Integrating Gender and Indigenous Knowledge in Sub-Saharan African Animal Agriculture: Pathways to Climate Resilience and Food Security

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ABSTRACT

Problem: Climate change exacerbates gender disparities and undermines IKS in Sub-Saharan African animal agriculture.

Objective: Explore synergies between gender equity, IKS, and climate resilience.

Methods: Systematic review of peer-reviewed literature and policy documents.

Findings: Women's empowerment and indigenous knowledge systems enhance adaptive capacity.

Implications: Policy integration of gender-responsive and IKS-based strategies.

Keywords: Sustainable Animal Agriculture, Climate Change, Gender Equality, Indigenous Knowledge Systems, Food Security, Sub-Saharan Africa

INTRODUCTION

Researchers Iram and Butt (2004) and Samim et al. (2021) characterize food security by the availability, accessibility, and quality of food, while food insecurity involves inadequate food consumption, limited access, and susceptibility to subsistence mechanisms. The United Nations Development Programme (2012) emphasizes that food security promotes human development, including long, healthy lives, education, decent living standards, and dignity in community life. Popp et al. (2010) highlight that animal agriculture plays a vital role in global food security, providing a significant source of food and accounting for approximately one-third of global human protein consumption. Godber and Wall (2014) project that animal agriculture will substantially contribute to sustainable food security in developing countries. However, Brears (2017) warns that climate change, population shifts, and urbanization will exacerbate hunger, food insecurity, and malnutrition, making it more challenging to address these issues. Udry (1996) stresses that understanding the relationship between climate change and animal agriculture and promoting gender equality are crucial for ensuring food security.

The current global food crisis severely affects Sub-Saharan Africa, where rapid population growth and failing agricultural production converge. The Food and Agriculture Organization (FAO, 2017) emphasizes that Sub-Saharan Africa must enhance its food production strategies to meet the demands of its growing population, unlike any other region in the world. Policymakers and stakeholders must improve food production strategies to fulfill the demands posed by Sub-Saharan Africa's increasing population. The United Nations (2017) projects that Sub-Saharan Africa's population will reach two billion individuals by 2050, posing multiple challenges for agri-system sustainability, including the need to simultaneously produce more food. To attain food security, farmers and producers must increase production, process more food, and supply a wider range of products.

By 2050, demographic growth projections (Lazuta, 2013) indicate that Sub-Saharan Africa will face food insecurity primarily due to a mismatch between demand and supply of poultry and livestock food production, which significantly influences food security. Researchers and experts have raised concerns about increasing food production on the continent and the need to shift food production methods in various forums (Bjornlund, et al 2022; Dodo, 2020; Reardon, et al 2019; Chauvin et al 2012). As continents strive to fulfill their food security requirements, they must understand all elements influencing production, including societal, economic, and ecological considerations, to guarantee effective food production strategies for the expanding human population (FAO, 1996; Assan 2023). Policymakers and stakeholders must balance the need for sustainability with the goal of food self-sufficiency, which poses a significant challenge for the continent (Agula et al 2018). Achieving this balance requires in-depth knowledge of sociological, economic, and ecological factors and their impact on agriculture (Zhou et al 2023).

Researchers have identified a complex and intangible conceptual overlap between the effects of climate change, the use of indigenous knowledge, and gender roles and equality in Sub-Saharan African sustainable animal agriculture. The Institut national de la recherche agronomique (2014) associates the sustainability concept in animal agriculture and food security with environmental, social, and economic aspects. Animal agriculture contributes significantly to food security, but faces mounting challenges due to rising food demand driven by population growth on the continent, while changing climates negatively impact animal farming (Assan, 2023). Climate change threatens food security in Sub-Saharan Africa by making it harder to raise animals. Unfavorable weather conditions worsen, leading to increasingly erratic animal productivity. Humphary et al. (2022) emphasize the importance of addressing gender gaps and integrating local knowledge in agricultural development to maximize its impact in a changing climate.

Assan (2023) reveals that gender-specific sociocultural factors closely interact with climate variations, which, in turn, significantly impact animal husbandry in numerous ways (All et al., 2023). Researchers emphasize that livestock production activities substantially contribute to the global climate (Jacquet et al., 2023). Global warming severely affects animal agriculture and food security, while also exacerbating global warming (Eisen and Brown, 2022). Kuraz et al. (2021) predict that animal farming will emit approximately 145 GHG, triggering climate change (IPCC, 2013). Climate change experts assert that changes in climate are not gender-neutral, as they disproportionately affect men and women due to their distinct roles and responsibilities at the household and societal levels (UNDP, 2016). Women, in particular, bear the brunt of climate change due to their heightened vulnerability to context-dependent events and increased reliance on subsistence agriculture (Apira et al., 2017).

Climate change affects the interconnectivity of indigenous knowledge bases and gender equality issues. Societal and institutional factors influence these complex and interconnected dynamics (Assan, 2022a). Globally, climate change severely impacts agriculture, a significant source of income. Environmental changes and variations pose serious challenges to agricultural smallholders, adversely affecting their production and income, particularly in developing countries (Kakota et al., 2011). Promoting gender equality enhances women's households and groups' resilience and adaptation abilities to climate change. The Food and Agriculture Organization (FAO, 2012) emphasizes that gender equity is crucial in the long run, and considering gendered roles and relations is essential for advancing agricultural development initiatives. Policymakers must reduce gender inequalities in livestock production and address climate change to achieve sustainable development (FAO, 2012). Boosting food production requires reducing gender inequalities in livestock production and increasing climate knowledge, as these factors negatively impact sustainability.

Climatic changes disproportionately affect women in livestock production, compared to men, as Laska and Morrow (2006) report. Chaudhary et al. (2022) demonstrate that indigenous knowledge provides valuable insights for addressing climate change. Therefore, researchers and policymakers must incorporate indigenous perspectives into establishing sustainable livestock and animal practices (Dakora, 1996). Eguru (2012) recognizes the worth and potential of traditional systems to contribute to climate planning. Nyong et al. (2006) highlight the practical application of indigenous knowledge in addressing climate-related issues in the Sahel region. Svotwa et al. (2007), Nyong et al. (2006), and Robinson and Herbert (2001) argue that combining indigenous knowledge with modern science enhances livestock's ability to cope with climate change and adapt to changing climatic conditions.

Indigenous knowledge contributes to animal agriculture and food security in various forms, including animal decision-making, climate change forecasting, and precipitation prediction (Jiri et al., 2016; Mafongoya and Ajayi, 2017). Researchers and experts actively debate and clarify the intersection of indigenous and scientific knowledge, recognizing the need to integrate all knowledge to address complex issues like climate change (Chaudhary et al., 2022). Gender equality and traditional wisdom play crucial roles in ensuring the long-term sustainability of animal production, profoundly impacting environmental and economic outcomes. Scholars continue to explore the extent to which socio-cultural elements influence animal agriculture and food security sustainability. Cultural norms dictate men's and women's roles in animal production (Piri et al., 2021). Researchers document that gender-differentiated roles, knowledge, and preferences vary among different gender groups in animal production (Yasehak et al., 2014). In many societies, gender-based discrimination and inequality limit women's participation in decision-making processes related to animal production, leading to unequal distribution of resources and opportunities (Makoka et al., 2018). Therefore, experts and policymakers must recognize and address these challenges to ensure the sustainable development of animal production and food security.

Researchers actively document that gender-differentiated roles and preferences in animal production vary among different gender groups (Yasehak, 2008). Principal development organizations must prioritize gender perspectives in animal husbandry development actions to promote social and gender equality. By strengthening social and gender equality, organizations can achieve food production goals and transform animal production into more resilient, equitable, and environmentally friendly approaches (Lecoutere et al., 2023). Empowering women and promoting equality is crucial for ensuring the long-term viability of the animal production sector. This review explores the theoretical connection between gender roles and indigenous knowledge systems (IKS) in sustainable animal agriculture and food security. Experts emphasize that understanding the intersection of gender and IKS is crucial for achieving sustainable animal agriculture and food security in the face of climate change.

METHODOLOGY

A systematic review was conducted using Scopus and Web of Science databases (2010–2023). Keywords included “gender”, “indigenous knowledge”, and “climate resilience”. Inclusion criteria prioritized peer-reviewed studies from Sub-Saharan Africa.

