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REVIEW

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Transitioning to sustainable food systems in a changing climate and gender equality: a brief review

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Abstract

Food security is unquestionably crucial to society's well-being. The world is experiencing unprecedented global shocks; therefore, it is critical to protect the agri-food systems. This concept is broad and complex, with various interpretations around the globe. The problems of social equity, environmental sustainability, and food security are interconnected and are rarely best addressed separately. The failure to address the farming sector, particularly that of women farmers, is the basis of the current discussion. Creating sustainable food systems requires moving from an agriculture-centred to a food system policy and research framework. This will be fundamental to fostering the complex and holistic transformation necessary to achieve sustainable food systems, which is, in turn, a prerequisite to achieving sustainable food and nutrition security. Therefore, the current study aims to establish the link between women's empowerment and food security. The study used a systematic literature review approach based on secondary data available in relevant and contemporary literature. The findings showed the scarcity of research in areas of gender response to climate change and coping strategies and cultural biases against women.

Moreover, most policies designed to improve and expand local communities' capacity for adaptation are gender-neutral. Interdisciplinary research and innovation are likely to be the most effective methods for tackling food insecurity while considering its complex social, economic, and environmental components. The objective is to advance sustainable solutions. Therefore, in addition to academic thought, a focused approach to the issue is required; one must act following reality.

Keywords Food security, Climate change, Women empowerment, Global agenda 2030, Coping strategies

Introduction

Climate change and food security are complex issues that span political boundaries [27, 44] report on the state of food security and nutrition in the world has raised doubts about the ambitious campaign to end hunger, food insecurity, and all forms of malnutrition (Sustainable development goal targets 2.1 and 2.2), expected to be achieved by 2030 [27]. The current trajectory in other critical areas, such as poverty (Sustainable development goal (1) and hunger (Sustainable development goal (2), indicates a troubling reversal of decades of progress [13]. At current rates of increased gender disparities in food security [27], more women and girls will be living in extreme poverty (on less than $1.90 a day) by 2030. Women and girls are subject to unique challenges in conflict and post-conflict settings, missing out on education [71] and, above all food.

Ever since the global food price crises of 2007–2008 and the 2008 World Development Report [80], which

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called for greater investment in agriculture in developing countries, there has been a lot of attention focused on food security from both academic and non-academic communities [1, 41, 48]. Despite decades of efforts to combat hunger and malnutrition, food insecurity remains a major issue [60]. The concept of food security is evolving and becoming more globalised and is closely tied to other challenges, such as global environmental change and energy markets [41, 78] Lang et al., 2009; [42]. As a result, academic institutions and policy discussions are increasingly embracing the concept of food security [14, 54, 78]. The WFP reports that the number of individuals experiencing acute food insecurity has increased by over three times between 2017 and 2021. The conflict between Russia and Ukraine could potentially increase by 17% to 323 million in the current year [78].

Food security is projected to be impacted negatively due to rapid population growth in developing countries [36], coupled with global climate change and the recent economic downturn [38]. The world's population is projected to reach 9.8 billion by 2050 [73, 16], and climate uncertainties show declining crop production [64]. A growing population pushing food demand to its limits already strains the Earth's resource capacity. Global agriculture faces the pressure of feeding the increasing mouths, constrained by climate change, land availability and degradation, loss of biodiversity and food insecurity [20]. Governments must discuss openly with industry, technical organisations, academia, and civil society to address the emerging risks. To prevent nutrition crises, the focus should be expanding the already-existing international frameworks, such as the Committee on World Food Security. These organisations serve as platforms for policy discussions and a repository for advisory tools [27, 69]. further acknowledged that "how" to achieve a sustainable food system is less well addressed in current scientific literature, and insights from the social sciences are frequently underrepresented. It is further argued that insights from the social sciences can be utilised to map and analyse the various food system components and their dynamics concerning sustainability goals. Promoting socio-economic and environmental sustainability in the agri-food sector for future generations must go hand-in-hand with unwavering commitment to food safety and consumer protection. Due to the need for such a transition, it is more important than ever to revaluate national and supranational strategies and policies, the lack of which has had a profound impact during Covid19 [50] and now it has been left bare in the current war in Ukraine [71]. The most crucial aspect of this discussion is the failure to address the farming sector and their safety, especially the women farmers. From this perspective, a gender-focused approach has been addressed in this study. Given this context, a gender-sensitive approach is essential, especially for developing countries' food systems, acknowledging gender equality and women's empowerment as key factors in improving food systems to address food security. Women farmers are often disproportionately affected by challenges in agriculture due to gender disparities in access to resources, land ownership, and decision-making power. Cultural norms and traditional gender roles limit women's access to education and modern farming techniques, making them more vulnerable to economic shocks and climate disasters. Women's roles as primary caregivers exacerbate food insecurity during crises like the COVID-19 pandemic or conflicts, where disruptions in food supply chains worsen vulnerabilities. A gender-focused approach is crucial for empowering women farmers and improving food systems, as gender equality is key to achieving food security, especially in developing countries. Addressing the specific needs of women farmers, such as access to resources and support services, can make agricultural systems more resilient and inclusive.

Global discussions on food security acknowledge gender equality to enhance agricultural and economic growth and ensure food security [5, 25]. Nonetheless, studies reveal that gender inequality contributes to food insecurity, especially for poor and marginalised women who have limited access to crucial agricultural resources [61]. While empowering women is linked to better food security, it has not been fully realised regarding investments and gender equality results. This is particularly relevant in light of increasing male out-migration trends and shifting towards a more female-dominated agriculture industry (Galieand Kantor, 2016).

Galie and Kantor [34] argue that the policy debate on women's empowerment often has a narrow and apolitical approach. Development programmes tend to focus on economic empowerment rather than addressing the root causes of gender inequality, which include norms, institutions, and larger political and economic structures. Economic empowerment alone does not address the deeper issues that (re)produce gender inequalities [34, 42]. Creating sustainable food systems requires moving from an agriculture-centred to a food system policy and research framework. This will be fundamental to fostering the complex and holistic transformation necessary to achieve sustainable food systems, which is, in turn, a prerequisite to achieving sustainable food and nutrition security. This study highlights the importance of a gender-sensitive approach to improve food systems and address food security in developing countries. Gender equality and women's empowerment are key factors in this regard. Sustainable food systems, food security, gender equality, and climate change are closely linked to

several Sustainable Development Goals (SDGs). These include SDG 2 (Zero Hunger), SDG 5 (Gender Equality), and SDG 13 (Climate Action). Therefore, addressing these interconnected issues is crucial for achieving multiple SDGs.

Theoretical framework

Definition of food security

The task of defining the concept of food security evolved from the World Food Summit in 1996, which says, "Food security exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences [59, 67] for an active and healthy life" [31, 65, 66, 81]. Food security is built on three pillars: availability, access, and utilisation. Food availability refers to the amount of food that is consistently available; food access relates to the resources needed to obtain the right foods for a nutritious diet; and food use refers to the appropriate use of food in light of basic nutrition and care knowledge, as well as access to clean water and sanitation [42]. Addressing food security is a complex issue that necessitates institutional collaboration across sectors. Berry et al. [9] reiterate that the concept of food security emerged because of the infrequent global food crisis. The recurrence of famine, hunger, and food crises demanded a new approach to food security that considered the critical needs and behaviour of potentially vulnerable and affected people. Jarosz [45] observes a shift in the definition of food security. The paradigm shifts from the international level of world regions and nations to the level of poor households and individuals, demonstrating a widening gap between the haves and have-nots, the powerful and the vulnerable.

The scientific community now advocate that "food must be viewed more as a common good rather than as a consumer good", as has been the tendency in the past. To achieve a sustainable food system, the central goal of all relevant policy development and assessment must be to ensure food sustainability in all aspects: environmental, social and economic (High-Level Panel of Experts on Food Security and Nutrition, 2020). The High-Level Panel of Experts on Food Security and Nutrition (HLPE) is an independent advisory body providing scientific advice to the Committee on World Food Security (CFS) to address global food security and nutrition challenges. SDG 12 aims to "ensure sustainable consumption and production patterns". Therefore, it is critical to comprehend what a sustainable food system is [39].

