Chapter

Goat - a Sustainable and Holistic Approach in Addressing Triple Challenges of Gender Inequality, Climate Change Effects, Food and Nutrition Insecurity in Rural Communities of Sub Saharan Africa

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Abstract

Goat-centered approach can transform rural agrarian households and communities toward gender inclusive climate change adaptation in agriculture to enhance food security and nutrition in Sub Saharan Africa. Gender inequality, climate change effect and food and nutrition insecurity are the most defining and deeply intertwined socio-economic and environmental challenges in rural communities in sub Saharan Africa. This chapter offers an overview of potentiality of goat rearing as a sustainable and holistic approach in addressing triple challenges of gender inequality, climate change effects and food and nutrition insecurity in rural communities. The failure to address gender inequality and deal with the climate change effect has thrown the Sub-Saharan Africa into a state of perpetual food scarcity due to compromised food production, consequently condemning the rural communities and its people to extreme poverty and nutrition insecurity. Because of this scenario, a number of both internal and external development agencies, have put several measures in place to alleviate the situation, which has for long preyed upon the region and continues to frustrate food stability in the region. The total failure of the previous autonomously attempt to address the triple challenges of gender inequality, climate change effects and food and nutrition insecurity at the household level give ground to prominence on the endorsement of more sustainable and multifaceted approaches. A proposition is made that goat rearing is one such initiative, which combines the empowerment of women in agriculture to ensure availability of the basic food needs of the household, while sustaining animal production due to goat’s adaptability to the climate induced harsh environmental conditions. The goat centered multifactorial approach to address the triple challenges is focused on the exploitation of the interlinkages among these socio-economic and environmental ills. The major assumption is that goat rearing in rural economies simultaneously curtails the risk of food and nutrition insecurity by acting as an entry point of gender equality, while leveraging on the opportunities that goat rearing will
effectively offset adversities posed by the climate change effect. In most instances, women are potentially more vulnerable compared to men as they directly experience the ponderous effects of climate change in agricultural production, in turn compromising food and nutrition security. Goat rearing is central in the removal of systemic barriers that hold women back from equal participation in agriculture, by broadening their socio-economic opportunities, hence, playing a significant role in agricultural value-chains. The goat-rearing sustainability concept is based on establishing and maintaining the circumstances under which people and nature can subsist in productive harmony, that allow fulfilling the social, economic, and other requirements of present and future generations. Despite the climate change adverse effects, the goat population has continued to proliferate in harshest agro-ecological regions, which demonstrate that goats have managed to adapt to the current unfriendly climate induced environmental conditions. It is assumed that promoting goat rearing will narrow the gender equality gap between men and women, and enhance the participation of women in agriculture, hence, improving productivity, and food and nutrition security. Goats due to their numerical population advantage and deeply embedment in rural communities have constantly contributed to rural poor resource farmers’ livelihoods in many ways, and their contributions tend to be significant. This chapter offers an overview of potentiality of goat rearing as a sustainable and holistic approach in addressing triple challenges of gender inequality, climate change effects and food insecurity in rural communities of Sub Saharan Africa.

Keywords: goat-centered approach, gender inequality, climate change, food and nutrition insecurity, rural, sub-Saharan Africa

1. Introduction

Goat-centered approach can transform rural agrarian households and communities toward gender inclusive climate change adaptation in agriculture in order to enhance food security and nutrition in Sub Saharan Africa. Goat rearing can act as a sustainable and holistic approach in addressing triple challenges of gender inequality, climate change effect and food insecurity in rural communities of Sub Saharan Africa. Gender inequality, climate change effect and food insecurity are deeply intertwined challenges and are among the most defining socio-economic, and environmental concerns in the rural communities’ livelihoods in sub Saharan Africa. Since these challenges are interdependent it is imperative that a sustainable holistic approached that integrates economic, social, and environmental variables to address them is sort.

The chapter discusses the potentiality of goat as a sustainable and holistic approach in addressing triple challenges of gender inequality, climate change predisposition and food insecurity in rural communities of Sub Saharan Africa. Agriculture (crop and livestock) is a key livelihood activity – but it is vulnerable to climate change [1]. For the past decades, global awareness on the need to adapt agricultural systems and rural resource poor livelihoods to the stressors emanating from climate change and variability has been intensified [2]. On the other hand, gender as a socio economic-cultural factor has been applied to assess the roles, responsibilities, constraints, opportunities and incentives of people involved in agriculture [3, 4]. On a similar note the awareness of integrating gender aspects in climate change action in the agricultural sector in order to enhance food security has been incredibly recognized. The disregard of gender-specific differences in adaptive and
mitigative capacity makes climate change worsen the existing gender inequalities in agriculture and beyond [5].

The question in this context is- “How do goats fit in this matrix?” Frame of reference is that goat rearing poses as an integral component of climate-smart livestock production strategy through augmenting rural communities’ resilience to climate change while improving food security and nutrition also acting as an entry point for gender equality [6]. Multifactorial role of goat “power” in sub Saharan Africa takes the form of, firstly acting as an entry point for gender equality [7] and secondly, as an agro-ecological zone-specific climate resilient thermo-tolerant animal species which capacitate them to sustain productivity [8] and enhance food and nutrition security. The inherent small size of goats is justifiable, for numerous ascribable reasons of socio-economic, managerial, biological traits, food security, socio-economic significance, survival, and advancement for productivity betterment [9].