The Sustainability Conundrum in Animal Agriculture: Implications for Food Security

The debate over food security and sustainability in animal agriculture intensifies as climate change worsens. Researchers define sustainability as a multifaceted concept comprising three key components: economic activity, environmental care, and societal well-being (Babajani et al., 2023). Experts emphasize that addressing environmental concerns and societal food challenges requires holistic approaches that consider ecological, societal, and economic implications. Scholars engage in ongoing debates about whether agricultural systems can achieve sustainability (Brodt et al., 2011; Lampkin Padel, 1994; Trewevas, 2002). Researchers employ various terms, such as biodynamic, community-based eco-agriculture, generative agriculture, precision agriculture, and sustainable agriculture, to define sustainability in agricultural systems (Gosh et al., 2022; Newto et al., 2020; Garnett et al., 2013; Gebbers and Adamchuk, 2010; Gliessman, 2005).

Sustainability in animal agriculture and food security is a complex, dynamic process rather than a fixed endpoint (Altieri, 1995). Environmental considerations drive enthusiasm for the agriculture sector's long-term viability, particularly regarding livestock operations (Jules, 2008). Smil (2000) predicts that increased consumption of livestock products will transform the world food system. As the economy grows, demand for animal-related products will surge, changing various aspects of agricultural systems and threatening environmental destruction.

To genuinely achieve environmental sustainability, farming must address the three key issues mentioned earlier (Brodt et al., 2011; Funes et al., 2008). Researchers continue to advance practical knowledge on sustainability concepts, encompassing environmental, social, and economic aspects, driven by contemporary concerns, perspectives, and beliefs (Pretty et al., 2002). Innovators and experts face the primary challenge of

developing innovations and procedures that strengthen agricultural production while minimizing adverse environmental impacts, ensuring system sustainability (Kesavan and Swaminathan, 2008). Policymakers and farmers must recognize that actions to boost output can have significant consequences on the natural resource base, exacerbating these concerns (Ghosh et al., 2022).

The fundamental principle of sustainable agriculture over time is that meeting our current needs must not compromise the ability of future generations to meet their own needs. Therefore, managing natural assets for the foreseeable future is just as crucial as maintaining human capital in the present. Hinrichs and Lyson (2008) argue that comprehending agricultural sustainability necessitates understanding the agricultural ecosystem. They define agrosystems broadly, encompassing individual fields, farms, and environmentally sensitive areas. Despite possessing technical proficiency, a skilled workforce, and specialization, agricultural systems cannot sustain themselves over the long term without effective management.

According to Gliessman (2000), the objectives of ecologically sound agriculture are to help ensure that there remains sufficient food to satisfy every person, lift communities out of poverty, improve the standard of living for farming families, and use farming practices that improve soil functionality and lessen dependency on fossil fuels to be able to maintain the long-term sustainability of the environment due to the dynamic site-specific character of food production. Resilience necessitates a broad and flexible body of realization that, constructed from both formalized empirical research and the farmers own firsthand localized experience, well-sustainable agriculture requires the convergence of social, economic, and environmental sustainability as essential elements.

The concept of sustainability in the agriculture-food system and the food supply chain can be characterized as a harmonious equilibrium between the effective utilization of valuable resources. These resources include agricultural land, water, fuel, and so on; greenhouse gases, e.g., carbon dioxide, methane, carbon monoxide, and so on; and social and economic issues and ethical considerations as an integral component that ensures the survival of subsequent generations (Flachowsky et al., 2017). The livestock industry is one of the specialties with the highest ecological footprint, so understanding the concept of being sustainable is essential. A viable agricultural system, in accordance with the Food and Agriculture Organization, should develop beneficial effects across all three dimensions simultaneously: economic, social, and environmental.

The fundamental premise of sustainability means that humanity ought to meet its core requirements while also protecting its innate surroundings. As a result, it is possible for the following generations to survive solely on their own (Aavik et al., 2017; Manhaes et al., 2018). Human and natural capital must be properly planned to maintain a sustainable environment (Munonye and Eze 2022), with the goal of safeguarding the harmony as well as the sustainability of the ecosystems that surround us. Balance and sustainability measures, notably those who are from the broader cultural and interpersonal aspects of livestock farming, offer substantial obstacles in comparison with standard indices (e.g., the quality of water participation of stakeholders or output from farming growth) due to their intrinsic complexity.

The notion of ecologically friendly agriculture projects is spreading throughout many facets of daily life. For instance, sustainability is built on profitability and is ecologically acceptable regardless of anticipated population expansion. In addition to meeting the needs of its evolving surroundings, it has contributed to and will continue to contribute to the abolition of harmful environmental practices (Karaca, 2023). The push for agriculture-based resilient practices, protecting the innate system, and looking at how individuals communicate harmoniously with nature around them, utilizing resources in a balanced way, promotes flexibility, supports plant and animal diversity preservation, or boosts the condition of the environment. Because it adopts pertinent technological advancements and promotes methods that enhance the production of livestock without adversely affecting ecological products or services, environmentally friendly farming is seen as the planet's savior (Pretty, 2008).

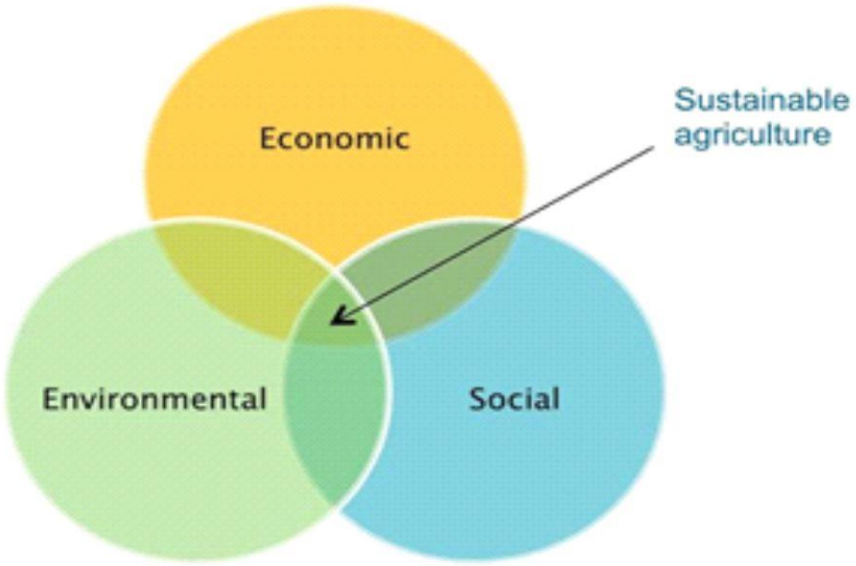
Being acquainted with the idea of sustainability is necessary since agriculture is essential to human existence and is inextricably tied to economic, social, and ecologically sustainable development complications. A great deal of the time, demand to satisfy the growing worldwide need for commodities connected to animals has led to the misappropriation and sometimes exploitation of the earth's resources in agriculture. As a result, there has

been a decrease in the genetic resources of animals, grazing damage to land, pollution from animal waste, and loss of biodiversity.

Agriculture on the opposite extreme of the range should be able to retain its work output and value to mankind in perpetuity (Ikerd, 1990). This can be achieved by fostering the well-being of not just landowners but the general population as a whole (Ikerd 1993). Above all reasonable doubt, livestock production and its affiliated sectors have to adopt environmentally friendly farming techniques while providing end-products that are vital to human survival. As a result, smart animal agriculture and food security encompass multifaceted production and ecological responsibility regarding the social, environmental, and economic aspects spanning from the farmland to the farmhouse to the natural environment to the water system and beyond (Kassam et al. 2020). Sustainable agriculture is defined by the FAO as rearing animals and cultivating crops with the intention of driving food items, fiber, and feed that satisfy present as well as potential societal demands.

A key element of such agriculture is maximizing the value of ecosystem-based services while avoiding the inappropriate use of biological diversity. The principle of efficiency in farming is continuous improvement practices via responsible utilization of existing assets, generating income, and increasing efficiency, but strategies for evaluating currently sustainable agriculture are unable to successfully address social and economic aspects of the environment at the same time (Trivino-Tarradas et al., 2019). Taking this viewpoint into account, Figure 1 illustrates how environmental, social, and economic issues in agriculture converge to form sustainable agriculture.