What is a sustainable food system

Food security is unquestionably important for society's well-being [50]. This idea has different meanings worldwide, adding to its complexity and broadness [22]. Social equity, environmental sustainability, and food security challenges are interconnected and are rarely

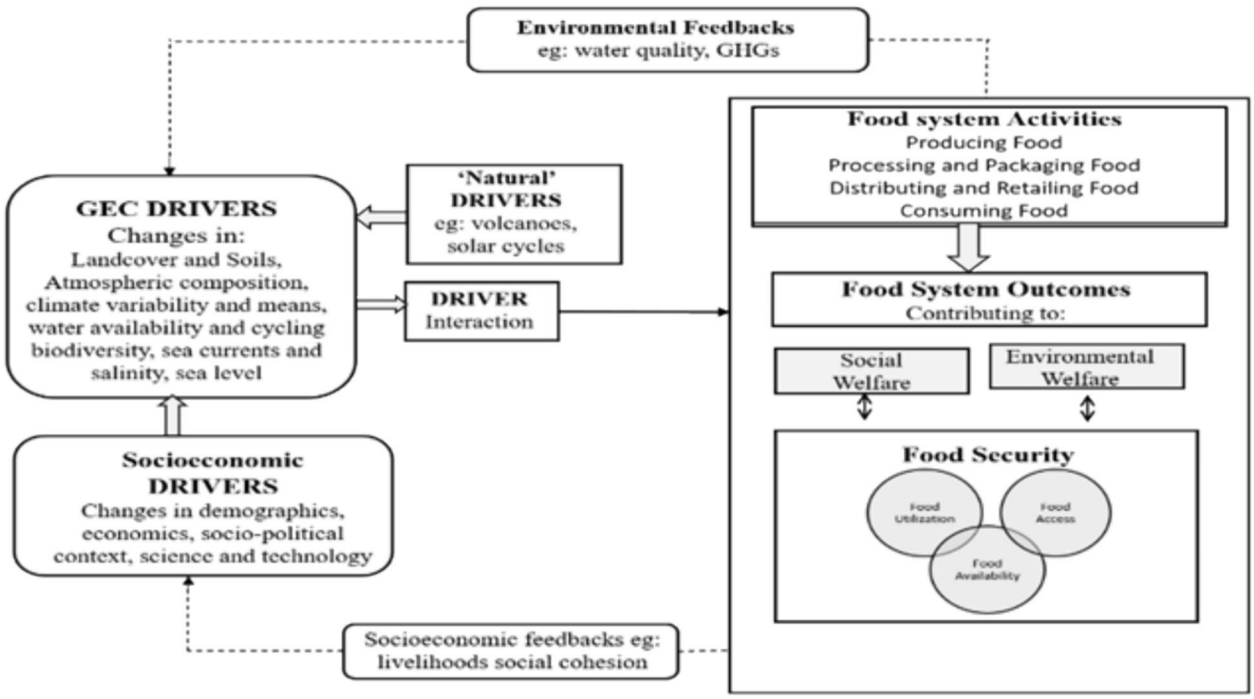

Fig. 1 A food systems diagram showing drivers of change and relationship with food system outcomes. Source: Garnett et al., [35]

best addressed separately. Policymakers and researchers increasingly turn to food systems to comprehend the inter-linkages of these issues with food and to address the complexity that results [12]. Food systems refer to integrating food into multifaceted and multi-layered processes that connect food production, distribution, processing, and consumption while acknowledging that these processes are supported by intricate political, economic, social, and ecological relationships [23]. A food system is defined as 'All elements and activities related to production, processing, distribution, preparation, and consumption of food' [77], as depicted in Fig. 1. The factors that go into getting food from a farm to the consumers include the environment, people, inputs, processes, infrastructure, and institutions [23].

How sustainable is the food system

The 2022 WFP report reveals alarmingly high levels of hunger exceeding those ever recorded. The need for resilient food systems cannot be overemphasised. Visser and Wangu [75] noted that multiple shocks and stressors operating at various scales can simultaneously affect people and communities. To ensure that everyone can meet their food needs, food systems are under tremendous pressure and becoming increasingly vulnerable [30]. These factors include a growing population, increased competition from non-food production for agricultural resources, such as biofuel crops, the effects of the agricultural output, socio-economic inequalities, and shifting dietary patterns [32]. Additionally, food systems interact with agricultural systems in the "food production" sector along with various services, technologies, and undertakings governing production, distribution, transportation, accessibility, and "food consumption". Food systems not only influence the production and consumption behaviour of the people, but also their prospective attitudes and perceptions towards a nutritious diet [30].

Therefore, production and consumption patterns are understood as the real discourse surrounding "sustainable food security", currently overshadowed by stress and uncertainty [29]. Several variables, such as geographic location, demographic trends, urban development, and globalisation, impact food production and consumption [63]. Drawing from Jaroze (2012), at the national, local, and household levels, socio-economic status, income level, consumer habits, religion, and culture also impact. The food system can be harnessed to improve and bind the urban and rural domains by establishing a new food industry, creating new jobs, and recovering the value of local products. This would ensure a regular supply of food products to meet the urban demand [12].

The authors contend that the various components of the food system are directly or indirectly related to the patterns of food production and consumption, which are the keys to achieving food security [12]. The positive and negative associations must be considered to simultaneously accomplish SDG 2 and SDG 12's multiple goals. The current food-crisis presents a serious challenge to the SDGs of the United Nations. Almost all SDGs are directly and indirectly involved with food security issues, and targets must be achieved to solve them [75]. To transition to a sustainable food system, it is crucial to investigate the connections between food security and the SDGs . To build a more resilient food system, it is imperative to avoid supply-chain disruptions by strengthening market management and implementing redundancy [75]. Environmental degradation caused by agriculture can diminish food production, weakening the food system and creating a vicious cycle. An inequitable food system that adversely affects the environment cannot be deemed sustainable [75]. Given this context, a gender-sensitive approach is essential, especially for developing countries' food systems, acknowledging gender equality and women's empowerment as key factors in improving food systems to address food security [3]. During the pandemic 2020–2021 period, it became clear that food systems had not met their objectives [75], which the world is reliving right now because of the conflict in Ukraine [71]. Interest in research and policy has primarily focused on productivity, food systems' environmental effects, and consumption patterns [15]. Despite its significance, discussions on enhancing the sustainability and resilience of food systems have scarcely included a gender perspective [75].

Both men and women participate in food systems, but the nature and extent of their participation varies depending on the economy's structure and gender norms. Women are actively involved in various roles, from production and processing to retailing and consumption; they grow and manage crops, tend livestock, and work in agribusinesses and food.

retailing, preparing food for their families, and much more [49]. However, women's contributions to food systems are often not formally recognised or appropriately valued. Women frequently face constraints that prevent them from engaging on equitable terms, in many countries, women have less schooling than men, control fewer resources, have less decision-making power over household income, and face time constraints because of their triple burden of productive, domestic, and community responsibilities [61].

The overall food security score of the Global Food Index has decreased because of the unprecedented number of global shocks that are currently occurring.

Stakeholders will need to adopt a systemic approach and build resilience in the food supply and the environment in which food is grown and distributed to combat these stresses and shocks and ensure food security in the future. A food system must still produce the desired results when exposed to these stresses and shocks to be resilient. Zohrabi et al. [82] note that a resilient food system can quickly bounce back from disruptions, resist them, and reorient itself toward more sustainable outcomes. Effectively addressing food insecurity necessitates interdisciplinary research incorporating new technologies alongside social, economic, and environmental considerations [53, 74].

Whether in business or government, a food systems approach to policymaking would have significant advantages. Focusing on a holistic approach and interdisciplinarity can ensure that problems are approached from various angles and comprehensively, more closely aligning policymaking with the actual situation on the ground. Identifying the issue comes first, followed by investigating the food system as necessary to determine its causes, and finally, developing strategies to address these [11]. Queiroz et al. [62] propose the possibility of redirecting financial resources toward resilience and sustainability. Regions vulnerable to environmental, socio-economic and political turbulence face high levels of disruption in local and regional food systems and have detrimental impacts on food security. That may pose a challenge to developing business and policy incentives for resilience-building. In this regard, a thorough scientific analysis of climate change and its effects on food safety is necessary due to the connections between the various research fields and the multidisciplinary nature of climate change effects [51].