Goats in rural areas have been deeply embedded in the socio-economic and environmental fabric apparently as a major livestock species that is incredibly rising in number which is unlikely to change significantly in the foreseeable future [9, 10]. The unquestionable potential of smallholder livestock systems to sustain livelihood to billions of rural food producers and reduce vulnerabilities in rural resource poor economies [11] render goats as an attractive option for pro-poor agricultural development agenda and enhancement of food and nutrition security. The diverse range of agro-ecological zones and management systems in sub Saharan Africa where goats are reared despite the harsh environmental induced vagaries of climate change is a testimony to their adaptability and the assumption is that they may preserve their productivity hence enhancing food and nutrition situation in rural areas. Majority of goats are kept in the rural resource poor agricultural systems and their relative distribution has been immense because of their comparative adaptive advantages over other animal species in most agro-ecological zones in sub Saharan Africa. These systems due to the effects of climate change are never static but are constantly evolving with changing internal and external climatic proponents, however despite this goat have continued to play a significant role in the food chain and overall livelihoods of rural households where they are largely the property of women and their children.

The inherent proficiency to survive, reproduce and produce of goats in the adverse climate induced conditions is ascribable to their adaptive traits, as they emerge as proffering multiple products and services, and make immense benefaction in rural economies [12]. The present chapter offers an overview of potentiality of goat rearing as a sustainable and holistic approach in addressing triple challenges of gender inequality, climate change effects and food insecurity in rural communities of Sub Saharan Africa.

2. Material and methods

To prepare this theme, a documentary research was carried out to propose a goat-centered approach as a sustainable and holistic approach in addressing triple challenges of gender inequality, climate change effects and food insecurity in rural communities of Sub Saharan Africa. The main sources of information were scientific papers, books, and statistical data from UN. This chapter covers the broader framework on interconnectedness of goat production, gender, and climate change and food security in rural economies in sub Saharan Africa. The concept is based on the realization that that multifactorial role of goat “power” in sub Saharan Africa takes the form of, firstly acting as an entry point for gender equality, and secondly, as an agro-ecological zone-specific climate resilient thermo-tolerant animal species.
which capacitate them to sustain productivity and enhance food and nutrition security in resource poor rural areas.

3. Human and goat population trends and production and their implications for rural livelihoods in sub-Saharan Africa

It was approximated that the population of Sub-Saharan Africa was 1.1 billion in 2019 [13], and this is tied to the existing growth rate of 2.3%. Two and two and half billion is the prediction for the region by 2050. This will drive the population density to 80 per square km. It should be noted that the larger proportion of population in the region dwells in the rural areas and mainly dependent of agriculture. It would be reasonably to assume that more pressure will exerted on natural resources utilization. According to [14] the projection in Sub-Saharan Africa population increment is that it will double by 2030. It would be reasonable to assume that there will be more persons to feed on the continent at that time hence there is need to strategize on enhancing food and nutrition security. The mere increase in Sub Saharan population and food provision of a growing population (more than 9 billion people by 2050), compounded by novel consumption patterns will put a burden on livestock production systems and products [15–17]. This scenario is more compelling due to the advent of climate change that would obviously reduce agricultural production in general, especially in rural areas. It has been projected that Sub Saharan Africa will outpace other regions in population growth (Figure 1) and in Figure 2 illustrates that the doubling of human population as projected will likely to pose a greater challenge in rural population that notably harbour the greater proportion of the human population in Sub-Saharan Africa [14]. On a similar note, Figure 3 shows that the human population in rural areas outpace that of urban dwellers in developing countries as a result giving pressure on natural resources.

Livestock systems as an agricultural sub sector are the major users of natural resources, this has a bearing on relationship between agriculture production and the resource use efficiency. Therefore, strengthening the role of livestock in rural areas is deemed a noble cause of sustaining the Sub Saharan rural food economies. In this respect, the socio-economic and environmental merits of livestock systems, and how they contribute significantly to the livelihoods of at least 1.3 billion people in rural areas has been focus of substantial public debate [10, 21]. The increasing disparity between population growth and food production in sub-Saharan Africa

![Population projections (1950-2100)](image)

**Figure 1.** Evolution of world human population between 1950 and 2100 [18].

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is also illustrated in Figure 4. Unless constraints to higher agricultural productivity are addressed, one-third of the population in this region will not have sufficient food by 2010. This on the background that poverty regional (Figure 5) and under-nutrition (Figure 6) are rife in Sub-Saharan Africa.

Figure 4 shows that goats’ population world over has steadily increased between 1994 to 2014 and in Figure 8 illustrates the wider proliferation of goats in all the key agro-ecological zones of Sub-Saharan Africa. Figure 8 shows that in terms of world production of share of goats by continent Africa is the second largest after Asia. This is an indication of the value of promoting goat production on the continent. Africa’s goat population increased by 75% between 1980 and immensely contributing to the livelihoods of millions of rural economies [27]. [28] approximated that the tropics and sub tropics harbor 94% of the world’s goat population. The reported
The livestock population of sub-Saharan Africa in 1999 comprised 182.1 million goats, [29] and about 64% are located in rural arid (38%) and semi-arid (26%) agro-ecological zones and that more than 90% of goats in these zones are indigenous.

All this statistic is against the background that Sub-Saharan Africa has the second largest number of poor livestock farmers and the poverty is rife on the continent as shown in Figure 5 and food insecurity and nutrition (Figure 6). In Sub-Saharan Africa, the greater proportion of the population remain undernourished, where Asia, the world’s most populous continent leads on hunger ranking, as it harbors more than 526 million people [18]. Climate variability and extreme weather events are among the key drivers of the recent rise in global hunger and one of the leading causes of other socio-economic and environmental challenges.