Fig. 1 Intersection of the environmental, social, and economic concerns in sustainable agriculture (Source: Institut national de la recherche agronomique, 2014).



To be sustainable, animal agriculture's support to food security must raise animals in an efficient manner that safeguards the surroundings, remains less expensive, and yields excellent-quality, safe goods. Animal-related commodities should be derived from an approach that maintains ethical principles and protects livelihoods. Such objectives must be carefully matched with the critical requirement of establishing options that minimize or do away with the effects of animal husbandry on the environment that has been most destructive for the purpose of meeting the objectives for climate change and preserving and replenishing the genetic diversity of animals. Raising livestock might find it exceedingly challenging to arrive at an equilibrium between these opposing goals.

Rethinking the Socio-Cultural Dimension of Sustainability: New Perspectives on Animal Agriculture

Social and cultural facets, which include equality between men and women and traditional knowledge, have been largely overlooked in the area of sustainability dialogue (De Olde et al., 2016; Vallance et al., 2011; Binder et al., 2010; Omann and Spangenberg, 2002). Their incorporation likewise seems divergent in the

advancement of environmental sustainability assessments. According to Boström (2012), past attention on ecological issues, the interdependence of the sustainability framework, the laden aspirations around the idea, nebulous, arbitrary, and philosophical platforms, and institutional inattention are among the causes of the lack of conceptual profundity. Thus, in the context of sustainability, it is still unclear what is meant by "social." In relation to this, the main domain of focus for agriculture continues to be resolving the dispute between degradation of the environment and commercial viability. Only by addressing the scope and standard underpinnings initially is it possible to achieve greater degrees of rigorousness and exhaustiveness within the social component of numerous instruments for assessing sustainability in the agriculture sector.

The term "sustainable" has a history of being used imprecisely, and researchers in agriculture have emphasized increasing productivity in a manner that is sustainable (Petersen & Snapp, 2015), consistently ignoring social sustainability components like gender equity (Zurek et al., 2015). As per several studies (Bezner Kerr, 2008; Croppenstedt et al., 2013; Kilic et al., 2015), males own an unequal degree of influence over agricultural assets and get a larger share of the advantages, for example. Because of this, academics are emphasizing increasing emphasis on the necessity of an expanded and inclusive SAI, taking equality and equity into account (Loos et al., 2014). This includes the manner in which labor requirements for intensification will be distributed, as well as crop rights and gender-specific and age-biased accessibility to land (Snyder and Cullen, 2015).

According to research by Musumba et al. (2017), the criteria for assessment adopted to explain sustainable development within agriculture as a whole frequently ignore the context of society, which includes variables like persons, gender, social systems, or domains, which have recently been relegated in favor of other sustainability branches such as efficiency and economic growth, as well as the quantity and correctness of the data. The expenditure of acquiring information and the instruction required for the tools used today to obtain information will probably be the key reasons for the downgrading of social domains in sustainability assessment (Grabowski et al., 2016). for instance, found that evaluating gender equity in agriculture typically takes a lot of time, money, and effort to develop sustainable livestock production actions. The aforementioned has forced academics to focus on easily and quickly obtaining readily quantifiable productivity as a whole, including commercial and environment-related variables. The evaluation instruments in these domains are probably less costly compared with a review of the social components of agriculture's sustainability.

Although the Agri-Gender Statistics Toolkit (FAO 2016) is an excellent starting point with beneficial details regarding analyzing numerical data concerning gender gaps, small initiatives may not be able to complete the necessary surveys of households and conduct statistical analyses using the social interaction approach, which emphasizes the analysis of gender equity across four institutional domains (Kabeers 1994). Family members, the neighborhood, the marketplace, and the government, where cultural standards could restrict the autonomy of women, may be relevant in an effort to further develop the social dimension as a factor that helps create sustainable development related to agriculture (Fischer et al. 2020).

The development of environmentally sound farm animal rearing will hinge on creating the necessary conditions for women to have the opportunity to be able to decide how to use productive resources (land, livestock, money, etc.). This will necessitate an important shift in the gendered expectations that currently dictate these choices (Grabowski et al., 2020). The development of innovative technologies to improve sustainability in animal husbandry has to take the gender implications of technology acceptance and utilization into account. Therefore, in order to develop animal agriculture, technological advancements must be grounded in factual data and practical outcomes, taking into account the social implications of agricultural changes brought about by the widespread implementation of new technology.

Whether to modify the technological innovations to promote changed relationships between genders and equality should be considered in the evaluation and monitoring of the advances in any action aimed at resolving the differences in gender environmental sustainability. In livestock farming, it is more crucial than anything else. When assessing sustainability from a social perspective, the goal should be to see how much they contribute to changing the norms and structures that support gender parity in animal husbandry. Regulations and rules for the long-term sustainability of domains that use land and water in farming should take factors related to culture and society into account in addition to environmental and economic variables (Throsby 1999; Hawkes 2001; Littig and Grieler 2005). The idea of an environmentally friendly future has had

four widely recognized parameters: social about the surroundings, the economy at large, and cultural (WCED 1987). However, there is continuous discussion on whether or not the fourth dimension, culture, should be included (Saastamoinen, 2005; Chan et al., 2012; Daniel et al., 2012). All areas utilizing assets from Earth expressly stressed their desire to improve knowledge and procedural advancement for cultural and social norms when preparing plans (Council of Europe 2000, WFD 2000).

In contrast, declared preferences in the past few decades of theoretical research on agricultural-food systems might include farming of animals, tending to focus further details on the economy. Han et al. (2021), Peterson et al. (2012), or environmental issues (Cranfield et al. 2010; Fairweather 1999; Padel 2001; Stofferahn 2009; Wernick and Lockeetz 1977). The social and cultural components of the agricultural-food systems that are vital to human civilization receive less recognition (i.e., despite studies focused on understanding factors influencing animal production, which is a crucial segment). Agricultural-food systems usually focus on one of the systems revenue generation or their effect on the innate resources (Sapbamrer and Thammachai, 2021).

There has not been much rigorous assessment of the social causes of the long-term sustainability outcomes of livestock food systems (Janker et al., 2019; Reganold and Wachter, 2016). rather than being unique to research on livestock production sequences to development, is indicative of uncertainties around the role limits in relation to sustainable development in general (Vallance et al., 2011). While assessing the long-term sustainability of livestock systems, it is imperative to take into account societal markers of socioeconomic accomplishments and their impact on the environment. There has not been much study done on this subject up to this point, notwithstanding the sporadic presumption or perhaps hope that the population size, market perspectives, and production means connected to agri-food systems, including animal production, will also be correlated with positive socioeconomic results.

Food Security in a Changing Climate: The Importance of Sustainable Animal Agriculture Practices

The raising of animals is negatively impacted by climatic stresses, yet on the other hand, livestock operations have a share in global warming (Kuraz et al., 2021); roughly 14.5% of GHG is an outcome of livestock farming operations (IPPCC, 2013). GHG predominantly influences climate change. Animal waste and feed fermentation produce CH4, N2O, and CO2, each of which fuels the warming of the planet (IPCC, 2007; Gerber et al., 2013). This scenario makes it challenging to strike the right equilibrium between environmental preservation, animal husbandry, and family food security. According to Wright et al. (2012), as ambient temperature increases and atmospheric CO2 concentration rises, the amount of rainwater and an amalgamation between these components are the primary consequences. Climate change implications for livestock production are overwhelming (IFAD, 2010; Henry et al., 2012; Polley et al., 2013).

In broad terms, the amount and nutritional value of feeds, water supply, animal reproductive success, and health and heat exhaustion are all impacted by climate change in terms of animal productivity. Future climate change's impacts are going to have major effects on the supply of water worldwide. This will have an impact on pasture output and animal feeding systems, in addition to sources of livestock water (Gaughan, 2017). Henry et al. (2012) reported that animals may become more susceptible to parasites and further infections due to temperature variation. Diseases transmitted by parasites will increase in intensity (Tabachnick 2010). Stress due to high ambient temperatures resulting from climate change has a major detrimental effect on an animal species ability to utilize feed nutrients (Made, 2003), intake of feed and productivity (Thornton et al., 2009), animal performance (Summer et al., 2019), reproductive success (Naqvi et al., 2012), animal well-being (Lactera, 2019), and mortality (Howden et al., 2008). According to Mckeon et al (2009) rising temperatures can make livestock more susceptible to worms and additional ailments particularly those that carriers are used to communicate (Tabachnick, 2010).