Materials and method

This study employed a qualitative systematic literature review methodology to meet the study's objectives. The study builds on secondary information found in relevant and recent gender and food security literature under a changing climate. A major research issue worldwide is the relationship between the impact of women's empowerment on women's nutrition and other development goals. The criteria applied to choose studies that fit the study's parameters are shown below:

1. A focus on climate change and its impact on food security.
2. Gender and the risk of climate change.
3. A gender-sensitive approach and coping strategy.

Due to limited access to Scopus and Web of Science, this study primarily relied on Google Scholar for relevant research outputs. The search terms used included "food systems and sustainability goals", "food security and climate change", "food security and gender", "gender equity and food security", "women farmers and developing countries", "smallholder farmers and climate change" some of the terms were used interchangeably.

Table 1 Quantification of data

Inclusion and exclusion criteria	Number of results
Availability	96
Suitability of results to research question	24
Inclusion of peer-reviewed results	13

The collected articles were screened for relevance to the topic. Both the title and abstracts were first reviewed for insertion or deletion. The most relevant articles were then read and included in the study. Except for a few exceptions, the study is limited to the post-2016 time frame to the most recent to get a sense of the current situation and what is accomplished under sustainability goals. Finally, screening to remove duplicates and include only peer-reviewed work to attain originality. Table 1 summarises and quantifies the data acquired using the given search strategy. In the first step of the analysis, the Köppen–Geiger climate classification system was employed to determine the climatic context of the studies reviewed. As Chen and Chen [17] suggested, adopting a climatic approach helps to organise the study in the context of the local microclimatic characteristics increasingly used by the scientific community. This empirical system aids in determining the climate type for any region over 30 years, as defined by the World Meteorological Organization (WMO). The literature is spread from tropical climates (Am/Aw/Af) through mild temperate (Cwa/Cfa/Csa) to dry climates (Bwh) across three continents.

Of the 96 available studies, as in Table 1, 24 were selected after screening the Titles and Abstracts. Finally, after a full-text review, 13 published articles were found relevant, matching the selection criteria and making them usable for this review article.

Data screening and analysis

To manage data collection and screening, the study used a PRISMA [52] (Preferred Reporting Items Systematic Reviews and Meta-Analyses) diagram. As depicted in Fig. 2, the diagram consists of four major steps. In the first step (identification), 96 relevant articles dating from 2016 to 2022 were gathered; those identified in search engines and additional sources found in the reference lists of these publications were

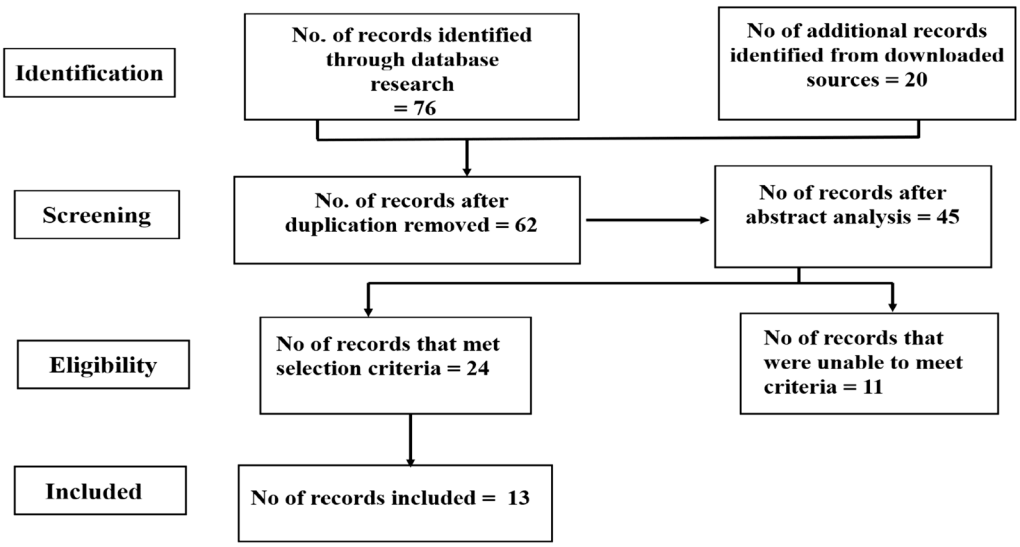

Fig. 2 A flow diagram of PRISMA

included in these publications. Next (screening), duplicates (e.g., multiple publications of one study) were removed, and the number of publications was reduced to 62 articles. In the same step, these articles' abstracts were analysed, resulting in 45 articles. Next (eligibility), the evaluation criteria were applied to these articles, and the final number at this step was 24. In the final step (included), after reviewing the full texts, only 13 publications were relevant, matching the selection criteria and usable for this review article (Fig. 3).

Results

The review resulted in several studies investigating the growing evidence of and pointing to the high cost of ignoring the significant "gender gap" in most nations' agricultural productivity and development. This relates to continued inequality and the lost chances to enhance development outcomes. In the context of climate change, it is essential to use the gender lens to understand how gender helps regulate opportunities and challenges. The prime focus was the relationship between women's

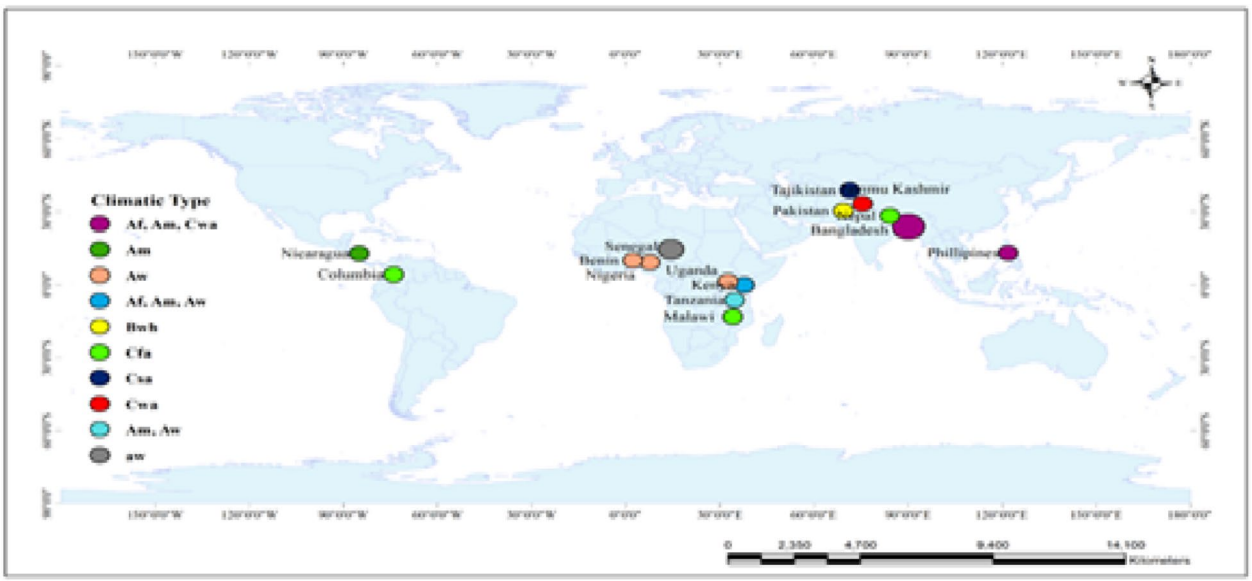

Fig. 3 Geographical distribution of countries where selected studies showed their climate regimes. Source: Authors

empowerment, food security, cultural background, socio-economic structure, and some responses to local adaptation to changing climates. It has been observed that the major focus of most studies has been on the decision-making power of women and their asset ownership in agriculture to improve nutrition and food security at the household level. The following sections provide an analysis of the profile of the studies reviewed.

Profile of reviewed studies

As presented in Table 2, all studies reviewed used concurrent field measurements with a questionnaire survey to collect data pertaining to the gender–agriculture–food security nexus.

In one study (Krisjanson, 2019), a remote survey was conducted that was preceded by in-depth interviews to understand the cultural background of participants. The selected studies are from 2017 to, most recently, 2022, mostly concentrated in the poor nations of Africa, Asia, and Latin America, which have diverse cultural, agro-economic, and dietary habits. The impact of climate, the most crucial factor affecting livelihoods, has been mostly underrepresented.

