa. While there is an abundance of credible scientific evidence on the impacts of climate change, there is a dearth of reliable disaggregated data and evidence on the impact of climate change on women. The review shows that climate change affects women more negatively compared to men in five impact areas: (i) agricultural production; (ii) food and nutrition security; (iii) health; (iv) water and energy; (v) climate-related disaster, migration, and conflict. The lack of gender-disaggregated data undermines efforts to design gender-responsive interventions to enable women to cope with and adapt to climate change impacts. While there is no consensus on what constitutes gender-responsive solutions to climate vulnerability and risk, the paper provides some priority action areas to stimulate debate and hopefully consensus for a starting point for deeper engagement of women's participation and motivating investments in creating frameworks for accountability for measurable gender-differentiated outcomes. Efforts to design and deploy gender-responsive solutions to climate change impact must take a holistic, asset-based approach, which meaningfully seeks to identify dominant causal mechanisms and develops context policy and institutional options to address interlocking asset or capital dis-endowments.

Keywords: resilience, gender-responsive, asset-based approach, gender-differentiated impact, climate vulnerability and risk

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INTRODUCTION

The understanding of the impact of climate change; sea-level rise, drought and heatwaves, storms flooding, land degradation, food security, conflict, disease, and economic losses is now robust. Advances in scientific understanding have refined the precision of the Fourth (AR4), Fifth (AR5), and more recently, the Sixth (AR6) Assessment Reports, specifically about the accelerating risk of severe and irreversible change arising from high levels of global warming (IPCC, 2021). No country, territory, or continent will be spared the impacts of climate change. However, climate change is not neutral by geography, socioeconomic groups, or gender. Hence, the vulnerability and impact of climate change are lived and experienced differently. Huyer et al. (2021) and Makina and Moyo (2016) discuss gender-based vulnerabilities and the fact that women are disproportionately vulnerable to the impact of climate change based on their roles, rights, and opportunities, which are defined by gender norms and socio-economic status.

In sub-Saharan Africa for example, even small temperature increases and changes in precipitation patterns could affect the dynamics of disease transmission and crop yields, with dire consequences for household health and income (World Bank, 2012). Spikes in global food prices can be attributed to a confluence of a myriad of factors. But the intensification of the impacts of climate change will become amplified in the future, imposing pressure on cereal prices, especially maize and wheat, which will likely have dire and gender-differentiated implications for food and nutrition security as well as overall household wellbeing. However, the impacts of climate change on cereal yields will be variable across Africa. Crop yield models show that the maize yield in southern Africa will decrease by 14 percent by mid-century and by 33 percent by the end of the century because of climate change (Msowoya et al., 2016). There is evidence that warming in the highlands of eastern Africa could lead to altitudinal range expansion of crop pests to areas where they have been cold-limited thus significantly reducing coffee and banana yields, which are important cash crops both for large and smallholder subsistence farmers (Jaramillo et al., 2011). The Striga weed causes major cereal yield reduction in much of sub-Saharan Africa. Cotter et al. (2012) estimate that changes in temperature and variations in the seasonality of rainfall will increase the geographic range of suitable land for Striga in central Africa.

It is estimated that the livestock sector contributes to the livelihoods of one billion of the poorest population in the world and employs nearly 1.1 billion people, most of whom are women (Hurst et al., 2005). Climate change will affect livestock production through competition for natural resources, quantity and quality of feeds, livestock diseases, heat stress, and biodiversity loss (Melisa-Rojas et al., 2017). Temperature rises may increase cell wall and lignin components that will in turn reduce digestibility rates leading to a decrease in nutrient availability in forage and feeds (Thornton et al., 2009). In non-pastoral mixed farming areas in East Africa, it is estimated that livestock production will be affected indirectly by a decline in maize crop residue availability due to a decrease in maize production by 2050 (Thornton, 2010). Concerning human health, climate change is expected to influence the incidence and geographic distribution of vector-borne diseases like malaria and Rift Valley fever (Chevalier et al., 2011; Chaves et al., 2012). Hence, interventions aimed at building adaptation and resilience must consider gendered impacts on pastoral households (Walker et al., 2022).

There is a growing understanding that the biophysical impacts of climate change are interlinked with socio-economic, institutional, and demographic factors and interact in complex and often non-linear ways to overwhelm the capacity of households or communities to adapt or cope. This is especially so where gender disparities and social and economic justice are not addressed. Climate change is now acknowledged as an amplifier of existing socio-economic inequities. Long-standing socioeconomic disparities among men and women are amplified by large orders of magnitude often through punitive customs and social norms, control over or access rights to assets or capital endowments. Assets or capital endowments may include, social, physical, financial, natural, political, and human capital (Meinzen-Dick et al., 2011). In the context of climate change impacts on livelihoods and household wellbeing, control over or access rights to assets is critical for women and the poor, where social capital, secure land rights, livestock, and technology can enhance the ability of households to adapt and cope with climate shocks.

With the heightened focus on adaptation to climate change, the need to recognize and address the uneven distribution of vulnerability to and gender-differentiated impact of climate change is critical[1]. The Paris Agreement (2015) acknowledges that adaptation action should follow a gender-responsive approach. The enhanced gender action plan sets five priority areas that aim to advance knowledge and understanding of gender-responsive climate action[2]. This paper is based on a review of available literature and data on the differentiated impact of climate change on women in Africa. With available, albeit scanty and often non-disaggregated evidence, this paper reviews climate change impacts on the livelihoods of women, with a focus on five areas, namely: (i) agricultural production; (ii) food and nutritional security; (iii) health; (iv) water and energy; (v) climate-related disaster, migration, and conflict. The overarching purpose of this paper is to review existing literature and identify options for gender-responsive actions across the five impact areas, to enhance adaptive and mitigation actions to secure the wellbeing and livelihoods of women. This paper suggests six priority areas for action to reduce women's vulnerability to climate change. These include (i) gender-sensitive legal and institutional framework; (ii) Women's representation and participation in decision-making; (iii) Information services for women; (iv) sex-disaggregated data and relevant gender indicators (included in the results and portfolio monitoring framework); (v) gender-responsive financial services; (vi) gender-sensitive adaptation/mitigation technologies.