Figure 8 shows the adaptive potential of goats which is clarified by the diverse worldwide proliferation across all key agro-ecological zones of Sub-Saharan Africa from the tropical highlands to the humid regions and environmental interface.
Figure 9 shows that Africa harbors 33.1% of the world goat population and a greater proportion of the livestock are reared by poor farmers (Figure 10). This approximate goats comprising about 36% of the total world population of grazing animals and is a vital entry point for the development of rain-fed less-favored areas [7]. These systems due to the effects of climate change are never static but are constantly evolving with changing internal and external climatic proponents.

The poor resource farmers in sub-Saharan Africa are highly vulnerable to climatic and environmental hazards as their choices for resources diversification is limited. In some cases, vulnerability due to climate change effect has worsened due to disparities in engendered climate change impact and response knowledge in agriculture. This solicit for clear response strategies from the point of view of mitigation and adaptation in order to deal with the threats posed by climate change.
on agriculture. In this regard that’s why the proposition of goat production centered mitigation and adaptation strategy which takes into account the gender relations, but also curtailing the adverse effects of climate change variability and food security.

4. Goat rearing- a potential strategy to mitigate climate change to cushion agriculture production and enhance food and nutrition security in rural economies in sub Saharan Africa

Agriculture is the backbone of rural economies in sub Saharan Africa, and of significance is its contribution to households’ food and nutrition security. However, despite agriculture sustaining livelihoods in rural resource poor farming sectors, it is one of the most climate-sensitive activities. Hence it’s imperative that mechanisms are put in place that cushion agriculture sector to minimize the adverse impacts of climate change consequently provide food and nutrition security to the world’s growing population. At the same time agriculture must mitigate its contributions to climate change (13.5 percent of global greenhouse gas emissions) to slow the progression of this global challenge [31]. As a result, it demands mitigation strategies which are not only effective but also sustainable. It is clear now that
climate variability and change impinges on both crop and livestock productivity and livelihoods [32]. The effects of climate variability and change’s adverse influence on rural agrarian households is anticipated to continue worsening in the future. Provision of coping strategies at agrarian household in addition formulating appropriate agricultural related policies will minimize the adverse effects associated with climate change.

Climate change is debatably one of the key challenges experiencing sub-Saharan African countries, primarily as a consequence of their greater reliance on climate-sensitive sectors such as agriculture, in addition to low capacitance in adapting to the changing climate [33]. Thus, there is a growing interest in devising strategies to cope with the eminent adversities of climate change effects on agriculture systems in order not to compromise agricultural productivity and enhance food security. In this context, a proposition is made that goat production is a potential mitigation strategy to climate change effects in rural economies in sub Saharan Africa. The practicability of this undertaking is based on the fact that the socio-economic role of goat rearing has constantly increased during the last decades’ world over, especially in developing countries that are routinely exposed to climate change adverse environmental conditions [34]. On the other hand, goats have a number of other merits for being an integral part of the resource poor animal production systems because of their short gestation period, high prolificacy, rapid growth rate, high feed conversion efficiency, high diseases resistance capacity as well as easy marketability.

The impact of climate change on goat production can be assessed by taking into account the direct or indirect effects of climate change on agriculture and food security. The direct consequences of climate change on agricultural systems and food security incorporate goat’s structural, functional and feeding behavior and their interaction with environmental conditions, as well as issues such as the optimal use of feeding resources which is one of the major component that has been greatly affected by climate change. The elevation in ambient temperatures across continents due to climate change would increase vulnerability of rural agrarian household and communities due to perennial drought and food and nutrition insecurity. Figure 11 shows the world average temperatures variation from 1850 to 1900, while Figure 12 illustrates the mean temperature increment for the past
100 years in Africa. The trends give evidence of the reality of climate change which in turn has a bearing on agricultural production.

On the same token climate change’s effects on distortion on rainfall patterns consistently pose a threat to food and nutrition as it will influence agriculture production. It is common knowledge that rising temperatures, and changes in rainfall patterns have a direct effect on agricultural productivity and food and nutrition security. However, the influence of these factors will differ among various animal species, and not to mention the annual and perennial crops, and agro ecological regions of the world. The proposed goat rearing as a sustainable and holistic approach to mitigating climate change effect and gender inequality is based on the notion that goats are relatively adaptable to harshest agro ecological regions and has the advantage of numbers. Largest share of goats is reared in all the rural agrarian systems and their numerical distribution has been vast because of their comparative advantages over other animal species in most agro-ecological zones in sub Saharan Africa.

Climate change and variability is a menace to general livestock production because of its impingement on quality of feed crop and forage, water availability, animal and milk production, prevalence of livestock diseases and parasites, animal
reproduction, and biodiversity [36]. However, despite of all the aforementioned climatic change intrusions goats have emerged as an animal species of choice because their adaptation under different extreme and harsh climatic, geographical and environmental conditions [37, 38] and have performed relatively better than other domesticated ruminants. The frequent drought due to climate change, [39] Horst, (1984) noted that the recovery capacity of goats from drought is exceptional as a result of their efficient reproductive behavior and variable body size.

One of the adverse effects of climate change on livestock rearing is on grazing quality and quantity [40]. Under most rangelands where goats survive forage has diminished over the years due to adverse climatic effects, therefore feeding behavior of animals becomes critical. In this case for ruminants’ energy requirements and digestive efficiency are very vital criteria for the selection of the most fitting type of animal to be reared in particular circumstances [41]. [42] observed that goats survive in differing ecological conditions surviving on different nutritional regimes under which they were evolved and consequently sustaining their productivity. Principally, goats feeding behavior is intermediate and fixed, that favor both grazing and browsing, while on the other hand utilizing grasses in addition to shrubs [43]. In this venture goats are extremely useful and effective in combating undesirable bush encroachment [44] which may be a dominant feature in most rural and poor communities.