Due to its substantial contribution to the production of livestock by humans, it plays a vital role in the phenomenon of changing the weather. Researchers understand that roughly 21 and 37%, both production and consumption, account for the production and sale of food items derived from animals and their related items (Mbow et al. 2019). Livestock GHGs are a primary factor in human-caused global warming (Reisinger and Clark, 2018). The agricultural industry must take proactive steps to promote environmentally friendly agriculture since it is susceptible to changing trends due to its reliance on meteorological consistency. This

emphasizes the necessity of giving integrated methods for adaptation and mitigation in agriculture, also known as climate-smart agriculture, more serious thought as they aim to simultaneously accomplish production adaptation and mitigation (Lipper et al., 2014).

Enhancing the adaptability of agriculture among populations reliant on agricultural activity requires responding to shifts in weather patterns and reducing the use of greenhouse gases (Humphary et al., 2022). The production of animal food items is severely impacted by the loss of animal genetic material due to global warming (FAO, 2019). The adaptability and responsiveness of the livestock system are also diminished when the array of animal genetic resources declines in relation to their surroundings or ecosystem, along with the numerous ecological services that biodiversity provides. The influence of climate change on animal genetic biodiversity due to their extinction will also have an effect on the supply of animal-derived goods.

Gender Dynamics in Animal Agriculture: Addressing the Complexities for Climate-Resilient Food Security

It is imperative for gendered measures to be sustainable in livestock production and to acknowledge the abilities of women to effect change regarding gender. Approximately 14 billion women worldwide who reside in rural regions depend on livestock as their primary source of income (Glazebrook et al. 2020). In the world south of the agricultural laborers, 43% are women and 66% are animal keepers. Approximately 60% of women will be employed in agriculture throughout the year, but in continents and nations that are less developed, gender plays a major role in ensuring family food needs because they produce up to 89 percent of the food that is consumed. In addition to maintaining the home water supply, tending to animals, harvesting food, fuel wood, and animal feed, and cultivating, preparing, preserving, and cooking food, women in the countryside also provide much of the labor needed in agriculture.

In a given civilization, the use and management of land and water are gendered, with differing degrees of authority and different degrees of knowledge. Men and women utilize and engage in natural resources, notably biodiversity, in diverse ways. They also have varied concerns and requirements for their livelihoods (Paudel 1999; Khadka 2000; Nightingale 2002; Rai-Paudyal 2008). In sustainable animal agriculture, gender is more than just women's problem. It is important to comprehend the complex problems that either support or impede women's involvement in agricultural growth operations, as well as how they may be able to access possibilities, incentives, and resources from nature. Gender inequality in Sub-Saharan Africa affects women's role in animal agriculture and food security, limiting their access to resources and decision-making power. Empowering women in agriculture can improve productivity and sustainable practices. Indigenous knowledge systems can inform sustainable animal agriculture and climate resilience. Recognizing and respecting indigenous knowledge can promote inclusive solutions. Climate change affects animal agriculture and food security, and sustainable practices like agroforestry and rotational grazing can help mitigate it. Climate-resilient agriculture can improve food security and livelihoods for Sub-Saharan African communities.

Gender and cultural norms dictate men's and women's roles in animal agriculture and food security (Phili et al., 2021). It has been widely documented that gender-differentiated roles, knowledge, and preferences among various gender groups differ in animal agriculture. Therefore, harnessing the differences in response to the changing climate is pivotal in mitigating and adapting to the adverse impacts, thus moving towards raising animals sustainably. Women play a crucial role and effect in livestock, so it is vital to address their problems and explore ways to get over them. Doing so will help develop actions for both attaining socioeconomic empowerment and unlocking the immense potential of women, necessitating a gender-balanced approach to applying sustainable animal husbandry practices while addressing structural inequities.

Among Sub-Saharan Africa's most urgent problems are yield disparities in both crops and livestock. The FAO has shown that women's limited accessibility to ways of production and their inability to take advantage of opportunities are the causes of disappointing productivity, especially in underdeveloped countries (Njobe and Kaaria, 2015). The goal of animal sustainability husbandry and its transition into resilient, just, and environmentally friendly practices may both be achieved by promoting gender and social equality (Lecoutere et al., 2023). Despite current institutional and sociocultural constraints, women are potent agents of change and must remain so in order to significantly advance sustainable development (Markham 2013).

We must foster an environment supporting women's empowerment as well as parity between genders if our goal is to ensure livestock sustainability. Recent years have seen a rise in interest in paying attention to gender disparities in agriculture, with a particular emphasis on the emancipation of women for sustainable livestock husbandry practices (Chanana et al., 2021). Improving delivery services by targeting the poor and gender sensitivity is a crucial strategy for solving gender inequality in agriculture. Hence, it is imperative that we comprehend the myriad implications of climate change while simultaneously promoting gender parity and women's agency in order to foster sustainable agriculture.

Findings on gender have brought attention to the tendency for bias against women to arise in livestock production from policies and procedures that have not been created and structured with the perspective of gender since gender represents one of the societal factors that might have an impact on the animal agriculture and food security enterprise. Reducing the disparity between genders will have a noteworthy impact on the industry's sustainability. Recognizing the social environment aspects of vulnerability and how it affects sustainability in a changing environment is presumably essential in order to address the impact of climate change on agriculture. This is necessary as a first step, as disparity between men and women is most frequently linked to unequal susceptibility to climate change in agriculture (Eriksen et al., 2015).

According to Rivera-Ferre and Varez (2017), we should reevaluate our conception of agriculture for sustenance as a lifelong endeavor and acknowledge the significance of women's knowledge and contributions to maintaining everyday life, whether or not it is sold outside of traditional marketplaces. Boo Tchouawou and Collinson (2014) assert that this concept unites male and female farmer organizations, connects them with extension agents, and fosters discussion about the common issues facing both men and women farmers as well as the requirements unique to each gender by meeting the needs of women producers whose goals and functions to adopt new agricultural management practices are often different from those of men. This helps to mitigate a portion of the customary shortcomings in farming extension programs (Quisumbing and Pandolfelli (2010). Disparities between genders may be lessened by imaginative strategies recognizing and specifically serving the needs of overlooked women. This promotes and raises output from agriculture land while promoting a sustainable agriculture sector.

Climate change mostly affects women because of their growing subsistence dependency on farming. Context-dependent vulnerability, whereby the phenomenon of climate change has a different impact on gender, is occasionally overlooked by policymakers (Aipira et al., 2017). Deliberate policy targeting women's participation in integrated agricultural projects to alter gender norms is one way that women may be empowered. This kind of action has been demonstrated to have positive impacts on agriculture and can vary across institutional, social, and economic frameworks. Bezner-Kerr et al. (2016) argue that as active participants in livestock husbandry activities such as feeding, watering, and animal health, women are crucial in the global animal agriculture and food security (Assan 2022).

Our voices are able to claim that women nourish the entire globe even though there is disagreement over the amount of livestock-related food items grown by women worldwide (Doss et al. 2018), and present statistics only take into account what is quantifiable and visible—that is, agriculture geared toward the regulated livestock and poultry market, ignoring subsistence along with household agriculture. Increasing women's capacity to produce more animals in agricultural enterprises is crucial to improving livelihoods by means of sustainable animal agriculture. The issue of gender dynamics in agriculture's general sustainability expansion is significant. Gender and women's inclusion, albeit mostly ignored, are occasionally discussed in strategies and discourses linked to the expansion of livestock production. Assan (2022) draws on a thorough assessment of scientific works and experience in providing perceptive insights into various ways gender differences affect sustainable animal husbandry. This is evidently especially helpful when examining the intangible role of women towards the achievement of sustainable animal husbandry practices. The review emphasizes the importance of empowering women in animal agriculture and food security through training, education, and leadership opportunities, advocating for gender-responsive policies and programs, and considering intersectionality to ensure inclusive and equitable solutions addressing intersecting factors.