Q (questionnaire survey)

Climate types: Am-Tropical monsoon climate, Aw-Tropical savanna, Af- Tropical rainforest climate, Bwh-Hot deserts climate, Cwa-Monsoon-influenced humid subtropical climate, Cfa-Humid subtropical climate, Csa-Hot-summer Mediterranean climate.

Gender and climate change: why are women at more risk from global warming?

Global warming is the long-term heating of the Earth caused by human activities like burning fossil fuels. These fuels release greenhouse gases that trap heat from the sun in the atmosphere, warming the planet. We are already seeing the effects of extreme weather, rising sea levels, and melting ice, and it is expected to worsen. To combat this, we must switch to renewable energy sources, become more energy efficient, protect forests, and adjust agricultural practices to reduce greenhouse gas emissions.

Adopting sustainable and climate-resilient food and energy systems and practices has never been more crucial [71]. Our understanding of climate change and potential threats to world food security raises serious questions about the viability and sustainability of all life [28, 40, 44]. Global and regional conferences merely serve as a forum for repeating the dominant narrative on food security and climate change, which calls for proactive participation from each region and the global community. The impacts of climate change disproportionately affect poorer regions and communities that are least responsible for the change and are less able to adapt [10, 44, 56]. The impact of climate change undermines human rights and reinforces inequalities and injustice [15]. Climate change undermines human rights and reinforces inequalities and injustice by disproportionately impacting vulnerable populations, exacerbating existing social, economic, and political disparities. Marginalised communities, with limited resources and adaptive capacity, bear the brunt of climate-related consequences, such as displacement, loss of livelihoods, and food insecurity. Wealthier nations' disproportionate greenhouse gas emissions further exacerbate these inequalities, while barriers to resources and decision-making processes perpetuate injustice. Addressing climate change necessitates tackling underlying inequalities to uphold human rights and ensure equitable adaptation and mitigation efforts.

Rural women are among the hardest hit by the crisis, given their vulnerability and lack of coping capacities [8, 63]. The agricultural sector and, in turn the food systems, are under considerable risk due to the impact of climate change [68]. It is clear that smallholder farmers, comprising women, youth, and indigenous people, are at the highest risk in developing nations [21, 19, 75]. Authors [6, 10] argue that the food systems are influenced by existing and evolving social and economic conditions. These include women's unfair socio-economic conditions because of their gender [6, 12, 47]. They are less likely to relocate to safer areas because of their limited participatory role in decision-making [6, 47, 75]. Besides, social and gender inequality is further aggravated in the changing scenario. The structural causes of gender inequality that lead to vulnerability are ignored [7, 76], while women are labelled as the victims of climate food supply constraints, skyrocketing food prices, and restricted access to fertilisers are having a drastic impact on women's and girls' food security and nutrition on a global scale (U.N. woman, 2022, [8].

Increased resilience [61], or the capacity of everyone to respond to the challenges posed by climate change, is essential for gender equality in a world that is 2 °C (or warmer). Resilience means that women, men, and their communities must be adaptable to prevent, manage, or recover from the shocks and stresses climate change brings [2]. Climate change impacts men and women differently. [47] observes that climate change accelerates the trend of agriculture becoming more female-oriented while driving men into migration. In developing countries, the rural livelihood is jeopardised as conditions are made worse by climate change. Therefore, adopting a gender perspective enriches and provides key insights to the discussion of climate change; involving women in the decision-making process should be considered part

Table 2 Summary of recent food security studies from a gender perspective

References	Location, climate, and methodology	F.S. Index used	Summary of findings	Keywords used
[55]	Senegal (Aw), interviews, participatory activities, observations, and questionnaire (Q)	Women's Empowerment in Agriculture Index (WEAI),	The study emphasises the need for more evidence-based, gender-sensitive VCD (Value Chain Development) initiatives in various situations and at levels of analysis. Future advancement in inclusive economic development depends on knowing the circumstances in which VCD can benefit women and other marginalised groups to make marginalised men and women food secure	Value chain; food processing; women's empowerment; development; gender; nutrition; dietary diversity; food security; religion; Senegal
[6]	Review of previous studies	–	Most studies have focused on women's decision-making power and asset ownership in agriculture to improve nutrition and food security at the household level. A positive correlation has existed between women's empowerment and food security	Food security: Women's empowerment: Systematic review: Review studies
[4]	Nigeria (Aw) Ordered probit model estimates	–	This finding provides key policy insights into how the national government and development entities can promote food security and female empowerment**.** Women must be sufficiently empowered to ensure food security in their households	Gender; economic resources; dietary diversity; nutrition; ordered probit
[76]	Bangladesh Af, Am, Cwa, Structured questionnaire PLS-SEM model	HFIAS represents a universal field of food insecurity experienced in various cultural contexts	According to the results, women with access to their legal and familial rights, participate in household decision-making, have access to ICT services, and live in areas with better infrastructure have significantly less food insecurity	Agency; food security; rural Bangladesh; structural equation modelling; women's empowerment
[61]	Bangladesh, Af, Am, Cwa, Philippines, Af, Am, Aw Benin Aw and Malawi Cfa	pro-WEAI + MI, a metric developed to measure women's and men's absolute and relative empowerment along value chains	To ensure that measures "do no harm" and do not intensify already-existing gender bias, it is suggested that initiatives aimed at empowering women in food systems and value chains consider the social and cultural contexts in which these food systems operate	Gender: Women's empowerment; Market inclusion; Value chains; Food systems
[75]	–	–	This study argues that because women are crucial to the resilience and sustainability of agriculture and food systems, discussions of food systems in developing countries must be framed through a stronger gender lens. Women are essential to functioning food systems because they are the primary food producers and household caregivers	Food security solutions; Food systems; Gender equality; Gender lens; Resilience; Sustainability

Table 2 (continued)

References	Location, climate, and methodology	F.S. Index used	Summary of findings	Keywords used
[40]	–	–	According to their assessment, women generally have less access to family labour and fundamental agricultural technologies. Innovative approaches are nevertheless required to combat the new threat posed by a changing climate	N.A
[7]	Azad Jammu Kashmir (Cwa) Tundra type and Structured interview and PLS-SEM approach was used	–	The statistical analysis allowed for modelling the outcome (food insecurity) as an attribute and the dimensions of women's empowerment as underlying explanatory variables	N.A
[3]	–	WEAI	The study evaluates women's decision-making power related to 1) productive resources, 2) agricultural management, and 3) agricultural income	N.A
[47]	Used both quantitative and qualitative research under CCAFS framework Kenya, Af, Am, Aw, Uganda, Aw, Senegal, Aw, Bangladesh, Af, Am, Cwa, Columbia, Cfa Nicaragua Am	Climate change, Agriculture and Food Security (CCAFS) approach to measuring gender and climate change issues	Lessons from this synthesis indicate the continued need to support these participatory "action research" methodologies, test new technologies, strategies, policies, tools, and methodologies, and co-learn with partners in the field. Use of innovative technology like mobile phones for dissemination of knowledge/awareness	Gender gap; agricultural development; climate change; development; adaptive capacity; resilience; vulnerability
[18]	Bangladesh, Am, Cwa, Nepal Cfa and Tajikistan Csa quesstionnaire (Q)	WEAI (IFPRI and OPHI)	The study analysed the causal relationships between women's empowerment and access to and food availability. It indicates the existence of a diversity of patterns and the diversity of roles that socio-economic structures play in shaping these patterns across countries. They emphasise the necessity for food security programmes to have a truly intersectional strategy that supports overcoming the institutional barriers that make marginalised sectors insecure	Food security; women's empowerment; gender; intersectionality; multi-country analysis; mixed-methods study

Table 2 (continued)

References	Location, climate, and methodology	F.S. Index used	Summary of findings	Keywords used
[33]	Tanzania, Am, Aw Structured questionnaire (Q)	Women's Empowerment in Livestock Index (WELI)	A mixed methods approach was chosen to address the complexity of the connections between empowerment, food security, and nutrition security because it offers an in-depth understanding of how these connections developed according to the respondents and a quantified measurement of these connections	Women's empowerment; household food security; maternal and child diet diversity
[8]	Pakistan Bwh	Qualitative approach	The findings indicate that women's farm experience is the primary factor influencing how they perceive and adapt to climate change. Women with more farm experience are better at diversifying their holdings, managing their finances, and dealing with the negative effects of climate change concerning women with limited farming experience	Women's perceptions; Coping strategies; Climate change; Heckman model

Shows no specific location of research or any index used

of the solution. To develop gender-responsive policies that support equality while enhancing resilience globally, building on earlier experiences and research and drawing lessons from them will be advisable [2].