In a related dimension indigenous small stock, such as goats are much better adapted to local conditions than exotic stock, and require far fewer inputs for survival [45]. Of significance goats have higher capacity with reference to other farm reared ruminants to efficaciously convert poor feed resources into animal products such as milk and meat. The inherent complexity of goat structural, functional and feeding behavior advantages have capacitated them to their production under climate change induced extreme environmental conditions. Principally, the structural, functional and feeding behavior of goats plays a critical role in enhancing production, reproduction and survival in climate change induced adverse conditions.

Multiple environmental stressors are a frequent occurrence in most rural agriculture systems in sub Saharan Africa and are presumably to increase due to climate change variability which may depress agricultural productivity and food security [9]. In the ranks of climatic change stressors, heat stress emerges to be the primary component which adversely influence livestock production. In this regard goat rearing becomes vital as an agro-ecological zone-specific climate resilient thermo-tolerant species animals to sustain livestock production and enhance food security. It is not a coincidence in proliferation of about 41.5% of the goat population existing in the harsh semi-arid/arid areas in tandem with continued syndrome of poverty-adaptation-fragile livelihoods [7], this explains the ability for goats to sustain their production under climate change induced extreme environmental conditions.

The concentration of goat population in the harsh tropical and sub-tropical agro-ecological regions of the world demonstrate that they are more heat tolerant as compared to other ruminant animals’ species [46]. In most cases black goats are prone to minimize energy disbursement in winter nevertheless experience greater solar heat load in hot conditions. Therefore, there is need for breeding for lighter coats in goats for future utilization in rural communities as it seems ambient condition might progressively get hotter and drier as a consequent of climate change variability.

Goats through alteration of behavioral, morphological or physiological responds to the changing environments have managed to various agro-ecological zone. This implies that goat’s adaptation mechanisms in response to climate change are important because of the possibility of finding a solution to animal adaptability to climate change and addressing agriculture productivity and food insecurity. It
is important to note that survival of animal species in dependent on the ability to cope with or adapt to the prevailing harsh climatic induced conditions. In order to preserve animal productivity levels in an environment impaired by climate change variability, it is a prerequisite for the animals’ species to be genetically adapted and/or suitable and have the ability to survive in diversified harsh environmental conditions. However, goat is among the animal species that can adapt to environmental heat stress by virtue of a composite of physiological, morphological, behavioral, and genetic bases. The inherent physiological mechanisms capacitate goats to evolve in extreme temperatures and limited water [47] which are now features associated with climate change. Goat are capable of repress the effect of high thermal stress by stirring behavioral responses namely feeding, water intake, shade seeking, and increased frequency of drinking.

Ambient temperature is a determinant of feeding behavior of goats; hence nocturnal feeding has observed in goats enabling them sidestep high temperatures during the day. In a related study [48] observed that goats which were both heat stressed and water deprived actually preserved their milk production for 48 hours notwithstanding a 20% decrease in body weight. This observation concurred with [49] who reported that despite elevated temperatures goats never displayed physiological stress and the mean values of magnitude reported were at the level of the limits of tolerance to heat stress. This is the reason probably goats maintained the milk production.

Desert goats reared in accordance with traditional resource poor systems were watered only once every 3–6 days, when water is scarce [50] and did not show much of physiological stress. Studies water deprivation in goats and other animals’ species in harsh environments are numerous and favoring that goats more tolerant to water deprivation [51] in West Africa; [52] in East Africa; [53] in Southern Africa. Feed intake were less influenced by water deprivation in adapted pygmy goats with reference to non-adapted breeds [54]. A report from [55] explained goat tolerance to water deprivation was ascribable to their ability to limit urine and fecal water excretion in high ambient temperatures. It is important to note that drinking behavior in animals is influenced by water restriction, in this case there is a tendency of water deprivation in goats, predispose animals to drink large volumes of water in one bout upon watering, and this behavior is more distinct in goats as compared to sheep [56]. Such a physiological behavior in goats will be critical in the advent of variability in temperatures due to climate change where temperature is expected to rise. This implies in order to mitigate the effects of rise in ambient temperatures due to climate change promoting animals’ species with an efficient physiological response to heat stress will be recommended. In this case, goats are inclined to tolerate heat stress better as compared to sheep [57]. The tendency of majority of goats having loose skin and floppy ears pose them to be more heat tolerant with reference to other goats’ breeds [58].

The morphological mechanisms which goats possess in order minimize the effects of heat stress relate to their body shape and size, light hair color, lightly pigmented skin, and less subcutaneous fat, and the physiological means are that of increased respiration rate, increased sweating rate, reduced metabolic rate, and change in endocrine function [59]. The aforementioned features afford hope taking into account of uncertainties associate with climate change variability and its adverse impact on agriculture which result in compromising food security. This also emphasize the choice and use of adaptive animals’ species such as goats which preserve their production in addition to reconciliation of the ability to produce and reproduce in climatic change effect stressed environment. Hence the understanding on how to confront climatic change variability with the view of cushioning the vulnerable rural communities through sustaining agricultural production using
adaptive species is essential in order to meet the food requirements at household level. This can only be attained through promoting adapted animals where the goat emerges as an ideal candidate in this regard.

The efficient reproductive system coupled with small body size where households can easily adjust flock size to correspond to scarce feed resources and water as a result of climate change. It is important to note that it is easy to facilitate the integration or promotion of goats’ rural communities because they are already embedded in the socio-economic rural fabric and they can have reared on limited space in addition to them being popular with disadvantaged groups such as women.