METHODOLOGY

The study sought to examine the literature on the gender-differentiated impact of climate change, with a focus on women in Sub-Saharan Africa. The study is based on a review of peer-reviewed literature related to the impact of climate on women. To search literature the Scopus electronic database was used. Scopus indexes peer-reviewed literature. A keyword search was performed within the Scopus electronic database using keywords (in all fields): ["gender" or "women"] AND ["climate* change" or "drought"] AND "impact" AND [Africa*]. All study designs were eligible, including modeling studies, narrative and systematic reviews, case studies, case series, and qualitative research. Articles were excluded if not published in English, or not published between 1992 and 2022. This yielded 190 document results. To further refine the search, only peer-reviewed journal articles were included. Furthermore, articles that did not have "gender" or "women" or "Africa" in the author or index keywords were

[1]FCCC/TP/2013/11, paragraph 15.
[2]FCCC/CP/2019/13/ Add.1, Annex 1.

excluded. This yielded a total of 59 articles published between 1992 and 2022.

Relying on the Scopus database presents limitations. For example, it excludes graduate thesis and reports published by African universities and research institutions not indexed in Scopus. Because of this major limitation, the question of which databases are necessary to retrieve all relevant references for a review remains unanswered. To address this limitation, Google Scholar, which performs a more complete text search, was used in addition to Scopus. The downside of Google Scholar is the inordinate rate of false positives, hence time-consuming. Furthermore, an additional 39 articles were retrieved organically from articles cited in the papers reviewed. Hence, a total of 98 articles were used in the review. The approach applied is therefore robust and realistically replicable. However, it is important to understand that while electronic databases are critical to ensuring the validity and completeness of references, they are not a panacea.

The review was guided by five areas of climate change impact: (i) agricultural production; (ii) food and nutrition security; (iii) health; (iv) water and energy; (v) climate-related disaster, migration, and conflict.

GENDER-DIFFERENTIATED IMPACT OF CLIMATE CHANGE ON WOMEN

Impact on Agricultural Production

Increased climate variability reduces agricultural productivity often with unequal impacts on women's and men's human, natural, physical, social, and financial assets. In the Sahel for example, women believe they would lose access to rangeland and other livestock production resources due to increased climate variability (Goh, 2012). Changes in crops grown by farm households in response to climate change have been shown to alter participation in decision making, division of labor, and control of income from crops. For example, while commercialization has been identified as a key strategy in assisting farmers to adapt to climate change, it tends to weaken women's control by focusing on sales rather than consumption decisions in East Africa (Tavenner et al., 2019). Walker et al. (2022) show that herd composition in response to drought is characterized by a shift from cattle or camel to sheep and goats for which women are responsible, leading to an increase in women's labor and responsibility compared to men. In southern Tanzania, increased rainfall variability, declining soil fertility, yield variability, and declining crop yields are forcing households to cultivate more land, which demands more labor (Nelson and Stathers, 2009). Voluntary seasonal migration among male household members seeking off-farm work is exerting more pressure on women who must assume expanded domestic roles in the absence of male members of the household.

Moreover, the need to replant more often as rains are unpredictable increases the demand on women's time because they must bear the brunt of replanting. Studies have shown that increasing livestock and crop diversity in response to climate change improved income (Makate et al., 2016) and food and nutrition security (Snapp and Fisher, 2015) for smallholder farm households. However, Teclewold et al. (2013) show that the adoption of crop diversification and the use of agricultural technology significantly increased agricultural labor demand for women in Ethiopia and diverted time away from childcare and food preparation. Previous studies (Maertens and Swinnen, 2009) showed that increased labor demand for female heads of the household has a negative impact because girls are removed from school to replace their mothers in gender-determined household activities.

Women have poor access to training, extension services, and technology necessary for effective adaptation to the impacts of climate change (Witinok-Huber et al., 2021). Moreover, constraints to technology adoption among women are evident across stages of technology adoption, which include awareness, testing, and continued adoption (Oyetunde-Usman et al., 2021). A comparative analysis of women's access to technologies for rice production in Ethiopia, Madagascar, and Tanzania showed that cultural and institutional factors were barriers to adoption (Achandi et al., 2018). Moreover, constraints on women's time and spatial mobility significantly shape the way climate and weather forecast information is received by women (Goh, 2012). Survey data from Kenya (Saito et al., 1994) revealed that female-headed households held less than one-half the total value of farming equipment of male-headed households. In response to input deficiencies, women-headed households are associated with low fertilizer application rates. For example, male-headed households in northeastern Ethiopia were more likely to use organic fertilizer by about 52 percent compared to female-headed households (Abebe and Debebe, 2019). Burke et al. (2018) found no evidence of a gender gap in skills after controlling for access to inputs, particularly for soil quality, suggesting that women are disproportionately disadvantaged. The comparatively low endowments in major productive inputs such as land labor, and capital make agricultural production among female-headed households relatively more vulnerable and less adaptive to climate change. Social norms and traditional gender roles, especially caregiving undermine women's capacity to reallocate time to work on family plots, diversify crop or livestock production or take up off-farm work (FAO, 2015). In some communities, only men have the right to cultivate certain crops or to access markets. In addition, many adaptation practices require investments in inputs, time or labor or technology or networks for collective action such as cooperatives and thus are costly for households with limited access to credit and with few, mostly female, working-age adults. Gender and social differences between men and women may also affect investment needs or priorities and access to weather and climate information.