The IPCC reports are constant reminders about the enormity of these changes. In 2018, the report reflected on how farmers were forced to relocate as temperatures rose, escalating inequality. The most recent [43] emphasises how severe food insecurity has been brought on by climate change in developing nations. Additionally, it addresses that smallholder farmers face severe adaptation gaps in regions that face serious development obstacles like poverty, limited access to basic services and resources, and a high reliance on livelihoods sensitive to climate change. Governments should set up or improve social protection systems to protect the most vulnerable. The food system must be made more resilient. These systems will function properly during the crisis if market management is strengthened and redundancy is built to prevent supply-chain disruptions [75]. Batool et al. [8] pointed out gaps in the literature addressing how climate change affects women, particularly rural women. Women are stereotyped as victims of climate change impacts. At the same time, the structural causes of gender inequalities that cause vulnerability are ignored, with climate change making access to traditional food harder and scarcer. Given the numerous environmental, economic, and social risks and unsustainability that endanger the planet and people's lives, livelihoods, and well-being, fossil fuel-based agriculture and energy are no longer practical. Ampire 2020 have assessed gender empowerment through two schools of thought: i. the process analysis and ii. the content analysis to analyse the quality of gender policies. While the process analysis looks at more gender-responsive policy formulation, with women's organisations and professionals participating at all stages, the content analysis method assesses the representation of women in policies or the degree to which their concerns and interests are met. The technique evaluated the degree to which climate change policies contributed to gender issues.

Gender equity and food security in the global agenda 2030

For all the goals to be achieved, gender equality is vital. They represent half of the global population and an equivalent workforce. Improving their lives benefits society as a whole and sustainable development in all its dimensions. Ensuring women access to respectable employment opportunities and steady income promotes better outcomes for women and girls regarding nutrition, health, education, and poverty reduction (SDG 1, SDGs 2, 3 and 4). SDGs, therefore, promise to improve the lives of women and girls. Still, additional action is required to accelerate the process, address the bottlenecks, and avoid any slowdown of decades of work. Despite gender equality being the driver of sustainable development in all its dimensions, progress on gender equality has been very uneven across the various dimensions of the 2030 Agenda (U.N. [72]).

The United Nations Food Systems Summit (UNFSS) (European [26]) was held in 2021 to achieve the SDGs, particularly SDG5, on women's empowerment and gender equality in food systems. Women play significant roles as producers, wage workers, processors, traders, and consumers in the food system. However, they face numerous obstacles and limitations, such as less resource access and weak tenure rights. Inequality in society, often present in food systems, strengthens these limitations. For instance, women's unequal access to critical resources in agriculture reduces their productivity and decision-making power (European [24, 26]).

A gender-sensitive approach and a lack of meaningful dialogue

Much evidence links women's empowerment to food security [3, 12, 18, 58]. Boosting women's education is likely the most important policy tool for increasing agricultural productivity and reducing poverty and child malnutrition, ensuring that food is always available at home for everyone [47, 58]. The Sustainable Development Agenda set a 2030 deadline for achieving gender equality and empowering all women and girls. With less than ten years left to achieve it, U.N. Woman (2022) [71] confirms that the progress on gender equality has not only stalled but is starting to reverse amid the intersecting crises of COVID-19, the climate emergency, and rising economic and political insecurity. The inability to achieve SDG 2 by 2030 is due to the instability of the factors that go into achieving food security, which has resulted in volatile food prices. This instability is especially evident for women smallholder farmers due to inadequate knowledge and access to means, making them most vulnerable to a crisis [12]. All of this is primarily due to political decisions made that are gender-blind and have not attempted to fix the flawed agri-food system. Even existing liberties and rights are being challenged by a rising backlash against women's rights around the globe [24]. According to the Global Report on Food Crisis 2022 Mid-year Update, up to 205 million people in 45 countries are expected to experience acute food insecurity. The 19 hunger hotspots identified urgently require targeted humanitarian action to save lives and livelihoods [79]. Due to the close association between poverty and food insecurity, rural women are more likely than men to be food insecure [37]. [61], have been critical of the effectiveness of gender-focused programmes in the food

system, whether through gender-transformative, sensitive, or supportive approaches. In essence, they will aid in identifying successful methods for empowering women and lowering gender inequality. Increasingly, it is understood that changing food systems for inclusion entails ensuring women's participation and access to benefits and giving them the power to make informed decisions about their lives [49].

The necessary systemic change has not recently occurred in the current food security paradigm, particularly in the discourse on food systems. OECD-FAO [57] is a joint report by two international organisations predicting agricultural, fish, and biofuel market trends for the next decade. It considers factors like economics, climate change, and policies as a reference for global agri-food planning. OECD-FAO [57] advocate integrating a gender perspective into the supply chain, taking proactive risk management measures, and making sure that no actions are taken that could jeopardise gender equality. Visser and Wangu [75] see the primary structural issues that disadvantaged women smallholder farmers face remain unaddressed, and the most likely scenarios for food security do not appear to have improved [46].

Although the issue of women's participation in food security has gained some common ground, Clement et al. [18] claim that this has not resulted in "actual investments dedicated to women's empowerment and resulting outcomes on gender equality and enhanced food security." Visser and Wangu [75] suggest meeting the current needs by adopting a food security solution for those most in need by building on their rich and resilient knowledge and practice.

Gender empowerment and coping strategies

Women's empowerment is increasingly seen to boost household nutrition and food security [18, 49, 58, 61]. An individual's capacity for self-determination, or living the life they have good reason to value, is acquired through empowerment. To assess this capacity for self-determination, scholars and development professionals continue to work to understand what factors influence it and to identify the major facets of empowerment. However, how women's empowerment affects household food security and nutrition is complicated and remains unclear [12, 33].

Scholars claim an increase in women's education was the single largest contributor to all reductions in child malnutrition [6, 18, 76] in sub-Saharan Africa [58]. Ampire (2020) has assessed gender empowerment through two schools of thought: i. the process analysis and ii. the content analysis to analyse the quality of gender policies. While the process analysis looks at more gender-responsive policy formulation, with women's organisations and professionals participating at all stages, the content analysis method assesses the representation of women in policies or the degree to which their concerns and interests are met. Scholars have employed this method to determine the degree to which climate change policies have contributed to gender issues.

Due to their high vulnerability to climate change and limited capacity for adaptation, women may only be able to cope with it rather than adapt to it and become more resilient in the long run [47]. Low-income families experience asset losses and diminished incomes during times of crisis. Women are prone to reduced spending on nutrition and family well-being because they typically have weak purchasing power in terms of household income. Women normally employ severe measures to minimise the impacts, such as reducing their consumption to feed others, gathering wild food, moving or selling assets, or even taking on risky jobs [70]. Batool et al. [8] make a strong point about women's perceptions of climate change, which can be the best coping mechanisms and are essential for mitigating the negative effects of climate change. Older women with a wide range of farming experience and education tend to better adapt to changing climates and, therefore, to climatic shocks.

Policymakers are tasked with educating the public about climate change, granting credit to women to implement adaptation measures, and fostering informal social networks among rural women. Quisumbing (2021) opines finding effective methods for empowering women and eradicating gender inequality will depend on the effectiveness of initiatives in the food system that explicitly take gender into account, whether through gender-transformative, sensitive, or accommodating approaches.