To enhance awareness and incorporation of gender-specific understanding, objectives, and demands in sustainable animal agriculture, researchers must first identify essential study gaps. Filling these gaps can

significantly improve environmental and social outcomes. However, agricultural sector initiatives often overlook crucial gender evaluations and equity concerns. Women must engage in politics and policymaking to achieve inclusive representation, combining traditional expertise with innovative solutions to define the agenda. Women can lead and drive transformative rural development agendas when designing livestock-related projects address poverty, hunger, and climate change. This review stresses the importance of leveraging gender-sensitive technology and innovation to boost productivity and climate resilience in animal agriculture. Experts recommend using gender-disaggregated data to inform policies and programs. Furthermore, fostering gender-inclusive partnerships among farmers, researchers, policymakers, and private sector actors is crucial. Addressing power dynamics that limit women's participation in animal agriculture is also essential.

We must not treat women as an afterthought in agricultural livestock development programs, as this oversight has derailed the success of most initiatives. Implementing programs without considering gender dynamics in decision-making leads to ineffective and flawed plans, hindering sustainability. Designing projects without gender consideration is pointless, as they rarely achieve sustainability objectives. To integrate gender and animal agriculture in a changing climate, experts must adopt a comprehensive approach that addresses gender disparities in resource access, decision-making power, and labor distribution. This approach involves implementing gender-sensitive climate-smart agriculture practices to enhance resilience, ensure equitable access to nutritious food, and consider gender-specific nutrition needs and preferences.

The Gender-Climate Nexus in Animal Agriculture: Exploring the Complex Relationships and Consequences for Food Security

Gender-based perspectives on climate variability indicate that its effects are greater on women as opposed to men. Assan 2023 climatic stressors as a major driver of gender disparities are becoming the most urgent challenges of our day. In order to have a greater knowledge of the relationship and draw interventions on climate variability, gendered approaches must be done in consideration of future possibilities. changing weather patterns, ensuring redress of gender disparities since their impact on men and women is different, mainly because of the roles, responsibilities, and capacities associated with various genders in the home and community, and the division of labor obligations and relationships between men and women in various age groups, socioeconomic classes, and educational backgrounds. The concept of risks and how they dissimilarly affect gender in terms of vulnerability to climate-related stress are determined by gender dynamics and the various tasks assigned by societies and relations, and hence may vary across time and place in society (Rao et al. 2019). The link between gender and climate change significantly impacts sustainable animal agriculture and food security, with women being more vulnerable to climate-related shocks and prioritizing climate-resilient practices, while men's adaptation strategies in animal agriculture differ.

There are gender differences in the ways that communities produce livestock and are affected by climate change. Men are not as badly affected as women are (Laska & Morrow, 2006). Women are more severely impacted than men (Laska & Morrow, 2006). This is because there is a circumstantial and unequal vulnerability of gender, which is typically associated with significant disparities between men and women who work in animal husbandry and face varying consequences of climatic variability based on their abilities to tolerate and adapt to further research. Rai et al. (2021) Rai, Mainaly (2018), Ahmed, and Fajber (2009) have corroborated this dedication to animal farming. Despite climate challenges, women are significant supporters of animal agriculture and food securityand play a critical role in solving issues and spearheading programs to increase animal productivity (Tangka et al. 2000). Climate change impacts women's nutrition and health, leading to gendered nutrition. Climate-related migration affects women's roles in animal agriculture, creating new challenges and opportunities. Gender-specific factors influence women's adoption of climate-resilient technologies in animal agriculture, including access to information and credit.

Because of longstanding gender disparities, women who practice agriculture have been particularly affected by the repercussions of rising temperatures. The impact of the changing climate has had diverse outcomes for different groups. Dissimilar adaptation techniques are needed given that both males and women are more affected in circumstances that vary. Women's restricted access to resources and assets makes it more difficult for them to adjust (Tsikata 2016). Due to gender disparities in the resources required for adaptation or the disparities in the distribution of resources based on agriculture, adaptive capacities are gendered. This means

that because different people encounter climate change susceptibility and adaptation capability differently, gender is a crucial axis of social inequality that may obstruct the development of sustainable animal husbandry (Rivera-Ferre 2021). Social norms have an impact on the distinct impacts of climate change on gender lines, risk perception behaviors, and climate change coping methods. Gender-specific norms, disparate control and access to important productive resources and assets, and dissimilar involvement in local, national, and worldwide decisions are some of the causes of greater climate risk for women in agriculture. Women in animal agriculture face limited decision-making power, limited access to resources like land, credit, and technology, and a disproportionate burden of labor, exacerbating their vulnerability to climate-related stresses, and face barriers in accessing essential resources like land, credit, and technology.

Equal opportunities for women's practice of agriculture must be considered in the management of climate change adaptation strategies in order to support women's empowerment in the implementation of policy solutions. Eliminating barriers to women's adaptation mitigation requires addressing the systematic discrimination seen in livestock production programs. It is not unusual for policies to address global warming. Gender parity may benefit from reductions in GHG and modifications to animal production, or they may have unexpected repercussions. Being aware of institutional impediments to equality between men and the opposite sex leads to unequal opportunities to get resources and services. It is more common for women than for men to experience the negative effects of local climate-related stressors, such as periods of drought, environmental harm caused by livestock grazing, and water scarcity.

Lecoutere et al. (2023) argued that preventing gender inequality in livestock systems will be just as important as eliminating it in the transition to fair and sustainable animal agricultural systems in the face of climate change. The raising of animals ought to give priority to initiatives that not only lessen their ecological impact but also advance equality between men and women. Interventions aimed at tackling disparities in gender can also significantly lessen the implications of climate change on the farming of animals. When solely gender or climate parameters are taken into account, policy priorities shift regarding the former. It can be said that gender standards will extend the influence of tackling climatic variability while also helping to close the gender gap. However, depending solely on gender criteria, it is unlikely to stop discrimination, so women alone have to have the chance to weigh in on issues related to global warming and its influence on livestock production.

The context-related heterogeneous vulnerability must be considered while developing climate change policies and activities to promote sustainable animal agriculture. Practically every adaptive approach will affect the distribution of resources and the formation of social interactions within a group of people (Eriksen et al., 2015). Not everybody, though, thinks that all of the aforementioned modifications are desirable. The question of whether and how adaptation closes the basic disparities in resource distribution can never truly be settled because it hinges on a variety of individual circumstances, decision-makers, and knowledge. In conclusion, women who are respected and encouraged in their communities are better able to lend a hand to climate change-resilient animal agriculture and food security as well as significantly improve their own and their family's quality of life (Langer et al. 2015).This necessitates highlighting the role that women undertake and how important it is, not for their position in developed agriculture—which is frequently controlled by men—but rather for their positive impact on community and household prosperity and the supply of food (Otieno Onyalo 2019).

Since women are major players in livestock farming, women are crucial in leading initiatives to promote sustainable animal production, which enhances household nutritional well-being in an ever-changing climate. Consequently, for the purpose to cope with the effects of climate change, methods that take into account contextual awareness of the gender-differentiated nature of climate exposure in livestock systems should be created. Women have a major part in the manner of reconstruction since they own a large corpus of this information which is usable in sustain agriculture. The structural discrimination that women face in patriarchal societies makes it difficult for women to reach their full potential. The significant effects of global warming on women have derail their contribution to sustainable agriculture. A clear picture of women's participation in and inclusion in agriculture is needed.

Given the changing environment, Belay Jimma (2016) and Sauer (2018) noted that gender-based research has shown that policy formulation acts that are not designed and prepared from a gendered viewpoint result in

gender prejudice. The results of Tsagkari et al. (2022), Ang-Benza 2021, Singh 2020, and Magnusdottir and Krosell (2014) provide confirmation that carbon reduction measures may contribute to gender disparity. Climate policies are not immune to this prejudice. Gender-blind policies and governance structures can perpetuate gender inequalities in animal agriculture and climate change responses. Addressing these intersections is crucial for promoting gender equality, climate resilience, and sustainable animal agriculture, ensuring food security.