Impact on Food and Nutrition Security

Climate change simultaneously affects food production, food availability, and access, diet quality, and nutrition at the household level. Climate change will affect the availability and access to food and nutritional security through direct and indirect pathways such as floods, drought, and land degradation and, indirectly through income shocks and health effects resulting from enhanced viability of pathogenic microbes and their

vectors (Sorensen et al., 2018). However, the adverse effects of climate change on food and nutrition security are not evenly distributed among men and women. In regions of high food insecurity such as sub-Saharan Africa, climate induced-food and nutritional insecurity will disproportionately affect women given their vulnerability due to socially defined gender roles and limited access to resources compared to men (IPCC, 2014; Botreau and Cohen, 2020). Climate-change-related risks to food and nutrition security include decreases in crop yields and crop failure, livestock loss, increased water scarcity, and destruction of other productive assets. Crop and livestock systems are subject to risks from climate variability and damage from extreme events such as drought, floods, disease outbreaks, and heat stress (Jones and Thornton, 2009). Research suggests that existing social, institutional, and structural biases and barriers exacerbate the negative impacts of climate change on food and nutrition security in women and female-headed households (Weiler et al., 2014). Extreme weather events depress crop yields that supply essential nutrients such as calcium, folate, thiamine, and pyridoxine, which are crucial during pregnancy (Blakstad and Smith, 2020). Climate change can cause maternal malnutrition to worsen directly. In rainfed production systems, unreliable rainfall affects rural households' ability to provide adequate food for their families. Infectious diseases have serious consequences on maternal, fetal, neonatal, and child health, and this effect is exacerbated by maternal malnutrition. In a systematic review of literature, Salm et al. (2021) show that malnutrition among women owing to the impact of climate change occurred because women: often skipped meals to feed other family members in times of hunger; traveled further for water and fuel. Serna (2011) showed that when food shortage was prevalent among communities in northeastern Kenya, a common practice among women was to reduce their food consumption so that male members of the household could have enough to eat. In Ethiopia and Kenya, two of Eastern Africa's most drought-prone territories, children aged 5 years or younger born during drought are 36 to 50 percent more likely to be malnourished (Smith et al., 2014).

In measuring the impact of climate and weather variability on gender and food security, Tibesigwa et al. (2015) show that while weather-related crop failure due to poor rainfall or wind or hailstorms reduces food consumption levels for all households, reduction of consumption was much greater amongst households headed by widowed, divorced, separated or single women. Moreover, Tibesigwa et al. (2015) observed a statistically significant consumption gap, of up to 21 percent, between female and male-headed households, where female-headed-headed households were more likely to be food insecure. This is consistent with earlier work, which suggests that women-headed households were disproportionately vulnerable to weather and climate variability (Deaton and Dreze, 2002; Babugura, 2010).

Impact on Health

The IPCC (2007) projects that climate change will undermine public health gains, especially in Africa where climate change impacts on health will manifest through malnutrition from drought-induced food insecurity, exacerbation of environmentally sensitive chronic diseases, reduced water quality, and enhanced viability of pathogenic microbes and their vectors (Sorensen et al., 2018). Climate change impacts on women's health, direct and indirect, are mediated and amplified through socio-economic disparities. Moreover, gender differences in the impact of climate on health are transmitted through physiological, cultural, and socio-economic factors. Women tend to suffer higher rates of chronic malnutrition and have a heightened sensitivity to climate-induced food and nutrition security, especially during pregnancy and breastfeeding (Sorensen et al., 2018). Additionally, infectious diseases have more serious consequences on maternal-fetal and child health, an effect that is amplified by maternal malnutrition (Blakstad and Smith, 2020). Thiede et al. (2022) have shown that women exposed to spells of above-average temperatures and below-average precipitation experience significant reductions in the probability of fertility in the subsequent year. Grace et al. (2015) examined the relationship between birth weight, precipitation, and temperature in 19 African countries and showed that climate affects birth weight in ways that were correlated with the dependence on the dominant food production strategy. Rosen et al. (2021) have demonstrated direct economic consequences of drought on women; from diminishing household assets to food insecurity, to increased risk of poor sexual and reproductive health outcomes.

Extreme events and natural disasters globally are projected to become more severe because of climate change. Neumayer and Plumper (2007) showed that culturally and socially determined gender-specific exposure and vulnerability of women that are built into everyday socio-economic patterns lead to disproportionately higher mortality among women in the wake of climate-induced disaster. In some famines, like the Ethiopian famine of 1984/85, more female than male victims die at a very young age or as infants largely due to inequitable access to food resources (Kidane, 1989). Furthermore, women giving birth during or in the period following a natural disaster have an increased risk of adverse reproductive outcomes, including preeclampsia (pregnancy characterized by high blood pressure and damage to vital organs), bleeding, premature delivery, and delivery complications (WHO, 2002; Tong et al., 2011).

Rising temperatures and changes in rainfall patterns may contribute to increased malaria transmission in sub-Saharan Africa. Nigeria, DR Congo, Uganda, Mozambique, Angola, and Burkina Faso account for circa 55 percent of the global malaria burden (World Bank, 2012). In the 33 countries that comprise the regions of West Africa, central Africa, and east and southern Africa malaria infections during pregnancy resulted in 819,000 children with low birth weight (World Bank, 2012). It is estimated that pregnant women are three times more likely to suffer from a severe illness from malaria infection compared to non-pregnant women, and have a nearly 50 percent mortality rate. Moreover, children born to mothers with placental malaria were more than twice likely to be underweight at birth (Ofori et al., 2009). While most low birth weight children have normal outcomes, as a group they generally have higher rates of subnormal growth, illnesses, problems in cognition, attention, and neuromotor functioning (Hack et al., 1995). Hence, the long-term developmental outcome of low birth infants increases the burden of care on female members of the family and could

undermine a mother's time investment in other productive activities, increasing overall household vulnerability.

Malaria undermines their labor output, interrupts the production cycle, and causes resources to be diverted from farm inputs. Girardin et al. (2004) have shown that in a single cabbage production cycle, farmers who reported being sick because of malaria for an average of 4.2 days had recorded 47 percent lower yields and 53 percent lower revenues compared to farmers who reported sick for an average of 0.3 days. Similarly, Fink and Masiye (2015) report large positive effects of preventative health investment on productivity among Zambian farmers provided with access to bed nets, where harvest value increased by 14.7 percent of the average output value.

Impact on Water and Energy

With only nine percent of global renewable water resources, Africa is the second driest continent on the globe after Australia. A decrease in total precipitation in the northernmost and southernmost regions of the continent. Climate change is projected to impact the hydraulic cycle, threatening water security which, plays a critical role in promoting health and wellbeing (Niang et al., 2014). Women's vulnerabilities to inadequate supply of water for domestic use, especially in the dry season are related to socio-cultural norms around the division of labor, especially for water collection (Dickin et al., 2020).