Discussion

To achieve food security in the face of climatically unpredictable conditions, the current review provides the findings of a literature review concerning the role of gender in the food system to attain food security under uncertain climatic conditions. A growing body of research suggests that empowering women may have positive nutritional effects on both the individuals and the households and communities in which they live, a key to achieving food security [4, 33]. Improving women's education is the most crucial policy to increase agricultural productivity and reduce poverty (U.N. Woman, 2022 [8, 58]). The study groups are mostly concentrated in sub-Saharan Africa and South Asia, with only a few from Latin America indicating the seriousness of hunger and malnutrition in these countries. Both mixed qualitative (questionnaire-based interviews) and quantitative (descriptive statistics) measures have been used by the studies reviewed so far. Four studies have followed the Women's Empowerment

in Agriculture Index (WEAI), a survey-based index designed to measure the empowerment, agency, and inclusion of women in the agricultural sector [55], while each HFIAS—represent a universal field of experience of food insecurity in a variety of cultural contexts [76]. Women's Empowerment in Livestock Index (WELI) to women's empowerment, a standardised measure to capture the empowerment of women involved in the livestock sector, which ILRI and Emory developed in 2015 based on the Feed the Future Women's Empowerment in Agriculture Index (WEAI) [33]. Pro-WEAI + MI is a metric developed to measure women's and men's absolute and relative empowerment along value chains (Quisumbing, 2021).

Despite the complexity of women's empowerment, studies [55] have emphasised the need for more evidence-based gender-sensitive value chain development (VCD) measures in various situations and at levels of analysis [3]. Gender equity-focused initiatives like the VCD can significantly better women's lives as individuals and citizens. Knowing the circumstances in which VCD can help women, and other marginalised groups will be essential to future progress in inclusive economic development. In this context, Quisumbing (2021) has introduced a socio-cultural element. The author sounds more advisory in documenting that initiatives aimed at empowering women in food systems and value chains consider the social and cultural contexts in which these food systems operate to ensure that approaches "do no harm" and do not worsen the already-existing gender inequalities.

The mixed (quantitative–qualitative analysis) approach adopted by Clement et al. [18] demonstrates a variety of patterns relating to empowerment and food security indicators, as well as the influences socio-economic determinants have on these patterns globally. They suggest giving meaning to local values, thereby overcoming the gap that keeps marginalised populations food insecure. Consistent with other studies, [6] finds limited asset ownership, market access, fewer educational opportunities, and workloads primarily cause undernutrition and food insecurity. This calls for strengthening nutrition-sensitive interventions for women, rural development for diverse food production and consumption, and eradicating gender-based cultural issues [7].

Following similar lines, Visser and Wangu [75] suggest a broad transformation of the current food security paradigm to improve the food system. To ensure that food security solutions benefit everyone, particularly in access and utilisation, they propose an inclusive and structurally integrated strong gender lens into the food systems by leveraging their rich and tenacious knowledge and practices. [76] seeks to promote gender awareness of rural women regarding their basic rights through different governing bodies that will improve food security. They relate to infrastructure investments, training, and job opportunities for rural women, which are crucial factors in reducing food insecurity and closing the gender gap. Determining the differences between women and men workers is an interesting technique that emerges from Andersen et al.'s (2020) work. Despite some studies testing for different economic returns by gender for a given agricultural intervention, they highlight the lack of focus on the financial impact of programmes aimed at empowering women in agriculture.

An enquiry into the perception of climate change on rural women farmers indicates that women's experience on farms is the primary determinant of how they perceive and respond to climate change [8]. However, landownership is a major criterion for women to encourage investments and embrace new technology. Moreover, Hurey [40] maintains that adverse effects of the climate, such as drought and deforestation, will significantly increase the workload for women. Adapting to the change and taking collective action helped generate positive results, creating programmes that are tailored to their needs and limitations, gaining gender equality and ensuring that their voices are heard.

Based on research results, [47] suggest a continuing need to invest in participatory "action research" methods, putting new ideas to the test and learning alongside local partners as they do so. Through such initiatives, gender and climate change issues can be better understood, and more importantly, local partners can develop climate change-appropriate skills. Additionally, many low-income countries severely lack the institutions and policies that support climate-resilient agricultural systems. Examining, challenging, and influencing gender norms and power are all aspects of gender-transformative approaches. By raising the status of women, altering the allocation of resources, and changing the roles that men and women play, gender imbalances can be corrected.

A thorough scientific analysis of climate change and its effects on food safety is necessary due to the connections between the various research fields and the multidisciplinary nature of climate change effects [51].

Conclusion

This review article focuses on gender empowerment and food security under the risk of changing climate. A significant international environmental and geopolitical concern is the seemingly impossible task of freeing the world from an unsustainable global food system. Addressing food insecurity among women in a food system that's (more) unstable and broken is more of a challenge. A shift from an agriculture-centred to a food system policy

and research framework is necessary to develop sustainable food systems. This is crucial for fostering the comprehensive transformation required to create sustainable food systems, which is needed for achieving sustainable food and nutrition security.

Increasingly, improving household food security and nutrition is seen as a goal of women's empowerment and achieving SDG 1 and SDG2. The eradication of hunger and the provision of sustainable food security are important indicators of sustainable development. Studies on food security at the village level are few, and those that have taken place internationally, however, have concentrated exclusively on particular facets of food security, with little focus on the socio-cultural and environmental factors. Increased barriers to incorporating a gender perspective into supply chain due diligence can assist businesses in managing risks proactively and methodically while avoiding actions that undermine gender equality.

The review study found that improving women's education positively enhanced agricultural productivity and reduced poverty. A gender-equity-focused initiative, Value Chain Development (VCD), could also help improve women's lives. Although most of the studies' main focus has been on asset ownership, the enquiry into barriers posed by gender-based cultural issues is limited, and there is a lack of focus on the economic impact of programmes aimed at empowering women in agriculture. Additionally, there is little in the literature about how climate change is affecting women, particularly rural women, who are more susceptible to the effects of climate change than men and have inadequate knowledge of coping mechanisms.

Researchers who want to construct an inquiry into the gender-based food security study will find the current research useful. Future researchers can focus on and study key aspects by being aware of the elements that directly and indirectly affect food security. Thinking systemically and across disciplines can ensure that issues are addressed from various angles and holistically, which better reflects the on-the-ground reality of policymaking. Applying innovative research and design can help us better understand and manage the consequences in a world where climatic uncertainty is rising and threatening the already overburdened food system. Besides academic thought, one has to see and act towards the reality on the ground.

From this perspective, a more focused approach to research on food security, gender equity and sustainability issues can be undertaken in the future:

1. Recognising the factors that directly and indirectly affect food security, more evidence-based gender-sensitive value chain development (VCD) measures in various situations and at levels of analysis are required.
2. A cross-cultural analysis to determine how women farmers perceive climate change at both local and global scales,
3. An interdisciplinary strategy to tackle the issue of food insecurity while taking into account its intricate social, economic, and environmental components.

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Declarations

Ethical approval and consent to participate
This study does not need ethical approval since it is based on secondary data. This article contains no studies with human participants performed by any authors.

Consent for publication
I consent to the publication of identifiable details in this paper under this Journal and Article.

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References

1. Allen P. Facing food security. J Rural Stud. 2013;29:135–8. https://doi.org/10.1016/j.jrurstud.2012.12.0021.
2. Ampaire EL, Acosta M, Huyer S, et al. Gender in climate change, agriculture, and natural resource policies: insights from East Africa. Clim Change. 2020;158:43–60. https://doi.org/10.1007/s10584-019-02447-0.
3. Anderson LC, Reynolds WT, Biscaye P, Patwardhan V, Schmidt C. Economic benefits of empowering women in agriculture: assumptions and evidence. J Develop Stud. 2020. https://doi.org/10.1080/00220388.2020.1769071.
4. Ashagidigbi WM, Orilua OO, Olagunju KA, Omotayo AO. Gender, empowerment and food security status of households in Nigeria. Agriculture. 2022;12:956. https://doi.org/10.3390/agriculture1207.
5. Asian Development Bank (2013), Gender Equality and Food Security—Women's Empowerment as a Tool against Hunger. Asian Development Bank. Mandaluyong City, Philippines, http://hdl.handle.net/11540/1503. License: CC BY 3.0 IGO.