Global climate change is primarily caused by greenhouse gas (GHG) emissions that result in warming of the atmosphere [60]. The livestock sector contributes 14.5% of global GHG emissions, however in ranking goat production is known for emitting relative less methane than other domestic ruminants, because within animal production, the largest emissions are from beef followed by dairy, and largely dominated by the methane produced during cattle digestion. The next largest portion of livestock greenhouse gas emissions is from methane produced during enteric fermentation in ruminants – a natural part of ruminant digestion where microbes in the first of four stomachs, the rumen, break down feed and produce methane as a by-product. The methane is released primarily through belching. The status of goat relative to global GHG emissions will relatively address the challenge to maintain a balance between productivity, household food security, and environmental preservation [61] in rural economies in sub Saharan Africa. Indirect effects consider limitations on goat production from socio-economic and environmental perspective which are mainly intended for decreasing the greenhouse gas emission effect, hence goat rearing present itself having merits for rural economies adaptation to climate change in and another way addressing the pertinent issue of food insecurity.

Arguably on the mitigation aspect, improvement of animal nutrition and genetics are essential because enteric fermentation is a major GHG emitter in livestock production. Climate models predict that without substantial reductions in GHG emissions, global temperatures will continue to increase, causing major changes in our weather patterns, environment, and way of life. Therefore, in this case selection of adaptable animal species and genetics such as goats that maximize feed efficiency, increase fertility, and improve overall flock health within the confines of adverse effects of climate change is recommended [59].

World over, considerable efforts are made by international organizations and governments to battle climate change and ensure food for the needy populations [61]. The present discussion offers an overview on the impact of climate change on the livelihoods of rural farm households and the adaption strategies used to cope with the effects of climate change in agriculture production and food security. To thoroughly explain the interlinkage between climate change and agriculture is a hypothetical matrix (Figure 11) where a notable consideration has been paid to gender dynamics and climatic change adaptation; the focus is to try and explain how gender issue and adaptation strategies are interrelated in rural households which are exposed to climate-related adversities which impinge on agriculture production and food security and nutrition. The discussion exposes visible linkage between gender relations and climate change adaptation in rural agrarian communities.

Due to gender disparities in climate change impact knowledge which favor men, women are vulnerable to the harmful effects of climate change, and this has compromised agriculture and food and nutrition security. This is because women are the major players in rural agrarian agriculture. This trend is worsened by the social norms and the customary laws which promote gender inequality in rural agrarian households. The discussion propose goat rearing has an entry point for gender
equality, while cushioning women on the vagaries of climate change on agricultural production and food and nutrition security. The discussion uses a hypothetical conceptual matrix, focusing on the inter-play between gender relations and climate change adaptation as a sub-sector of the matrix. The overview concludes that adaptive capacity can be enhanced through the advancement of gender equality and women empowerment through climate change knowledge and promoting goat rearing.

Resource poor livestock production systems due to their reliance on specific climatic conditions will in turn translate to the overall climate change effects impinging on productivity and food security. In this case, goats’ adaptive features will provide effective solutions to livestock production systems as a mitigation strategy to climate change adversity. As climate change emerge as pivotal in shaping future livestock rearing systems and their performance, this implies it will have more influence on what livestock species to raise. In this case, choice of agro-ecological zone-specific climate resilient thermo-tolerant species animals to sustain livestock production and enhance food security is imperative in sub-Saharan Africa. This is on the premise that the choice or selection of adapted livestock species to rear such goat will be part of a strategy to offset the adverse effects of climate change on livestock production at the same time preserving animal productivity which in short or long term sustain food security. This suffice to engage the idea that the development and promotion of goat rearing would be a viable option in the context of climate change mitigation where other animal species seem to be relatively vulnerable.

There is the possibility that as adverse climate effects climatic continue impinging on rural livestock production, goats rearing will assume a critical role due to their numerically strength and adaptive features such as feeding behavior, disease and heat tolerance which gives them comparative advantage on survival in harsh environmental conditions. In this regard goat due to their plethora of adaptive traits emerges as a key facet in offsetting the destabilizing proponents related to the uncertainties of climate change effects. Their ability to survive, reproduce and produce in harsh environmental conditions is sufficient evidence for its capacity for sustainable utilization in resource poor farming communities in order to preserve productivity and enhance food security in the long term. As indicated by their numerical proliferation in sub-Saharan Africa differentiated agro ecological zones, goats have proved irrefutably that there are a resilient livestock animal genetic resource that can be utilized to offset the effects of climate change and promote livestock production for increased food resources. Due waters scarcity as result of climate change goats have the capacity of walking considerable distances in search of water and forage, and make use of poor forage for their production and survival. In view of this rural resource poor entitled production systems could be only sustainable in the long run, only if adaptive animals’ genetic resources species such as goats are promoted in order to offset the adverse environmental effects and preserve their performance levels. These are inherent adaptation characteristics embedded in their genetics which implies that they are inheritable which favor the survival of goat populations in harsh environmental conditions. It is important to note that the climate resilient potential of goats is influenced by both phenotypic and genotypic characteristics and there are a number of candidate genes that are highly associated with adaptation of small ruminants to heat stress. Therefore, species and/or breed selection focus on resilience is a worthwhile tool for sustaining animal production under an increasingly challenging climate induced harsh environment [62]. Of interest is that some animal species tolerate heat better than others which may be very critical is choice of species to raise in the advent of harsh climatic conditions in rural economies. The goat is less susceptible to environmental
stress than other domesticated ruminant species [57]. Goat is a good candidate that offers a relatively sustainable alternative to other ruminants.