Studies have documented higher rates of disease; missed social, educational, and economic opportunities; and overall lower quality of life associated with this lack of access to clean water and energy sources. For example, Graham et al. (2016) show that between 46 and 90 percent of adult females in 24 sub-Saharan African countries were the primary collectors of water, an activity that consumed more than 30 min of their time. Moreover, across all the 24 countries, which include Liberia, Cote d'Ivoire, Nigeria, Niger, Ethiopia, Burundi, and Mozambique, 62 percent of female children, compared to 38 percent of male children were responsible for water collection. Pickering and Davis (2012) have shown that a 15-min reduction in one-way commute time between home and water source could reduce the prevalence of diarrhea by 41 percent and cause under-five mortality to decline by 11 percent.

Climate change worsens the direct and indirect health outcomes of energy insecurity and exacerbates cumulative risk, such that those already experiencing energy insecurity are most affected by climate events because they are less able to cope. An estimated 6.8 Mt of fine particulate matter ($PM_{2.5}$) was emitted in Africa in 2018 of which about 85 percent was due to indoor burning of biomass for lighting and cooking (IEA, 2019). Particulate matter is a leading contributor to household air pollution (HAP), which is associated with a range of morbidity, including acute chronic respiratory disease, low-birth weight, cardiovascular diseases, and cataracts (Gordon et al., 2014).

Using data on 24-h personal exposure to HAP from participants in Ethiopia and Uganda, Okello et al. (2018) showed that $PM_{2.5}$ exposure concentrations were highest among adult females (177 to 205 $\mu g/m^3$) compared to 26.3 to 30.3 $\mu g/m^3$ among young males. In the same study, Okello et al. recorded a median $PM_{2.5}$ exposure of 276.1 $\mu g/m^3$ among women who cooked with livestock dung compared to pared to 185.7 $\mu g/m^3$ and 119.9 $\mu g/m^3$ exposure experienced by women who cooked with crop residues and wood respectively. The highest hourly median $PM_{2.5}$ concentration recorded by Okello et al. (2018) ranged between 308 to386 $\mu g/m^3$ and was recorded between 11 am and 2 pm, which coincides with meal preparation time in the diurnal calendar for rural women.

Water and fuelwood collection labor can negatively affect women's health, exerting significant demands on metabolism as well as causing musculoskeletal damage leading to the early onset of arthritis (Fry et al., 2010). Climate change will exacerbate the rate and magnitude of ongoing land degradation processes and introduce new degradation patterns. Therefore, land degradation and climate change, singularly and in combination exacerbate the already precarious household water and energy situation for hundreds of millions of women and girls, often with severe health and livelihood consequences.

The Impact of Climate-Induced Disaster, Migration, and Conflict

Invariably, the increase in disaster risk due to climate change will magnify the gender-specific impacts of climate-induced hazards. Projected declines in soil fertility, crop yields, energy, and water resources undermine the viability of smallholder subsistence livelihoods. While declines in natural-resource-dependent livelihood push men to migrate to cities and other rural areas for off-farm work, such adaptation strategies by men have been shown to increase vulnerability among women (Djoudi and Brockhaus, 2011). Furthermore, gendered migration often results in increased workload for women left behind who tend to have fewer off-farm options compared to men.

As noted previously, social and cultural norms, lack of decision-making authority, limited or unclear property rights, and time constraints prevent women from leveraging the full spectrum of on-farm opportunities to diversify their livelihood options and enhance their wellbeing in the absence of the male household head. In Zimbabwe, women's contribution to disaster risk mitigation and management is limited in communities that are strongly regulated by cultural and traditional norms of patriarchy that confer property rights and decision-making, especially over cattle (Ndlovu and Mjimba, 2021). Hence, men decide when to dispose of or transfer fungible assets to mitigate drought risk without reference to women. Climate-induced disasters such as drought or famine or floods or disease outbreaks and the human displacement in their wake, increase the risk of gender-based violence and harmful practices including child marriage (McLeod et al., 2019). Moreover, during climate-induced natural disasters and conflicts, sexual and reproductive health needs are overlooked, often with bad outcomes such as a high risk of maternal deaths, child marriage, and unintended pregnancies (Behrman and Weitzman, 2016). These patterns of exclusion or disenfranchisement further transmit and entrench disparities in wealth, health, educational attainment, and labor participation among women.

Social and cultural norms and expectations limit the ability of women to get out of the way in the wake of climate-related disasters In the absence of data or evidence from sub-Saharan Africa, it is instructive to note that the impact of natural disasters is contingent on vulnerability and exposure, which differs across

gender, age, ethnicity, and economic class. In a sample of 41 countries over the period between 1981 to 2002 Neumayer and Plumper (2007) showed that women do not often move from harm's way promptly because socially produced gender relations such as caregiving cause them to prioritize the health and safety of more needy household members such as children and the elderly. Juran and Trivedi (2015) argue that women's exposure and vulnerability to natural disasters are socially constructed through gender, where women have access to limited information, health, and food resources and are granted less decision-making power. In northern Mali women's vulnerability has been shown to increase when men migrate for employment, a fact exacerbated by the fact that the women left behind did not have men's rights to secure tenure of control of fungible resources[3]. Moreover, disaster impacts may also be amplified by a lack of gender perspective in humanitarian response and recovery operations, where for example women often face difficulties proving ownership of property or discrimination when authorities demand the distribution of property and assets are made through male heads of households (IFRC, 2017). More importantly, Neumayer and Plumper (2007) concluded that socially constructed gender-specific inequalities in access to resources, capabilities, and opportunities females built into everyday socioeconomic patterns explain higher female disaster mortality rates compared to men.