Harnessing the Hybridity of IKS and Climate Research for Resilient Animal Agriculture and Food Systems

Sub-Saharan Africa ought to endeavor to establish a series of concrete and workable steps for integrating traditional viewpoints based on the available local knowledge, which has sustained livelihoods since immemorial. This can approach from the policy formulation front, with research targeted on the use of IKS in climate issues and agriculture development. There is a need for awareness among policymakers, academics, decision-makers, and specialists involved in the sustainable development of animal husbandry to realize the role of IKS across disciplines. Traditional knowledge has contributed significantly to the decades-long survival of how to raise animals on the continent. Chaudhary et al. (2022) pointed out that local climate-resilient agricultural practices could provide lower yields than substitutes derived from contemporary agricultural expertise. As a result of this, there has been a tendency for local communities to shift to "hybrid knowledge," which combines Indigenous and contemporary science, technology, and practice, in order to maximize production while addressing issues related to climate change. The bimodal approach of integrating portions of IKS and modern science into both agriculture and climate issues has resulted in achieving better productivity while also making them less vulnerable to extreme weather events.

Ascertainment of the point of convergence of IKS and contemporary climate science will enhance the raising of animals that is sustainable. IKS are described as a complex collection considering information and technological advancements that have occurred around distinctive conditions among inhabitants and communities in a certain geographic location (Parrotta and Trosper, 2012). According to Odora-Hoppers (2001), IKS are ingrained in a people's history and cultural web and have their roots in their social, economic, scientific, and technical identity. IKS are becoming more recognized for their value and their ability to assist with achieving sustainable development and climate mitigation (Eguru, 2012). In relation to the utilization and management of biological variety, they have created distinct knowledge systems and innovation behaviors (Omotayo, 2015). A large portion of information was crucial to research and growth, especially in fields like agriculture, which is frequently both ecologically adaptable and culturally acceptable, making it a valuable foundation for agricultural innovation. Caudhary et al. (2022) observe that the conversation and misconceptions around the interplay between science and traditional wisdom are evolving into a movement to include all forms of knowledge in order to address intricate problems, including climate change.

Small-scale farmers Livestock producers' access to local insight based on the knowledge acquired through time immemorial provides important perspectives for tackling climate change (Chaudhary et al., 2022) and attaining ecologically friendly animal agriculture and food security (Dakora, 1996). IKS, livestock production, and the impact of climate change are interrelated in various settings in ways that overlap or converge (Chaudhray et al., 2022). In accordance with their societal and ecological beliefs, livestock producers in resource-constrained Sub-Saharan Africa have historically employed a variety of native markers to predict the climate (Ubisi et al., 2019). Remote farmers who raise livestock use animal, plant, atmospheric, and human health indicators far more frequently. These signs are used at the farm level in order to make decisions about farming adaptation to changing climates (Mosime, 2018; Acharya, 2011). Indigenous Knowledge Systems (IKS) and modern climate science can enhance sustainable animal agriculture and food security by integrating traditional practices with scientific knowledge and combining IKS-based adaptation strategies with modern climate modeling and forecasting.

It is likely that IKS networks will look to traditions that support a lifestyle that is environmentally friendly and fosters social cohesion in order to meet the challenges of making the transition to future eco-friendly agriculture practices (Sderholm 2020). In this situation, it can act as a starting point for addressing the significant sociocultural, economic, or ecological issues at hand. It can highlight the value of being aware of

the links between culture and sustainability without undervaluing or downplaying the crucial role of other factors. It provides the framework in which agricultural practices and initiatives evolve if animal agriculture and food security is to become deeply embedded in daily activities. According to UNESCO (2013), the most powerful force at our disposal for constructing and preserving viable agro-food systems is community and local knowledge. The study focuses on integrating Indigenous Knowledge Systems (IKS) into modern breeding programs for climate-resilient animal breeds, integrating IKS-based conservation practices with sustainable agriculture methods, fostering collaboration between indigenous communities and climate scientists, and integrating IKS into climate change policy.

It is necessary to contemplate the following inquiries: Do traditional knowledge systems encourage climate-smart agriculture? A vast body of research indicates that global food production has decreased due to human-caused climate change (Ortiz et al., 2021); furthermore, the production of CH4 and N02, two potent GHGs, and the deposition of biomass CO2 on land used for raising livestock are two of the main ways that livestock production contributes. phenomenon of global warming (Eisen and Brown, 2022) How much can livestock production use IKS to mitigate the impact of warming temperatures? has been the unresolved issue surrounding the role of IKS in addressing climate change mitigation and prevention. Climate change and animal farming are all related in many ways. Based on this relationship, it is interesting that they are not explored in greater detail in the literary works. The wildly divergent policy and research frameworks that each profession developed from may help to partially explain this. Nyong et al. (2006) presented confirmation of the usefulness of IKS in the Sahel region of Sub-Saharan Africa for coping with and adapting to weather changes. This is taking place against the backdrop of local communities in this region developing and implementing into practice comprehensive mitigation as well as adaptation plans that permit them to lower their exposure to adverse environmental conditions even more than previously predicted.

However, the planning and implementation of existing mitigation and adaptation strategies for sustainable development, which include animal husbandry in Sub-Saharan Africa, do not always take this understanding into account. This paper argues that there may be some major benefits to mixing elements of indigenous wisdom with worries about contemporary climate studies and notions, ideas, and plans to promote environmentally friendly animal agriculture and food security expansion. There is no need to deviate climate issues from their impact on achieving climate-smart livestock farming (Cohen et al., 1998; Swart et al., 2003), since this could represent the best approach to addressing the problem of reduction in intensity as well as a significant portion of transition and repercussions. Observations worldwide have validated this method, which is useful for evaluating and foreseeing modifications to meteorological factors in which IKS can be included (Manyanhaire and Chitura, 2015).

The synchronization of IKS with contemporary research on climate is going to enhance livestock's aptitude to adapt to changing climate conditions and deal with uncertainty in weather conditions. This is in addition to animal food production's capacity to cope with risks associated with warming temperatures (Svotwa et al., 2007; Nyong et al., 2006; Robinson and Herbert, 2001). Agro-advisory solutions and climate data are essential for subsistence livestock producers across Sub-Saharan Africa in order to cope with the risks associated with climate change and adjust to it (Radeny et al., 2019). Nonetheless, there are large gaps in the availability of climatic data that adequately meets individual farmers' demands. Therefore, in order to monitor and anticipate conditions related to the weather, cattle producers rely on indigenous knowledge (IK), which is based on local indications and observations.

Khadka and Verma (2012) asserted that the IKS integrative model and their roles in exploiting diverse animal types present across numerous habitats are extremely important to environmentally friendly livestock production, the health of the planet, the economic sustainability of the people who live there, and their societies, according to Kiggundu (2007). IKS are derived from the partnerships between people in communities and their surroundings over the boundaries of a particular region. IKs is the cogent of all facets of human existence, encompassing social, economic, political, pharmaceutical, and wellness systems in most Sub-Saharan African societies. This is because local know-how is derived from extensive intimate experiences with the surrounding environment and its various forms. The empirical and theoretical are the foundations of western scientific understanding (Oguamanam 2006).

Approaches for the growth and viability of livestock that account for ecological balance in Sub-Saharan Africa need to be reevaluated since they seem to be centered around replacing traditional or indigenous knowledge with modern knowledge systems (Warren, 1992). This method, which is founded on the concept of substitution and tends to reject traditional values, has not proven very effective as traditional values are usually the major social asset of the poor. Kolawole's 2001 developmental initiatives may be made more durable and successful by using established values that have been shown to be beneficial. Abioye et al.'s (2011) primary objective should be to assess the viability of incorporating indigenous knowledge systems related to animal husbandry into climate science and, as a result, provide reasonable perspectives on their foundations to help advance ecologically friendly animal farming.

Bringing together IK's scientific and technological expertise is necessary for confronting global warming challenges since traditional approaches to coping with climate change are not adequate alone (Imoro et al., 2021). The reason is that IKS and technology in synchrony can complement analyzing the effects of climate change along with developing practical adaptation and mitigation plans, notwithstanding the ways in which Sub-Saharan African communities have utilized and will persist in making use of contemporary science in addition to their IKS in climate change plans. Novoo (2007) contended that the results have proven disastrous, causing disagreements over environmentally conscious ways of meeting the needs of the local population and going head-to-head with the concept of sustainable development; rather, they think that the concept of sustainable development is actually much more intimately associated with the modern practices that the local people practice.

To advance climate-smart animal agriculture and food security, experts should create a convergence point that leverages conventional and indigenous knowledge systems (IKS). It is essential to acknowledge the complementary roles of contemporary science and IKS, rather than neglecting them, to capitalize on their benefits in today's hybridized context. Researchers must gather these insights to inform sustainable animal husbandry practices that support climate research. By integrating IKS and modern climate science, innovators can develop novel solutions for sustainable animal agriculture and food security, empowering indigenous communities to lead initiatives and respecting their rights to their knowledge and resources. This collaborative approach enhances food security and promotes sustainable agriculture practices.