5. Goat rearing - a potential strategy in addressing gender inequality while sustaining animal production and enhancing food security in rural economies

Food and nutrition insecurity is a socio-economic, environmental and political subject, nevertheless, first and foremost, it is a gender issue which has resulted as a major cause and an outcome of compromised food production, food insecurity and nutrition. Closing inequality gaps between females and males in food production systems will enhance women's ability to make themselves heard and direct the course of their own lives [63]. There is overwhelming evidence that indicates a strong correlation between gender inequality, agriculture and food and nutrition insecurity [64]. Social and economic inequalities between men and women undermine food security and hold back economic growth and advances in agriculture [65]. It has been acknowledged that livestock production is one of the core sectors to address the perpetual food scarcity and to bring future food stability to sub Saharan Africa [66]. This is on the background that micro livestock such as goats has emerged as an integral livestock sub sectors, apart from its adaptability to the harsh environmental condition induced by climate change, have enormous potential for enhancing animal production consequently enhancing food security in the rural communities [67].

Goat rearing emerges as an appropriate conduit for enhancing food security and rural livelihoods, besides acting as an entry point for gender equality and the empowerment of rural women [63]. [68] supported that women play major roles in rearing sheep and goats, hence any developmental projects which ride on this will empower women in food production and nutrition. It has been noted that failure to identify agricultural sub sectors where women are effectively engaged, such as goat production has been the major reason for the unsuccessful of most of the development initiatives on food production and security in rural economies [69]. In the same study it was observed that livestock development projects fail partially because the roles of women are neglected in the planning process.

Goat is the choice of animal species that serve the purposes that are within the domain of women's participation and responsibilities, hence any goat centered approach in rural development will consequently improve the lives of women in addition to overall enhanced food production. In most cases due to expansion in human population the capacity for large ruminants' animals, for example cattle and buffaloes have decreased, in this regard shifting focus to micro livestock such as goats which are prolific and easy to manage is recommended. The inherent small size of goats is justifiable, for numerous ascribable reasons of socio-economic, managerial, biological traits, food security, socio-economic significance, survival, and advancement for productivity betterment [7]. This sanctions serious attention of goat rearing in rural communities as one of the major component of the livestock production systems where women can be empowered and improve household agriculture, food and nutrition. Goat have continued to play a significant role in the food chain and overall livelihoods of rural households where they are largely the property of women and their children [45].

Goat rearing act as an avenue to spruce women's capacity to develop as productive members of society while elevating women's economic empowerment. In this case goat rearing acts as a gender-transformative intervention which is decisive in building resilience and coping mechanisms among women and will help reduce
vulnerability and improve food security and nutrition [69]. [70] observed that reduction in the gap between men and women with respect to ownership of resources, decision making and control is necessary for attainment of food security. Women's lack of participation in agricultural activities and general engagement with in other community activity are symptomatic of the entrenched norms and broader gender inequities. The shift in policy that acknowledge women's role as a critical aspect to food production and nutrition security has resulted in increasing women's productive and economic capacity. However, there is need to further the root cause of the entrenched gender inequalities that prevent women in general from fully participation, poverty and discrimination.

Gender inequalities in rural communities are prevalent and will persist because of a range of intertwined social, economic and political factors which need to be addressed holistically. There is proliferation of engendered development studies claims about the merits of focusing agricultural investments at women, especially in sub-Saharan Africa [71]. The argument is that increasing women's empowerment will translate into overall increase in agricultural productivity hence reducing poverty and food insecurity. This notion is based on the premise that addressing food security requires more than the initiation of opportunities for community individuals to earn sustainable livelihoods, it also demand the creation of a conducive environment for men and women to acquire those opportunities.

Achieving gender equality and women's empowerment is critical to the success of addressing food insecurity. It has been authenticated that gender inequality has translated into loss of opportunities or potential gains on livestock production and food security. Goat production, as a sub sector of agriculture production help poor households to increase their food security, reduce their vulnerability and start a process that will move them out of poverty [72]. Gender-cognizant perception of food security, it has been debated that gender-blind diagnoses of the challenges of food insecurity is resulting to inadequate policy responses, which has culminated into perpetuation of food insecurity. For effective and promising strategies to address food insecurity, they need to be gender-just and environmentally sustainable in the long term.

Studies have proved that gender inequalities both inside as well as outside the household compromise not merely the capacity to produce and acquire food, for good measure the nutritional security of that food, which is so central to household welfare [73]. Gender mainstreaming in agriculture has been proposed as an indispensable strategy for attaining gender equality and food security. However, this takes into account that agricultural growth is a key pathway toward addressing development issues such as food and nutrition insecurity and poverty, which climate change is already exacerbating [74]. There is conclusive evidence that when women are granted broader opportunities to participate in agricultural activity, the benefits expand far beyond themselves as individuals but also to their families, to their communities, to societies and economies at large [65].

The development and promotion of goat production directs an ambitious path toward enhancing opportunities for women because it is critical to individual household welfare and socioeconomic development. Goat rearing as a strategy in addressing gender inequality builds on solid evidence that long standing gaps between men and women impose real and significant disparities that need to be addressed. Since goat rearing is an important agricultural activity in rural economies of Sub Saharan Africa, its development and promotion is a promising intervention that can achieve tangible, real-community results that can reorganize rural economies and positively addressing gender in equality.

There is overwhelming evidence that provision of opportunities to women to partake in agricultural related activities has positive effects to their families and
communities in the form of improved household health, nutrition and disposal income [63]. Advancing women’s participation and control over micro livestock which include goats' supported by training in husbandry and animal health in addition to increasing access to education, veterinary and financial services is essential to improving household’s food security and nutrition. Finally, the battle on gender inequality and food insecurity will be practically out of reach at minimum women be able engage in food production and earn sufficiently to guarantee their family’s livelihoods.