Women in rural areas rely solely on natural resources as vital inputs and assets for livelihood for themselves and their families. However, increasingly, climate change and climate-induced degradation of vital resources such as fresh water, land, and pasture increases competition and often aggravates or amplifies the risk of violent conflict. It is important to emphasize that climate change is a risk amplifier, which aggravates pre-existing political, socio-economic, and structural conditions and can push tensions over the threshold giving rise to conflict and violence (Raleigh, 2010). For example, Sudan is highly vulnerable to climate change impacts and North Kordofan is stalked by drought, desertification, and extreme temperatures. These hazards are intensifying land degradation and crop failure, further stressing already limited natural resources, including fresh water and pasture. Hence as the producers of food and primary water collectors, women and girls are disproportionately affected by crop failure and water scarcity. Hitherto mobile pastoral communities are becoming sedentary, creating competition over depleting water, pasture, and land resources, which leads to tension and conflict with farming communities (Bronkhorst, 2011). Women and girls are disproportionately affected by water scarcity and the conflict it generates.

GENDER-RESPONSIVE SOLUTIONS TO CLIMATE CHANGE IMPACT

The literature reviewed demonstrates that climate change-induced vulnerabilities and their impacts on livelihoods and wellbeing are gendered. Men and women have unequal access to decision-making power, knowledge, skills, assets, and networks (Nelson and Stathers, 2009), which translates into gender-differentiated exposure and sensitivity. Essentially, climate change is likely to exacerbate gendered vulnerabilities and compound intersecting forms of discrimination against women. But policies aimed at developing the adaptive capacity at the community level, especially among agricultural and pastoral communities often fail to recognize and respond to the gendered nature of women's experiences.

Hence, climate change response actions need to be gender-sensitive or responsive. However, there is no shared understanding among policymakers or the expert community about what constitutes gender-responsive solutions to climate vulnerability and risk. Even among key stakeholders, knowledge and understanding of the intersection between the socio-economic and political dimensions of gender and climate change are both limited and uneven. Implementation of decisions with gender-specific mandates has been uneven and where there has been an attempt, gender dimensions were implemented in a superficial manner or as an add-on activity (Glemarec et al., 2016). Moreover, the categorization of women as a vulnerable group serves to emphasize women's needs while their leadership and active participation are unsupported and not quantified. Systematically identifying and addressing gender gaps in policy and action in responding to the impacts of climate change is critical to building climate resilience at the household and community level.

This section presents priority areas for action to reduce women's vulnerability and enhance resilience and adaptive capacity to climate change. These priorities include me) gender-sensitive legal and institutional framework; (ii) Women's representation and participation in decision-making; (iii) Information services for women; (iv) sex-disaggregated data and relevant gender indicators (included in the results and portfolio monitoring framework); (v) gender-responsive financial services; (vi) gender-sensitive adaptation/mitigation technologies. This list is only suggestive and attempts to stimulate debate and hopefully consensus for a starting point for deeper engagement of women's participation and motivating investments in creating frameworks for accountability for measurable gender-differentiated outcomes. The purpose of this section is not to prescribe what works or does not work. But it attempts to provide the policy and practice community with an understanding of complex social interventions, which would be invaluable when planning and implementing programmes at the household, community, and national levels.

Gender-Sensitive Legal and Institutional Framework

There is an overarching imperative to address underlying inequalities and adopt proactive measures to promote gender equality and women's empowerment to address gender inequality. These include women's rights to participate equally in lawmaking and governance, and equality in access to land and other productive resources, all of which contribute to women's

[3]UNFCCC/SBI/2019/INF.8 paragraph 21.

capacity to respond to and cope with climate-induced shocks. Secure rights to land and the ability to make decisions over productive resources are critical for women's capacity to respond to climate change and vital for strengthening climate action and building resilience (Monterroso et al., 2021). Hence, it is important to establish and enforce women's legal rights to assets and resources, including gender equality in access to and control over land. There are exemplar sub-Saharan countries that have explicitly recognized women's land rights at a constitutional level and introduced relevant policy, legal and institutional reforms. In Kenya for example, the 2010 Constitution establishes that gender discrimination law, customs, and practices related to land property in land must be eliminated[4]. Similarly, in Tanzania, the rights of every woman to acquire, hold and use the land to the same extent as any man is protected under the Village Act of 1999. Rwanda's 1999 Inheritance Law grants equal rights to sons and daughters and protects the property rights of legally married women.

However, barriers continue to exist, limiting women's access to and control over and use of land and other productive assets even when formal laws and regulations exist. The barriers emerge from implementation gaps owing to inadequate legal frameworks and ineffective policy at the national and local, sub-national levels. Barriers also arise from contradictions between traditional customary norms and formal legal and policy arrangements that confer and guarantee women's rights. Such norms perpetuate discriminatory practices that constrain recognition and adoption of women's constitutional and legal rights. Moreover, a high prevalence of illiteracy, inherent cultural disempowerment, and poverty limit women's ability to access information. Furthermore, customary norms and practices inhibit women from speaking out, curtailing their ability to assert their rights even when they engage. But there are promising grassroots initiatives. In Kenya for example, a national movement of grassroots women-led community-based and self-help groups called GROOTS[5] is providing alternative dispute resolution, legal aid, and mediation on inheritance rights cases. These kinds of nimble grassroots initiatives that build on consensus have the best chance to succeed where formal constitutional and legal structures encounter immutable customary norms.

Climate Information Service (CIS) for Women

Weather and climate information and related advisory services are critical to supporting farmers in managing climate-related risks and better anticipating and preparing for climatic hazards (Hansen et al., 2011). However, compared to men, women face challenges accessing and utilizing weather and climate information services. Women in Senegal preferred climate information delivered via: SMS messages in their local languages; community radio; forecasting boards; broadcasting at public places such as boreholes and mosques (Tall et al., 2014). Diouf et al. (2019) have shown that membership in a community organization has a positive impact on women's access to climate information as was literacy or ability to read and write in the local language. Men in the Upper West Region of Ghana were found to be more responsive in adopting climate information services compared to women because they had access to more financial resources through unfettered control of household income, which allowed them to purchase mobile phones (Partey et al., 2020).

With evidence from baseline assessments, Twyman et al. (2014) show that men in Kenya, Senegal, and Uganda access weather and climate information more than women. However, Gumucio et al. (2020) caution against broad generalizations of observed gendered patterns of access use and benefit of weather and climate information. This caution is especially important because the studies reported were not conducted in the context of interventions to enhance farmers' access to weather and climate information. The pathways for improving uptake and use of climate information among women include; access to ICT devices and channels, participatory downscaling of climate and weather information, delivering information, and agro-advisory services relevant to women's needs as well as a group approach to acting on the information. Rwanda's "Climate services for agriculture" project reported by the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) presents an instructive model that incorporates baseline research on men's and women's control and access to ICT or media-based communication tools that enable farmers to access climate information (Nsengiyumva et al., 2018).