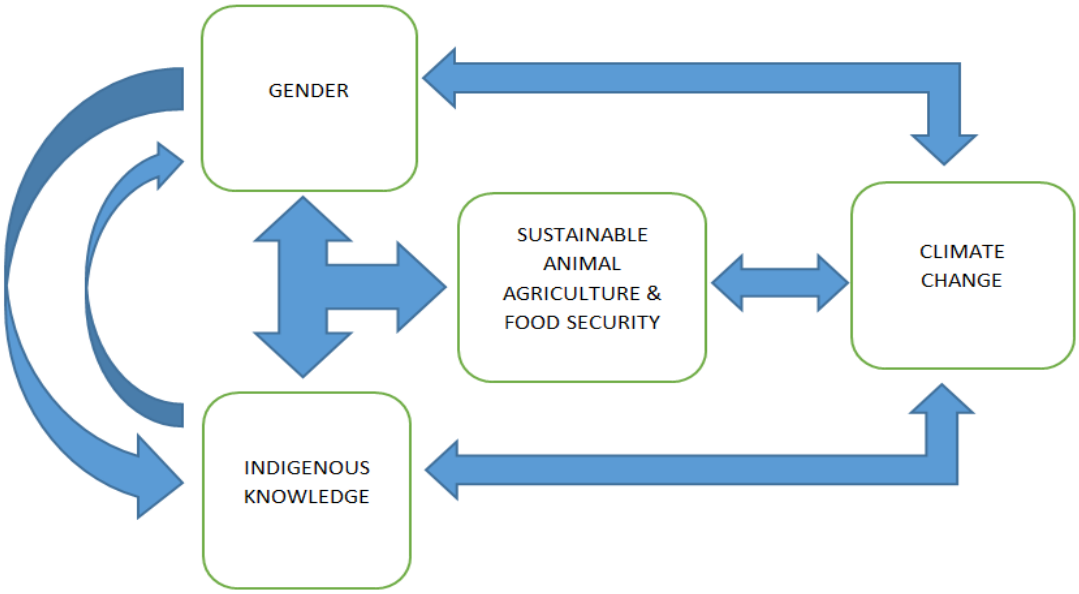
Convergence for Sustainability: Gender, Indigenous Knowledge, and Climate Change in Animal Agriculture and Food Systems"

This study examines the sociocultural influence on sustainable animal agriculture and food security within the context of a changing climate, using a casual loop framework (Figure 2). To improve oversight of ecological diversity, researchers must address several intertwined questions, including the environmentally friendly disparities between genders in raising livestock and the role of indigenous knowledge in livestock production (Singh and Mukunda, 2020). Figure 1 illustrates the unstructured cycle frameworks, societal nature, and ecological implications for sustainability. Researchers identify differences in gender and indigenous knowledge regarding climate change and agricultural aspects. Gender significantly impacts how knowledge is differentiated, recognizing gender-specific positions and their influence on the intrinsic value of indigenous knowledge systems. Norem et al. (1989) advocate for critical analysis, understanding, and dissemination of this information. Women rely on their local knowledge when adapting to changing environments. Akeba et al. (2012) argue that indigenous knowledge has taken too long to be valued, despite its proven value in addressing livestock and climate change-related challenges. Experts emphasize that integrating gender and Indigenous Knowledge Systems (IKS) is crucial for sustainable animal agriculture and food security, empowering indigenous women and integrating gender-sensitive adaptation strategies in climate-resilient agriculture based on local knowledge.

This article argues that studies of native knowledge systems often overlook the crucial role of gender. Researchers must recognize the intrinsic link between gender distinctions and traditional wisdom. By acknowledging the interdependence between gender, indigenous knowledge, and the earth's climate, and by promoting equality between men and women, experts can facilitate a transition to eco-friendly livestock farming. Assan (2023) emphasizes that local knowledge structures can form the basis for sustainable growth only if their ability to innovate through gendered knowledge-generating practices is recognized and respected.

To preserve environmental sustainability in contemporary livestock farming, researchers and policymakers must integrate gendered and indigenous knowledge. Addressing the challenges associated with gendered and Indigenous Knowledge Systems (IKS) is crucial for maintaining environmental sustainability. Piri et al. (2022) argue that advancing gender-based expertise and abilities, as well as cultural and socioeconomic diversity, is essential for tackling components of the agro-food chain, such as animal husbandry (Scantlebury, 2014).

Figure 2: Conceptual Framework Linking Gender, IKS, and Climate Resilience (Author)



Traditional knowledge systems are deeply rooted in the experiences of gendered individuals (Wannen, 1989) and are driven by the experimentation and inventiveness of groups assigned specific production and management responsibilities. Gender differentiation emerges from the unique experiences, knowledge, and skills that women and men develop as they fulfill their assigned productive and animal production responsibilities (Feldstien and Pabs, 1988). As policymakers and academics focus on Indigenous Knowledge Systems (IKS), they sometimes overlook the significance of gender in shaping societal structure. However, researchers increasingly recognize the ongoing importance of IKS and their potential role in conceptualizing fair and sustainable development. Scholars in fields like agriculture, land management, and livestock production are placing greater emphasis on gender, while research on IKS rarely acknowledges the role of gender.

The degree to which men and women adapt to their assigned activities and the division of duties between genders shape a community's perception of distinctiveness regarding gender knowledge and abilities. As a result, both sexes experience these circumstances differently. The economic, political, social, cultural, and geographical environments in which men and women live influence their creation, adaptation, and use of technological and scientific information (Appleton, 1993a). Researchers have overlooked the importance of understanding traditional knowledge in sustainable agriculture by focusing on generalities. Hill (1993) highlights the crucial role of gender in sustainable development and the value of native wisdom in addressing situation-specific problems (Krishna and Aisha, 2003).

To fully harness the potential value of Indigenous Knowledge Systems (IKS) in promoting agricultural environmental responsibility, researchers must address the gender issue and establish a platform to discuss its impact on understanding these systems. IKS are complex, multipurpose issues that span various fields, and men and women perceive, learn about, and respond to conventional analysis differently (Gautam, 2020, and Bhandari, 2020b). Gender disparities in expected responsibilities and prior exposure to different tasks in daily duties lead men and women to develop varying levels of intelligence and skill sets. These distinctions influence access, usage, and oversight, shaping viewpoints and intentions for creative thinking and utilization (Krishna and Aisha, 2003). Women's agricultural practices actively employ IKS, highlighting the need for researchers to understand this critical gender perspective.

Women in Sub-Saharan Africa actively experience marginalization and limited access to information production and policy-making roles due to the intersection of gender disparities in the formal system and the declining value of Indigenous Knowledge Systems (IKS). By examining the connections between gender and IKS formation, researchers aim to unlock a valuable resource for developing environmentally friendly development strategies. Achieving this goal requires a collaborative effort from stakeholders in the fields of gender and IKS. The exclusion of gender-based IKS development paradigms across Sub-Saharan Africa has significantly hindered the advancement of agriculture-related competencies. Women not only have the right to participate directly in decision-making processes but also offer unique insights, skills, and talents that differ from those of men.

Researchers and policymakers often overlook or undervalue indigenous knowledge when different groups lack oversight in technological development processes, leading to exclusion and forfeiture of the will to create suitable and relevant technology (Esiobu, 2020). Experts emphasize that understanding the intersection of gender and indigenous knowledge systems is crucial for sustainable animal agriculture and food security in the face of climate change. This review highlights the importance of respecting indigenous women's knowledge, addressing gender-specific climate vulnerabilities, fostering collaborative learning, developing culturally appropriate climate-smart agriculture practices, and advocating for policies that support gender-sensitive IKS-based agriculture. By converging gender and IKS, stakeholders can improve climate resilience, promote gender equality, empower indigenous women, ensure food security, protect biodiversity, and foster inclusive sustainable agriculture practices. This convergence is essential for addressing climate change, gender inequality, and unsustainable animal husbandry practices.