6. Interconnectedness matrix- goat production, gender, climate change & food security in rural economies in sub Saharan Africa

Figure 13 models the interconnectedness of goat production to gender, climate change & food security in rural economies in sub Saharan Africa. Responses to climate change tend to focus on scientific and economic solutions disregarding addressing the critical importance human and gender dimensions. Gender relations are still largely absent from debates on climate change and animal production related issues. Generally, all inequalities are many a time contribute to environmental change, and transforming them is therefore an indispensable proponent of a more effective and sustainable strategy to building resilience. This implies addressing gender differentiation in livestock production and disparities in climate change impact and response knowledge will facilitate a sustainable community resilience.

This sustainable and broad based approach matrix of gender, climate and food and nutrition security takes cognizance of the complexity of social, economic and ecological aspects of rural agrarian communities through adequately and acknowledging the interrelationship of these factors. This understanding has a provision

![Figure 13](image_url)

*Goat, gender, climate change and Food & Nutrition Security Matrix. Source: Author.*
of development of gender sensitive goat production policies that fit in with the complex livestock livelihood strategies especially for the resource poor livestock keepers’ household. The matrix attempt to apply a gender perspective for understanding how goat production can be a pathway to food security possible through scrutiny of other elements such as climate change and its impact on food security. The matrix is being modeled to explore different aspects of goat production, such as goat adaptability to adverse climatic condition and less exposure of goats’ parasites and which makes goats an appropriate candidate for climate change mitigation strategy.

The two assumed goat production pathways out of food insecurity, gender inequality and enhancing food security are: (i) Understanding disparities in livestock resource allocation and equal participation of men and women in goat productivity to address gender inequality and enhance food security. (ii) Manipulation of engendered impact and response knowledge to reduce community vulnerability to climate change effects hence increasing and sustain goat productivity to address food insecurity and address gender inequality. A general phenomenon is for men to own large livestock and particularly, work animals, while women own micro livestock.

Strategies meant to enhance women’s access to, and control over, agricultural resources or other assets have resulted in enhancement of food security, as well as the wellbeing of women themselves [67, 70, 75]. By virtue of collection of agricultural resources supports arguments for a gender dimension in livestock development in order for it to be really sustainable which result in improved livestock productivity and food security. Men and women often manage different types of animals and are responsible for different aspects of animal care. Given women’s traditional responsibility for household food security, their level of control over decisions about whether to sell or consume the family’s animal products, as well as over how to use any income obtained from the sale of animal foods, could greatly determine the nutritional wellbeing of household members.

For each pathway, findings are organized around key questions on the role of women and lessons about interventions targeting women. Assembling this information is a first step toward identifying some of the main gaps in our evidence base as well as some of the kinds of research and development interventions, made in which species and value chains, that are most likely to benefit poor women and their families. Women play an important role in livestock management, processing and marketing, acting as care providers, feed gatherers, and birth attendants. Despite their considerable involvement and contribution, women’s role in livestock production has often been underestimated, if not ignored.

There is a potential effects of goat centered approach in transforming rural farm households toward gender inclusive climate change adaptation in order to enhance food security and nutrition in Sub Saharan Africa. As regards the matrix (Figure 11) the dependent factors of gender, climate change and food security are deeply intertwined hence placing goat production as a redress factor the matrix becomes an engendered livestock-based food security model that takes into account the adverse effects of climate change. The matrix is a departure from previous numerous hypothesized discussions which have focused on addressing gender inequality, food insecurity and climate change adversity variables as isolated entities. This has posed challenges because these aspects of the socio economic and environmental nature of communities are interdependent hence the need to establish a holistic approach in addressing these adversities. The matrix [Figure] is based on the understanding that goat rearing in rural economies will simultaneously curtail the risks of food insecurity and gender inequality and capitalizing on the opportunities to offset adversities posed by climate change.
Gender differential in livestock production and disparities in climate change impact knowledge and response are the underlying root cause of vulnerability and food insecurity rural communities in sub-Saharan Africa. Agriculture is a key livelihood activity—but it is vulnerable to climate change [1]. There is overwhelming documentation that climate change is having serious adverse impact on agricultural production and the livelihoods of millions of farmers which has changed the rural people life style across the world [76]. For the past decades, global awareness on the need to adapt agricultural systems and rural resource poor livelihoods to the stressors emanating from climate change and variability has been intensified. In tandem with this awareness the importance of integrating gender aspects in climate change action in the agricultural sector has been incredibly recognized. Therefore, this suggest climate change discussion should afford adequate attention to gender differentiated roles and vulnerability, in view of the fact that the impact of climate change has differentiated implications upon men and women. [77] reported that women and men experience climate change impacts differently due to their socially constructed roles and responsibilities. Hence it is imperative in designing interventions that guarantee cushioning both men and women from the vagaries of climate change to take cognizance of gender roles. This is based on the understanding that both men and women have a critical function to play in agriculture, hence acknowledging gender distinction facilitate appropriate targeted interventions that offset vulnerability to climate change and contribute to gender equality and food security [76].

Assessment of adaptation, vulnerability and resilience of communities against climate change and variability in rural communities can be applied using gender as a socio-economic variable [78]. In most cases there is a missing link to scientific assessment of climate change impact through a gender integration approach in order to effectively mitigate and adapt to its impact. A consequential consideration of gender dimension of assessment of climate change impact in agriculture intervention strategies is anticipated to culminate into effective interventions assisting both men and women to deal with the impacts of climate change and bring about resilient and comprehensive food security systems. Both men and women can only play an important role as effective agents of change with reference to climate change mitigation and adaptation if only there is equal access of information on climate change response. This is because both men and women are not only vulnerable to climate change but they are also actors in climate change mitigation and adaptation. This implies that climate change response knowledge empowerment of men and women can effectively advance sustainable agricultural production in rural communities as a result offsetting the impact of climate change and enhancing food security. Provision of men and women with extensive theoretical and practical knowledge of climate change effect on agriculture should be given high regards. Broadening their role as agents of change in climate mitigation should be an integral part of the intervention strategy and this aspect need to be sufficiently exploited. However, the impact and response knowledge should be accurate and available to general populace to accommodate the anticipated changes.