Despite the existence of extension networks to disseminate weather and climate information services, establishing grassroots-level of women communicators would be deed a good practice to improve access and use of weather and climate information. Moreover, capacity building processes that focus on women's use and uptake of weather and climate information and the value addition necessary to turn the information into agro-advisories and reduce the risk in production is a potential strategy in dealing with gender-based inequity (World Meteorological Organization, 2015; Rengalakshmi et al., 2020).

Women's Representation and Participation in Decision-Making

Participation in climate decision-making, policy formulation, and implementation action have been identified as areas of difference between women and men. Women and women-led organizations are under-represented in advocacy, policy, and decision-making roles and processes (Mavisakalyan and Tarverdi, 2019). The Environment and Gender Index (EGI) data set shows that in six out of nine decision-making processes analyzed women represent less than one-third of decision-makers, based on averaging the percentage of women's representation across Conferences of Parties and the three Rio Conventions (IUCN, 2015). The Gender Action Plan recognizes that women's empowerment is central to climate policy and action and notes that "full, meaningful and equal participation and leadership of women in all aspects of the UNFCCC process and in national- and local-level climate policy and action is vital for achieving long-term climate goals" (UNFCCC, 2019).

[4]The Kenya Constitution 2010.
[5]https://borgenproject.org/tag/groots-kenya/

The lack of information, data, and measurement of women's participation in environmental decision-making processes remain a key constraint to advancing equal and meaningful participation by women in the environment and policy arena. Moreover, women encounter barriers to political participation due to inherent patriarchal structure at the national and local levels, even where strong national gender policies are in place. For example, the Kenya Constitution requires the state to take legislative and policy measures to ensure that no more than two-thirds of members of elective bodies are of the same gender[6]. However, the implementation of such progressive constitutional provisions has been very slow because male-dominated institutions, traditional beliefs, and norms regarding women's roles and status remain largely unchanged, especially in rural parts of sub-Saharan Africa (Sadie, 2005).

Women's participation in decision-making can be increased by adopting a range of supporting actions, including adopting flexible meeting timings that don't conflict with women's domestic obligations, and recognizing potential safety concerns when determining meeting venues, mobility, and duration of meetings. Capacity-building programmes at multiple levels could be a potential strategy in breaking entry barriers to representation and participation for women in policy and decision-making, as well as capacity-building on gender as an integral component of climate response projects or programs. According to O'Neil and Domingo (2016), only legal rights and formal rules that are tailored to the context and anticipate how they work alongside existing laws and social norms are informal rules are likely to work. Moreover, women's representation and participation are strongly associated with their economic plight. Hence, multi-sectoral interventions are needed to create opportunities for women through access to assets and affordable credit to engage in enterprise, which in turn confer voice and decision-making power even at the household level. O'Neil and Domingo (2016) further suggest that there needs to be a deep and long-term commitment to women's economic power by investing in training and capacity development to increase labor participation and institutional support to women-focused and women-led organizations. Discrete gender programmes, they argue cannot increase women's power.

Sex-Disaggregated Data and Relevant Gender Indicators

Sex-disaggregated data and gender analysis are the most effective tools for identifying differentiated impacts as well as conducting analyses such as vulnerability assessments (UNFCCC, 2019). However, the collection of sex-disaggregated data is not consistent or standard practice by public agencies, national or inter-governmental organizations (Lambrou, 2006). Moreover, official national data on basic demographic and social issues are deficient or unavailable (UNSD, 2007).

For many sub-Saharan African countries, the capacity to produce reliable and timely data is at best weak. Hence, governments need to build the capacity to conduct at least a decadal population and housing census and establish and maintain vital statistics and civil registration systems. Moreover, mainstreaming gender perspectives into national statistics, from the design of survey tools to the analysis and presentation of results is critical. More importantly, there is a need to mandate sex disaggregation within legislation or regulation that governs the collection, analysis, and dissemination of official national statistics. For countries that have nascent national statistics offices, initially setting up dedicated gender statistics units can be instrumental in institutionalizing and keeping track of, and mainstreaming a gender perspective into national statistical systems.

Two examples of promising approaches are worth mentioning. Canada through its Feminist International Assistance Policy (FIAP) is supporting governments and public servants to collect and analyze disaggregated data and evidence to support better decision making and will help to design and implement initiatives that address the differential needs and opportunities of women and girls, including through gender budgeting (Global Affairs Canada, 2017). Other methods identified as relevant to collecting sex-disaggregated data were gender budgeting and participatory, multi-stakeholder consultation. Gender-based budgeting ensures that gender perspectives are incorporated at all levels of the budgetary process and restructuring revenues and expenditures to promote gender equity. The most frequently used gender budgeting tools are *Ex ante* and *ex-post-gender* impact assessment, offering a systematic continuum of gender-focused assessment and monitoring across the budget cycle, as opposed to *ad hoc* funding initiatives that risk missing opportunities to mainstream gender (Downes et al., 2017).

Gender-Responsive Financial Services

Gender-responsive climate financing instruments and funding allocations are needed. Without financial resources, women cannot adapt to or build resilience to climate change. Social and cultural constraints related to intra-household bargaining power and the social status of women limit the broader impact of financial inclusion on women's economic empowerment. Hence, adaptation projects that target smallholder households need to consider the gender dynamics of access to productive assets and the distribution of benefits. There is a growing body of evidence that confirms the value of integrating gender responsiveness into project design and implementation. However, the effective use of climate finance requires integrating climate change needs and priorities into gender-informed development policy and planning to achieve equitable outcomes. The Green Climate Fund which, started with a mandate to integrate gender into its policy and operational models could set a benchmark for global best practices for gender responsiveness (GCF, 2015).