6. Aziz N, He J, Raza A, Sui H. A systematic review of review studies on women's empowerment and food security literature. Global Food Secur. 2022;34:100647. https://doi.org/10.1016/j.gfs.2022.100647.
7. Aziz N, Nisar AQ, Koondhar AM, Meo SM, Rong K. Analysing the women's empowerment and food security nexus in Rural areas of Azad Jammu & Kashmir, Pakistan: by giving consideration to sense of land entitlement and infrastructural facilities. Land Use Policy. 2020;94:104529. https://doi.org/10.1016/j.landusepol.2020.104529.8.
8. Batool H, Ali W, Manzoor R, et al. Women's perception of climate change and coping strategies in Pakistan: an empirical evidence. Earth Syst Environ. 2018;2:609–19. https://doi.org/10.1007/s41748-018-0073-7.
9. Berry ME, Dernini S, Burlingame B, Meybeck A, Conforti P. Food security and sustainability: can one exist without the other? Public Health Nutr. 2015;18(13):2293–302.
10. Botreau, H. and Cohen, J.M. (2019), Gender Inequalities and Food Insecurity: Ten Years After the Food Price Crisis, Why are Women Still Food-Insecure? Oxfam Briefing Paper 2019, https://reliefweb.int/report/world/gender-inequalities-and-food-insecurity-ten-years-after-food-price-crisis-why-are-women
11. Bhunnoo, R., (2018), Director of the Global Food Security Programme, A Food Systems Approach to Policy for Health and Sustainability- Think Piece https://www.tabledebates.org/research-library/food-systems-approach-policy-health-and-sustainability
12. Botreau H, Cohen JM. Chapter two - gender inequality and food insecurity a dozen years after the food price crisis, rural women still bear the brunt of poverty and hunger. In: Cohen MJ, editor. Advances in food security and sustainability. Amsterdam: Elsevier; 2020.
13. Calicioglu O, Flammini A, StefaniaBracco S, Bellù L, Sims R. The future challenges of food and agriculture: an integrated analysis of trends and solutions. Sustainability. 2019;11:222. https://doi.org/10.3390/su11010222.
14. Candel JJL, Breeman GE, Stiller SJ, Termeer CJAM. Disentangling the consensus frame of food security: the case of the E.U. common agricultural policy reform debate. Food Policy. 2014;44:47.
15. Caron P, de Loma-Osorio F, G., Nabarro, D., et al. Food systems for sustainable development: proposals for a profound four-part transformation. Agron Sustain Dev. 2018;38:41. https://doi.org/10.1007/s13593-018-0519-1.
16. Charles H, Godfray J, Beddington JR, Crute IR, Lawrence Haddad L, Lawrence D, Muir JF, Pretty J. Food security: the challenge of feeding 9 billion people. Science. 2010;327(5967):812–8. https://doi.org/10.1126/science.1185383.
17. Chen D, Chen HW. Using the Köppen classification to quantify climate variation and change: an example for 1901–2010. Environ Dev. 2013;6:69–79.
18. Clement F, Buisson MC, Leder S, Balasubramanya S, Saikia P, Bastakoti R, Karki E, Koppen B. From women's empowerment to food security: revisiting global discourses through a cross-country analysis. Global Food Secur. 2019;23:160–72.
19. Cornwall A, Edwards J. Introduction: negotiating empowerment. IDS Bull. 2010;41(2):1–9. https://doi.org/10.1111/j.1759-5436.2010.00117.x.
20. Dawson PT, Perryman NA, Osborne T. Modelling impacts of climate change on global food security. Clim Change. 2014;134(3):1–12. https://doi.org/10.1007/s10584-014-1277-y.
21. De Pinto A, Seymour G, Bryan E, Bhandari P. Women's empowerment and farmland allocations in Bangladesh: evidence of a possible pathway to crop diversification. Clim Change. 2020;163(2):1025–43.
22. Dehrashid AA, Bijani M, Valizadeh N, et al. Food security assessment in rural areas: evidence from Iran. Agric & Food Secur. 2021;10:17. https://doi.org/10.1186/s40066-021-00291-z.
23. Dekeyser, K., Rampa, F., D'Alessandro, C., &Bizzotto Molina, P. The food systems approach in practice: our guide for sustainable transformation. Maastricht: European centre for development policy Management 2020.
24. Doss C. Women and agricultural productivity: reframing the issues. Dev Pol Rev. 2018;36(1):35–50.
25. Duflo E. Women empowerment and economic development. J Econ Lit. 2012;50(4):1051–79. https://doi.org/10.1257/jel.50.4.1051.
26. European Union, 2021. United nations food systems summit 2021: Process, Challenges and the way Forward, A Briefing, 18–11–2021 https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2021)696208
27. FAO, Ifad, UNICEF, WFP and WHO. The state of food security and nutrition in the world repurposing food and agricultural policies to make healthy diets more affordable. Rome: FAO; 2022.
28. FAO. Climate change: unpacking the burden on food safety food safety and quality series 8. Rome: FAO; 2020. https://doi.org/10.4060/ca8185en.
29. FAO (2019), The State of Food Security and Nutrition in the World, www.fao.org/state-of-food-security-nutrition/en/
30. FAO, Ifad, UNICEF, WFP and WHO. The state of food security and nutrition in the world, building climate resilience for food security and nutrition. Rome: FAO; 2018.
31. Fraanje, W. and Lee-Gammage, S. (2018), What is food security? (Foodsource: building blocks). Food Climate Research Network, University of Oxford. https://foodsource.org.uk/
32. Fujimori S, Wu W, Doelman J, et al. Land-based climate change mitigation measures can affect agricultural markets and food security. Nat Food. 2022;3:110–21. https://doi.org/10.1038/s43016-022-00464-4.
33. Galiè A, Teufel N, Girard WA, Baltenweck I, Dominguez-Salas P, Price JM, et al. Women's empowerment, food security and nutrition of pastoral communities in Tanzania. Glob Food Sec. 2019;23:125–34. https://doi.org/10.1016/j.gfs.2019.04.005.
34. Galie A, Kantor P. From gender analysis to transforming gender norms using empowerment pathways to enhance gender equity and food security in Tanzania. In: Njuki J, Parkins JR, Kaler A, Ahmed S, editors. Transforming gender and food security in the global south. Oxon: Routledge and International Development Research Centre; 2016. p. 189–215.
35. Garnett, T., Benton, T., Nicholson, W. and Finch, J. (2016). Overview of Food System Challenges (Foodsource: chapters). Food Climate Research Network, University of Oxford, https://foodsource.org.uk/sites/default/files/chapters/pdfs/foodsource_chapter_1.pdf
36. Guzman,O.E.M. (2011), Food Security and Population Growth in the 21st Century, E-International Relations, https://www.e-ir.info/2011/07/18/food-security-and-population-growth-in-the-21st-century/
37. Gornick J, Boeri N. Gender and poverty. In: Brady D, Burton LM, editors. The oxford handbook of the social science of poverty. Oxford University Press: New York, NY; 2016.
38. Gopinath G. (2020), The Great Lockdown: Worst Economic Downturn Since the Great Depression, IMF Blogs, Insights and Analysis on Economics and Finance, https://blogs.imf.org/
39. HLPE. Food security and nutrition: building a global narrative towards 2030 a report by the high level panel of experts on food security and nutrition of the committee on world food security. Rome: FAO; 2020.
40. Hurey, S. (2021), Building farmers' resilience to climate change means addressing gender inequalities. CGIAR GENDER Platform Evidence Explainer. Nairobi, Kenya: CGIAR GENDER Platform. https://hdl.handle.net/10568/114266.
41. IEA (2022), How the Energy Crisis is Exacerbating the Food Crisis, IEA, Paris https://www.iea.org/commentaries/how-the-energy-crisis-is-exacerbating-the-food-crisis
42. Ingram J. A food systems approach to researching food security and its interactions with global environmental change. Food Security. 2011. https://doi.org/10.1007/s12571-011-0149-9.
43. IPCC. Climate Change 2022: Impacts, Adaptation and Vulnerability. In: Pörtner H-O, Roberts DC, Tignor M, Poloczanska ES, Mintenbeck K, Alegría A, Craig M, Langsdorf S, Löschke S, Möller V, Okem A, Rama B, editors. Contribution of working group II to the sixth assessment report of the intergovernmental panel on climate change. New York: Cambridge University Press; 2022.
44. Islam MS, Kieu E. Tackling regional climate change impacts and food security issues: a critical analysis across ASEAN, PIF, and SAARC. Sustainability. 2020;12:883. https://doi.org/10.3390/su12030883.
45. Jarosz L. Defining world hunger, scale and neolibral ideology in international food security policy discourse, food culture and society. Int J Multidiscip Res. 2011;14:1.
46. Kabeer N. Gender equality and women's empowerment. A critical analysis of the third millennium development goal. Gend Dev. 2005;13:13–24. https://doi.org/10.1080/13552070512331332273.
47. Krisjanson P, Bryan E, Bernier Q, Twyman J, Meinzen-Dick R, Kieran C, Ringler C, Christine Jost C, Doss C. Addressing gender in agricultural research for development in the face of a changing climate: where are we and where should we be going? Int J Agric Sustain. 2017. https://doi.org/10.1080/14735903.2017.1336411.