Climate change is recognized as a global crisis, but responses tend to focus on scientific and economic solutions rather than addressing the vitally significant human and gender dimensions. Because of gendered social roles, women are in the front line of climate change impacts, such as droughts, floods and other extreme weather events—yet they are the least responsible for environmental destruction. How then do we move toward more people-centred, gender-aware climate change policies and processes? How do we both respond to the different needs and concerns of women and men and challenge the gender inequalities that mean women are more likely to lose out than men in the face of climate change? The matrix helps to
intervention points through engendered climate change and food security perspec-
tive address the wider issues of voice, representation and participation in general
livestock production and decision making in rural communities.

The three pillars of this matrix is enshrine based on the acknowledgement of
social, environment and economic dimensions that influence rural communities
which are very critical in discussions of gender inequality, food insecurity and
climate change vulnerability. The triple challenges are seemingly posing high social,
environment and economic costs and leading to immense food insecurity in rural
economies. The adoption of a goat-centered approach is based on the assumption
that goat production is a predominant agricultural activity for livelihoods of rural
communities in sub Saharan Africa. The matrix give avenue for pairwise analysis
between subsectors such as gender and climate, gender and food security and
climate change and food security. Therefore, it is imperative that the explicit atten-
tion must be given to relationship between gender and food security, gender and
climate change and climate change and food security and how these dovetail with
goat production. An attempt to proffer a holistic approach that integrates scientific,
technical, and economics of goat production aspects with social and human dimen-
sions for their livelihoods is the major aim of this matrix.

Goats are deeply embedded in almost every sub Saharan African rural econo-
mies and is a major agriculture sub sector for most resource poor farmers which can
be exploited in addressing the triple frontier of gender inequality, food insecurity
and climate change adversity. However, it is important to note that the holistic
perspective on gender inequality, food insecurity and climate change adversity are
some of the most difficult issues to write about because of their direct and indirect
connectedness. The matrix attempt to illustrate this phenomenon of interconnec-
tion of gender, climate change and food security. Literature courageously broaches
the issues in its discussion about possible ways in which to sustainably address gen-
der inequality, climate change menace and food insecurity in rural economies, with
a diversity of approach which might pose challenges in rural communities set up.

The numerical status of goat species and composition in rural communities
are critical to acknowledging the trends in livestock ownership in rural economies
and their impact on the vulnerability of resource poor household to climate change
hence food security. Although this matrix has holistic approach is more difficult to
achieve due to a variety of factors which need to be taken into accounts. However,
it is imperative to improving our understanding of how the interaction of gender,
climate variability and change affects and food security, particularly in resource
poor rural communities is critical or relevant to decision making on appropriate
interventions for the wellbeing of individual households and communities at large.
Therefore, it is important to understand pairwise relationships of different compo-
nents of the framework. The understanding of gender differentiation in livestock
production and disparities in climate change impart and response knowledge, will
lead to more complete understanding the influence gender differentials in livestock
production and disparities in climate change impart and response knowledge their
implications for gender inequality, food insecurity and climate change adversity.

7. Conclusion

Goat-centered approach can transform rural agrarian households and com-
munities toward gender inclusive climate change adaptation in agriculture in order
to enhance food security and nutrition in sub Saharan Africa. Gender inequality
and climate change effect are compounding socio-economic and environmental
determinants which grossly compromise the stability of food production and food
and nutrition security. Gender, climate change, agriculture and food security are interrelated and their dynamics are heterogeneous, complex and rooted in social, economic, and institutional factors. The proposition in this chapter is that goat rearing can be a sustainable and holistic approach in addressing the triple challenges of gender inequality, climate change predisposition, and food and nutrition insecurity in rural communities of sub Saharan Africa. This is grounded on the fact that goat rearing is an embedded integral component of climate-smart livestock production strategy to increase rural agrarian resilience to climate change while improving food security and promoting gender equality. Apart from goat acting as an entry point for gender equality, it has become usable agro-ecological zone-specific climate resilient thermo-tolerant animal species to sustain livestock production and enhance food and nutrition security. It is hypothesised that livestock production's susceptibility to the vagaries of climate change can be mitigated by promoting adapted livestock species such as goats which possesses the ample degree of adaptation traits in terms of physiological, functional and adaptive feeding behavior. This is on the premise that climate change induced variables continuously impinge on livestock productivity which in most cases is the major cause of food and nutrition insecurity in rural agrarian households. Over the decades, goats have inherently acquired distinctive diverse physiological, morphological, and reproductive attributes which comparatively advance their survival and proliferation in unfavorable harsh heterogeneous agro ecological niches of sub Saharan Africa. In this regard goat due to their plethora of adaptive traits emerges as a key facet in offsetting the destabilizing proponents related to the uncertainties of climate change effects, in addition to goats being a women's animal. However, there is need to put mechanisms to develop and promote viability of goat production through various operational and institutional strategies. The challenge is most sub Saharan African countries do not provide adequate policy and priority to acknowledge and maximize potential of goat productivity in rural communities. In conclusion it very disheartening, there is still a significant proportion of prejudice and ignorance persisting of the critical socio-economic and environmental role of goats to farmers, despite the overwhelming evidence targeting the resource poor rural communities in sub Saharan Africa.

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