While women have low levels of financial literacy, formal training programs have shown little impact (Hastings et al., 2013). Wagh (2017) suggests that financial services for women should be accessible and integrated with women's social networks and, support life's transitions by stabilizing incomes and mitigating risks. Climate risk insurance is an important risk management strategy and can strengthen resilience, and protect livelihoods and assets. However, given that women are disproportionately

[6]Kenya Constitution 2010.

represented in poor and vulnerable populations; impacted by poverty, and climate change, and excluded from the formal financial system programs should incorporate a full range of financial products, including affordable longer-term credit for investment. Ng'weno et al. (2018) and Wagh (2017) argue that technological innovations such as mobile phone applications in financial education that adapt individual experiences to women's needs hold more promise for impact at scale than a one-size-fits-all approach but need further testing and refinement. There is a need to collect sex-disaggregated data to evaluate women's needs to tailor and target financial products to meet the unique needs and preferences of women.

Improved gender-disaggregated data, with stronger quantity and quality, will strengthen the business and policy case for financial inclusion for women entrepreneurs. While there are promising trends of increasing access to financial services among women in sub-Saharan Africa, women may have access to financial services such as bank accounts only in name. The authority to make financial decisions on the account often lies with a male relative. In DR Congo, for example, women need authorization from a male to open a bank account, obtain loans, enter into a contract or register a business. There is a need to institute legal reforms to accelerate financial inclusion for women. For example, owing to progressive legal reforms to the Family Code, wives in Cote d'Ivoire are no longer barred from heading a household and can now claim tax deductions. However, effort should go beyond the amendments of legal texts and provisions. Hence, policies aimed at enhancing financial inclusion for women will benefit from addressing inequalities in women's access to property rights and labor markets to ensure that women are creditworthy and have secure collateral for lending in the formal financial sector.

Gender-Responsive Adaptation/Mitigation Technologies

Gender remains a critical analytical category and fundamental to our understanding of technology for adaptation to climate change impacts. Different socioeconomic factors such as gender, age, and experience in crop farming, institutional factors like access to extension services, and access to climate change information significantly influenced the adoption of climate change adaptation strategies among beneficiaries (Thinda et al., 2020). Mutenje et al. (2019) showed that women's bargaining power, drought shock, and access to CSA technology information positively influenced the probability of investing in Climate-Smart Agriculture (CSA) technology combinations (improved maize varieties, soil and water conservation, and cereal-legume diversification) among smallholder farmers in Malawi, Mozambique, and Zambia.

It is important to understand that like men, women are value-driven entrepreneurs who seek and respond to critical incentives for their decisions. For example, Lambrecht et al. (2016) have shown that women adopt less risky but more labor-intensive CSA technologies if they have bargaining and decision-making power to allocate their labor and accrue the benefits for themselves. Hence, it is important to understand why especially the decisions and constraints they face at the household and community level. More importantly, it is critical to building a reliable baseline knowledge base to understand the dynamic effects of technology adoption and to anticipate changes in patterns of labor allocation, production, consumption, marketing, and income allocation (Doss and Morris, 2001; Lambrecht et al., 2016; Thinda et al., 2020).

The use of technology for climate change adaptation and mitigation has the potential to bridge the gender gap by providing a menu of options for both men and women. Differences in priorities and division of labor ability to adopt the technology must be considered. For example, gender division of labor implies that women might prefer to invest in crops that contribute to household food and nutrition needs or new crop varieties or supplement traditional revenue with diversified production activities (World Bank, FAO, IFAD, 2015). Accordingly, and arising from these differences, women, and men will have different needs for weather and climate information, training, and technology options based on their access to productive assets, social, gender norms, and household division of labor.

AN ASSETS-BASED APPROACH TO UNDERSTANDING AND RESPONDING TO GENDER-DIFFERENTIATED IMPACTS OF CLIMATE CHANGE

Women experience climate change and its associated impacts differently. Women's experiences vary based on access, opportunities, and rights to assets or capital which are defined by institutions and gender roles in the context of socio-cultural norms (Fisher and Carr, 2015). Access to assets or capital is critical to understanding vulnerability and the impact of climate change on women, as well as designing plausible pathways for adaptation. An asset-based approach has been used to understand poverty traps and household wellbeing dynamics, and their intrinsic heterogeneity across space and households (Carter and Barrett, 2006). These assets or capitals include:

1. Natural capital: land, water, trees, livestock, soil fertility, germplasm
2. Human capital: education, knowledge, skills, motivation, time, health, and nutrition
3. Financial capital: savings, credit, and transfers (remittances); insurance
4. Social capital: institutions and networks of relationships that facilitate or enable engagement or participation or inclusion; here we include social-cultural norms, laws, and institutional arrangements.
5. Physical capital: input into the process of production; technology, infrastructure (power, water, and sanitation, roads/rail)

The assets or capital endowments define risk and vulnerability as well as adaption and resilience pathways with different livelihood and wellbeing outcomes determined by access to food and nutrition, agricultural production, health, and access to water and energy resources. Moreover, these assets or capitals

invariably account for gender gaps in agricultural output and labor participation because they determine access and control of key resources and inputs such as land, energy, time, labor, technology, knowledge, and information. There is evidence to show that women face a persistent gender gap in access to assets (land and livestock), inputs, and services, especially in natural resource-based enterprises. For example, women represent 15 percent of landholders in Africa, a proportion that masks huge disparities across countries; from five percent in west Africa to 30 percent in southern Africa (FAO, 2011). Similarly, Dillon and Quinones (2010) have shown that the value of men's livestock holdings is nearly twice that of women.

Low levels of human capital, especially poor access to constative elements such as education, health, time, labor, and, nutrition hinder women's full participation and constrain productivity in land-based enterprises (Behrman et al., 2004). Household and gender-specific care responsibilities constrain women's capacity to engage in crop and livestock production as effectively as men. In Malawi for example, Gilbert et al. (2002) showed that male farmers used more fertilizer and dedicated more land area to cash crops compared to women. Drawing from 25 years of experience in designing technologies for African women farmers, Doss and Morris (2001) that African women are less likely to adopt improved crop varieties and management systems compared to women. Meinzen-Dick et al. (2011) argue that women are seldom included in research and development and design and implementation of extension systems and the adoption and evaluation of new agricultural technologies. Kilic et al. (2013) have shown that female-managed farm plots in Malawi were on average, 25 percent less productive than farm plots managed by men. In the case of Malawi, Kilic et al. (2013) further reveal that the capital or asset endowment effects account for 82 percent of the gender gap, especially concerning fertilizer application, labor, and restricted access to appropriate tools.