48. Lang T, Barling D. Food security and food sustainability: reformulating the debate. Geogr J. 2012;178(4):313–26.
49. Malapit H, Ragasa C, Martinez ME, Rubin D, Seymour G, Quisumbing A. Empowerment in agricultural value chains: mixed methods evidence from the Philippines. J Rural Stud. 2020;76:240–53.
50. Mardones FO, Rich KM, Boden LA, Moreno-Switt AI, Caipo ML, Zimin-Veselkoff N, Alateeqi AM, Baltenweck I. The COVID-19 pandemic and global food security. Front Vet Sci. 2020;7: 578508. https://doi.org/10.3389/fvets.2020.578508.
51. Martini D, Ragone G, Cazzini F, Cheli F, Formici G, La Porta CAM, Pinotti L, Pomodoro L, Restani P, Scaffardi L, et al. The need for a multidisciplinary approach to face challenges related to food, health, and sustainability: the contribution of CRC I-WE. Sustainability. 2021;13:13720. https://doi.org/10.3390/su132413720.
52. Moher D, Liberati A, Tetzlaff J, Altman DG. The PRISMA group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med. 2009;6:e1000097.
53. Mokari YA, Alizadeh-Sani M, Khezerlou A, Zolfaghari FN, Akbari Z, Ehsani A. Resolving food security problem with an interdisciplinary approach. J Nutr Fasting Health. 2018;6(3):132–8. https://doi.org/10.22038/JNFH.2018.34180.1132.
54. Mooney PH, Hunt SA. Food security: the elaboration of contested claims to a consensus frame. Rural Sociol. 2009;74(4):469–97.
55. O'Brien C, Leavens L, Ndiaye C, Traoré D. Women's empowerment, income, and nutrition in a food processing value chain development project in Touba, Senegal. Int J Environ Res Public Health. 2022;19:9526. https://doi.org/10.3390/ijerph19159526.
56. Naheed S. Understanding disaster risk reduction and resilience a conceptual framework. In: Eslamian S, Eslamian F, editors. Handbook of disaster risk reduction for resilience, vol. 1. Switzerland: Springer Nature; 2021.
57. OECD-FAO (2021), Integrating a Gender Perspective into Supply Chain Due Diligence. OECD Publishing, Paris, https://mneguidelines.oecd.org/Integrating-a-gender-perspective-into-supply-chain-due-diligence.pdf
58. Olumakaiye FM, Ajayi OA. Women's empowerment for household food security: the place of education. J Hum Ecol. 2006;19(1):51–5. https://doi.org/10.1080/09709274.2006.11905857.
59. Popp J, Lakner Z, Harangi-Rákos M, Fári M. The effect of bioenergy expansion: food, energy, and environment. Renew Sustain Energ Rev. 2014;32:559–78.
60. Pollard CM, Booth S. Food insecurity and hunger in rich countries—it is time for action against inequality. Int J Environ Res Public Health. 2019;16(10):1804.
61. Quisumbing A, Heckert J, Faas S, et al. Women's empowerment and gender equality in agricultural value chains: evidence from four countries in Asia and Africa. Food Sec. 2021;13:1101–24. https://doi.org/10.1007/s12571-021-01193-5.
62. Queiroz C, Norström AV, Downing A, et al. Investment in resilient food systems in the most vulnerable and fragile regions is critical. Nat Food. 2021;2:546–51. https://doi.org/10.1038/s43016-021-00345-2.
63. Rao N, Lawson TE, Raditloaneng NW, Divya Solomon D, Angula NM. Gendered vulnerabilities to climate change: insights from the semi-arid regions of Africa and Asia. Climate Dev. 2019;11(1):14–26. https://doi.org/10.1080/17565529.2017.1372266.
64. Ray DK, West PC, Clark M, Gerber JS, Prishchepov AV, Chatterjee S. Climate change has likely already affected global food production. PLoS ONE. 2019;14(5):e0217148. https://doi.org/10.1371/journal.pone.0217148.
65. Rukhsana, Alam, A. (2021). Agriculture, Food, and Nutritional Security: An Overview. In: Rukhsana, Alam, A. (eds) Agriculture, Food and Nutrition Security. Springer, Cham
66. Rukhsana,. Dimension of food security in a selected state Uttar Pradesh. J Agri Exten Rural Develop. 2011;3(2):29–41.
67. Rukhsana & Alam A. Micro level analysis of food security and agricultural development: a case study. Int J Adv Stud Humanit Soc Sci. 2013;2(3):149–58.
68. Schmidhuber, J., and Tubiello, F.N. (2007) Global Food Security Under Climate Change, 104 (50) 19703–19708, PNAS, https://www.pnas.org/content/104/50/19703
69. The European Commission (2020), Towards a Sustainable Food System, Moving from Food as a Commodity to Food as more of a Common Good, Group of Chief Scientific Advisors Scientific Opinion No.8,
70. The Global Food Security Index (2022), Economist Impact, https://impact.economist.com/sustainability/project/food-security-index/download-the-index
71. UN WOMEN (2022), Generation, Equality, Accountability Report 2022. https://commitments.generationequality.org/. Accessed 4 10 2022
72. U.N. Woman (2018), Turning promises into action: Gender equality in the 2030 Agenda for Sustainable Development,
73. United Nations, Department of Economic and Social Affairs, Population Division (2019). World Population Prospects 2019: Highlights (ST/ESA/SER.A/423). https://population.un.org/wpp/Publications/Files/WPP2019_Highlights.
74. Vandermeer J, Aga A, Allgeier J, Mbadgley C, Baucom R, Blesh J, Shapiro LF, et al. Feeding Prometheus: an interdisciplinary approach for solving the global food crisis. Front Sustain Food Syst. 2018;2:39. https://doi.org/10.3389/fsufs.2018.00039.
75. Visser J, Wangu J. Women's dual centrality in food security solutions: the need for a stronger gender lens in food systems' transformation. Current Res Environ Sustain. 2021;3:100094.
76. Wei W, Sarker T, Roy R, Sarkar A. Women's empowerment and their experience to food security in rural Bangladesh. Sociol Health Illn. 2021;00:1–24. https://doi.org/10.1111/1467-9566.13273.
77. Willett W, Rockström J, Loken B, Springmann M, et al. Food in the Anthropocene: the EAT-Lancet commission on healthy diets from sustainable food systems. Lancet. 2019;2(393):447–92. https://doi.org/10.1016/S0140-6736(18)31788-4.
78. World Food Programme (WFP) (2022), A Global Food Crisis, https://www.wfp.org/global-hunger-crisis
79. WFP and FAO. 2022. Hunger Hotspots. FAO-WFP Early Warnings on Acute Food Insecurity: October 2022 to January 2023 Outlook. Rome
80. World Bank. (2007),World Development Report 2008 : Agriculture for Development. Washington, DC. World Bank. https://openknowledge.worldbank.org/handle/10986/5990 License: CC BY 3.0 IGO." pdf
81. Ziervogel G, Ericksen PJ. Adapting to climate change to sustain food security Wiley interdisciplinary reviews. Clim Change. 2010. https://doi.org/10.1002/wcc.56.
82. Zohrabi N, Linkous L, Eini R, Keegan B, et al. Towards sustainable food security: an interdisciplinary approach 2021 IEEE smartworld, ubiquitous intelligence & computing, advanced & trusted computing scalable computing & communications. Int People Smart City Innov. 2021. https://doi.org/10.1109/SWC50871.2021.00069.

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