Small Ruminant Production: A Scalable Social Enterprise Promoting Gender Equality and Climate Resilience

Small ruminant production emerges as a sustainable and scalable social enterprise that actively promotes gender equality in response to climate change. Assan (2023) suggests that raising sheep and goats can effectively tackle gender imbalances in animal agriculture and food security, empowering women in the process. Sustainable animal agriculture and food security prioritize small ruminant agriculture because it leverages the significant contributions women make to raising sheep and goats, as well as the innate capacity of these animals to adapt to changing climate conditions (Assan, 2014c). This single animal-based livelihood activity offers a convergence point for an integrated and long-term strategy to address the triple challenges of malnutrition, poverty, gender inequalities, and climate change in rural areas (Assan, 2014a). Assan (2013a) emphasizes that inaction due to gender disparity has increased vulnerability, impacting livestock production. Rural populations are now perpetually vulnerable to food insecurity in livestock production. Implementing a small-ruminant-centered strategy can achieve viability. Assan (2013b) recommends evaluating livestock production metrics through a gendered lens, providing easy access to the social aspect of animal husbandry sustainability. By giving women ownership of assets, income, and decision-making power, small ruminant production actively promotes gender equality.

Researchers can advance environmentally friendly practices by understanding the significance of gender roles in animal production and pinpointing the interplay between conventional science and Indigenous Knowledge Systems (IKS). By combining these approaches, experts can address the complex social, economic, and ecological issues facing the agricultural sector, providing food for hungry people while protecting the natural world. Future generations will rely on livestock products to deliver high-quality nutrition, improve ecosystem services, and enhance human well-being. Sustainable agriculture choices are driven by the need for livestock to meet social needs, and stakeholders worldwide are working to address poor livestock production exacerbated by global warming. Rather than neglecting gender roles and gendered traditional knowledge systems, experts should collaboratively understand and promote gender equality in utilizing complementary local knowledge systems through the care and breeding of sheep and goats.Small ruminants like goats and sheep are climate resilient, adapting to changing environments and thriving in diverse environments.

Women have actively demonstrated their commitment to ecological soil practices and production while addressing inequality and socioeconomic disparities in their neighborhoods (Hulela, 2010). In sheep and goat production operations, women face gender disparities in controlling workforce distribution and decision-

making, as well as accessing resources, which contribute to low livestock output. Implementing gender-sensitive measures or policies can address the differences in livestock ownership, decision-making participation, and resource access between men and women. Recognizing gender roles as a societal variable can advance efforts towards sustainable agriculture, given that women traditionally care for sheep and goats due to cultural customs. The disregard for small stock is likely the primary factor contributing to sustainability issues in animal agriculture, rendering previous detached plans to address gender inequality, climate change effects, and food insecurity futile. Throughout the Sub-Saharan African continent, women are closely connected to sheep and goats due to cultural and economic factors. Moreover, women have shown a stronger affinity and passion for sheep and goats compared to other animals. The International Fund for Agricultural Development (IFAD) acknowledges that breeding sheep and goats can improve the lives of underprivileged women (IFAD, 2016).

Women play a crucial role in raising goats and sheep, and this is no coincidence. Since gender differences within families pose a significant barrier to sustainable agriculture, herding sheep and goats offers a strategic solution to achieving sustainability. Researchers have demonstrated that empowering women in underprivileged Sub-Saharan African communities through goat and sheep keeping is a successful tactic (Ogolla et al., 2022). Women actively devote an estimated five hours a day to maintaining and supervising sheep output, as reported by IFAD (1994). Women prefer goats and sheep due to their low upkeep costs, rapid maturity, and relatively simple reproduction, which contribute to a swift population increase and establish the sustainability boundaries arising from the relationship between women and small ruminants (Elliot et al., 1998). Women leverage the advantages of small ruminants, which grow swiftly and thrive in challenging conditions, resisting drought more effectively than cattle. These characteristics make raising small ruminants, like sheep and goats, more manageable for women.

The increasing popularity of sheep and goat farming stems from the growing demand for diversified and sustainable animal husbandry practices. Researchers have developed a multidisciplinary approach centered on goat keeping to address the triple constraints of food instability, gender inequality, and climate change by leveraging the connections between these environmental and socioeconomic problems. This approach provides a pathway to gender fairness by promoting goat farming, which reduces the risk of nutritional and food poverty in rural communities while utilizing the potential of small stock to provide household needs in a changing climate. Sheep and goats help mitigate the threats associated with crop cultivation for human consumption during unfavorable weather conditions, generate income for diverse agricultural families to maintain their financial well-being, and assist in the care of large ruminants (Misra et al., 2007). Fathelrahman (2014) reveals a significant correlation between women's experience handling sheep and goats, their technical ability, and the variety of sheep and goats. By acknowledging this overlap, experts can facilitate sustainable animal agriculture and food security while addressing food scarcity and gender inequity. National and global food system development bodies have shifted their focus to the small ruminant-centered agriculture-driven paradigm to promote sustainable livestock production and address protein deficiency.

Given its focus on addressing gender inequity and empowering women, it is understandable that this approach leverages the fact that small ruminants thrive in extreme conditions brought on by climate change. Raising sheep and goats actively reduces gender inequality in the agriculture sector and empowers women, meeting sustainability standards in the process. Women can successfully rear goats independently due to their modest size, making them an outstanding example of a species that can adapt to its environment. Researchers recognize goats as a climate-smart species model due to their morphological, physiological, and ethological characteristics, which enable them to adapt to climate change, as well as their connection to women (Assan, 2021). Small ruminants like goats and sheep actively adapt to changing environments, thriving in diverse settings. To cope with unfavorable climatic circumstances imposed by warming temperatures, goats modify their physical characteristics, habits, and biological responses. These responses are essential for matching goats to specific habitats and ensuring achievable levels of output.

Experts promote rearing sheep and goats as a strategy that incorporates the empowerment of women in the livestock industry, ensuring basic family nutritional needs while bolstering sustainable animal production. Goats adapt to challenging climatic circumstances caused by climate change. Rural women's traditional knowledge about livestock and their care is often underestimated in poor countries (IFAD, 1994). Women

engage in gender-specific activities, such as helping animals reproduce, feeding, and caring for their health on a daily basis. By supporting small ruminant production, experts can foster gender equality, sustainable agriculture, and climate resilience, providing social, economic, and environmental benefits.

Small ruminant production generates significant social impact by creating jobs, improving livelihoods, and enhancing food security. This rural livelihood income generation model stimulates rural economies and leverages technology to boost efficiency in animal production. Sheep and goat farming fosters community engagement, promoting gender inclusivity, collective action, and improved nutrition and health outcomes for rural households. By rearing sheep and goats, farmers encourage responsible land use and natural resource management, aligning with environmental sustainability goals that mitigate climate change and protect women. Overall, small ruminant production contributes to sustainable development and community engagement, making the attainment of gender equality and food security feasible.

Key Findings:

- Despite playing an important role, women in animal agriculture continue to face major obstacles in gaining access to resources, and decision-making authority.
- The traditional knowledge and methods of Indigenous cultures may greatly enhance food security and climate resilience in animal husbandry.
- Indigenous communities and women are disproportionately affected by climate change, which exacerbates already-existing vulnerabilities and disparities in animal husbandry.
- Women and indigenous groups often have limited access to technology, markets, and resources needed for climate-resilient animal husbandry.

Proposed Solutions:

- Advance gender equality and empower women by enhancing their access to resources and decision-making authority in the agricultural sector.
- Incorporate indigenous knowledge and methods into animal agriculture practices that are resilient to climate change.
- Improve the availability of technology and other essential resources for women and indigenous communities, which are vital for climate-resilient animal agriculture.
- Adoption and promotion of climate-resilient agricultural practices, such as agroforestry and conservation agriculture, to achieve sustainable and eco-friendly farming.
- Build collaborations and partnerships across various sectors to advance climate-resilient animal agriculture.
- Develop and implement strategies and programs to support gender equality, indigenous knowledge, and climate-resilient animal agriculture.

Implementation Strategies:

- Offer training and capacity-building initiatives for women and indigenous communities focused on climate-resilient animal agriculture techniques.
- Promote policies and programs that support gender equality, indigenous knowledge, and climate-resilient animal agriculture.
- Back community-driven projects that advance climate-resilient animal agriculture and gender equality.

- Engage in research and development of climate-resilient animal agriculture practices and indigenous knowledge systems.

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