The lack of basic services such as water health, transport, child care, and clean domestic energy sources erodes significantly the time women would spend on productive and remunerative activities that could reduce their vulnerability and build their resilience to climate change. Hence, assets or capitals that women have access to matter when designing or implementing gender-responsive interventions. Most importantly, assets or capitals held by women are critical to reducing women's exposure and vulnerability to the impacts of climate change. There is evidence that assets or the capitals forestall poverty shocks and reduce the likelihood of households resorting to coping strategies that may further undermine their capacity to cope with the impacts of climate change. Moreover, lack of assets or the inability to use available assets effectively may contribute to poverty, persistent exposure, and chronic vulnerability to climate change impacts. Conversely, high asset endowment is critical to virtuous feedback and synergies that enable durable pathways to resilience and reduced vulnerability to climate risk.

An asset-based approach to understanding exposure and vulnerability to the impacts of climate change is critical to constructing gender-responsive interventions. Different initial asset endowments between men and women lead to qualitatively different vulnerability or resilience outcomes. Invariably, women in rural sub-Saharan Africa possess less education, information, and time or labor (human capital) that would allow them to manage climate-related risks compared to men who are more likely to have high endowments of human capital (Goh, 2012). Similarly, gender differences exist in favor of men concerning land holdings, livestock ownership, access to financial services especially credit, technology, modern inputs such as chemical fertilizers improved seeds, and extension services (FAO, 2011).

The underlying causes of gender asset gaps in favor of men are consistent across many contexts in sub-Saharan Africa. These include statutory and customary norms, property rights, and household and reproductive roles that impose time constraints on participation in off-farm employment. For example, women receive <10 percent of the credit from small farmers in Africa and cannot purchase, for example, new varieties of plants or new farming technologies to adapt to warmer or drier climates (Nair et al., 2006). Without equitable access to land, credit, information, and agricultural technologies, women face major barriers in their ability to diversify into alternative livelihood options to cope with the adverse impacts of climate change (World Bank, 2012).

The most fundamental connection between the dynamics of climate risk and gender-differentiated impacts is that most women depend heavily on biophysical resources for their livelihoods. However, we know very little about the nature of feedback between tightly coupled human and biophysical systems in sub-Saharan Africa. It is important to understand that in the long run smallholder households typically generate income from land-based activities such as crop farming, livestock, fisheries, and trade. In turn, households save proceeds, which they reinvest to bolster physical, human and financial capital. Hence, the apparent but little understood coupling of assets and women's wellbeing raises the possibility of a climate-induced gender-differentiated asset or capital poverty traps.

More importantly, interlocking asset or capital dis-endowments, enabled by dominant norms and institutions, interact in complex and reinforcing ways to produce and maintain differential vulnerability to climate risk between men and women, and even create intractable poverty traps. Any efforts to design and deploy gender-responsive solutions to climate change impact must take a holistic, asset-based approach, which meaningfully seeks to identify dominant causal mechanisms and develops context policy and institutional options to address interlocking asset or capital dis-endowments.

KNOWLEDGE GAPS

The review suggests priority evidence gaps and possible research focus areas to respond to gendered impacts of climate change. A more nuanced understanding of household-level gender differences and dynamics will be important for determining how to prioritize and bundle gender-responsive policies and actions. Three research opportunities, in no order or priority, emerge:

1. More research is needed to understand how members of households, men and women, perceive climate risk, make decisions about how to respond, and the place of technology

in adaptation. This research will fill the evidence gaps on women's roles and responsibilities, and help anticipate what dynamics interventions such as technology, rights to productive assets, and decision-making power would introduce into the household.

2. Household gender roles are dynamic. Men are no longer the sole decision-makers. Hence, we need to understand systems of norms and behavior in the household in crop/livestock and pastoral communities. Hence more research is needed to understand within household decision-making processes on the allocation of access and rights (temporary or durable) to productive assets, especially to female members of the household.
3. Social justice and equity-oriented research on vulnerability are needed to understand how, socio-economic, political, and cultural structures intersect with the biophysical process to make create, sustain and propagate gender-differentiated impacts of climate change.
4. Overall, future research should be informed by a deep and appreciative understanding of local knowledge within household decision-making processes and seek to understand how gender interacts with other socioeconomic attributes for evidence-based targeting of bundled, synergistic, and responsive policies and interventions of gender-based climate information needs.

CONCLUSION

The existing knowledge base on gender differences concerning climate change impacts may be limited and tends to focus on the context-specific nature of gender dynamics. However, the literature reviewed shows that climate change affects women more negatively compared to men in five impact areas: (i) agricultural production; (ii) food and nutrition security; (iii) health; (iv) water and energy; (v) climate-related disaster, migration, and conflict. Factors related to socio-cultural norms that shape gendered labor roles, resource control, and decision-making power can also influence women's and men's differing responses and adaptive capacity to climate change impacts.

There is no silver bullet; policy or intervention or technology will alleviate the gendered impact of climate change. The effect of any policy or intervention or technology will vary depending on men's and women's access to assets or endowments and commensurate access rights to production, and income allocation. However, the lack of gender-disaggregated data undermines efforts to design gender-responsive interventions to enable women to cope with and adapt to climate change impacts.

National policies need to support women's access to other assets and services, such as education, land, finance services, and diverse income-earning opportunities. Without these provisions, especially education and alternative livelihood options beyond subsistence farming, economic choices and off-farm work and income opportunities for women will remain limited. But more importantly, efforts to design and deploy gender-responsive solutions to climate change impact must take a holistic, asset-based approach, which meaningfully seeks to identify dominant causal mechanisms and develops context policy and institutional options to address interlocking asset or capital dis-endowments. It is important to keep in mind that the societal impact of climate change, winners and losers, is ultimately about power relations and complex and dynamic structures negotiated through norms, values, and institutions in different contexts.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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