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Review article

Indigenous livestock and poultry rearing for improved resilience and rural household welfare and livelihood outcomes under climate risks in Sub-Saharan Africa

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ABSTRACT

Sub-Saharan Africa is endowed with diverse and locally adapted indigenous livestock and poultry breeds/varieties that have continued to sustain production in rural areas, despite the climate change induced harsh and extreme environment associated with diseases and parasite infections, heat stress and installments of feed and water scarcity. The indigenous livestock and poultry genetic resources are critical to the rural communities' welfare and livelihoods, food security and nutritional status, and other socio-economic environmental benefits. This scenario is on the background that the larger proportion of the Sub-Saharan Africa population resides in rural areas and are mainly dependent on agriculture for their livelihood, especially the reliant on indigenous livestock and poultry populations. Now, the major challenge is that this subsector is highly vulnerable to climate change that has impinged on their ability to sustain their productivity in rural areas. In this case, rural communities should adopt coping strategies to arrest the vulnerability of animal agriculture to avoid food and nutrition deficit at the household level. Climate change impact on indigenous livestock and poultry rearing among rural resource-poor farmers will take different forms that include unsettled rainfall onset and stoppage (which are each either early or late), poor seasonal distribution of rainfall, and less than normal rainfall. Trends in temperature and rainfall have displayed an increase in average

maximum temperatures, at the same time average annual rainfall showed a general decline in most cases, which has impacted negatively on grazing or indigenous livestock and poultry feed resources. Drought is a perennial feature associated with climate change, and increasing indigenous livestock and poultry disease and parasite incidences, dwindling water sources, which result in lack of flourishing grazing and livestock pastures are the major climate-related risks that hurt smallholder indigenous livestock and poultry production. Considering all these interrelated issues, an urgent arise for fostering adaptive capacity and resilience to climate change-related risks as a viable option to enable them to protect their livelihoods and ensuring their food and nutrition security. The resource poor rural dwellers have not been passive observers in combating the effects of climate change as they have adopted several local coping strategies seeking to sustain indigenous livestock and poultry production through building resilience in the indigenous and poultry rearing systems. The adopted different forms of coping strategies include promoting native animal genetic resources, diversification, crop-livestock integration, and micro-livestock farming and fodder conservation technologies. Diversification of indigenous livestock and poultry portfolios is a feasible option in fostering resilience to climate risks and thus improving the well-being outcomes of smallholder animal agriculture. The ability to cope with the impact of climate change depends largely on household's resilience, or its capacity to absorb the impact of and recover from, climate change shock or risks. Therefore, there is a need to develop resilient indigenous livestock and poultry production systems in smallholder resource-poor rural areas. Developing resilient and diverse breeds, climate-smart livestock and poultry husbandry practices and policy support programs are the potential areas for strengthening resilience livestock and poultry rearing for resource-poor rural farmers in Sub-Saharan Africa. With the advent of climate change, there is a concern on how to manage the indigenous livestock and poultry sector's growth, so that their socio-economic and environmental benefits can be attained at a lower environmental cost. This present discussion examines climate change risks and coping strategies at the household level in livestock and poultry rearing among rural resource-poor farmers in Sub Saharan Africa.

1. Introduction

Climate change as of now has, and will further, lead to environmental disruptions that increase the vulnerability of resource poor rural indigenous livestock and poultry rearing systems of Sub-Saharan Africa. More changes are anticipated to present themselves in rural resource-poor of the region than anywhere else and risk aversion is urgent. The climate change-related risks pose socio-economic and environmental challenges to rural resource-poor communities that depend on agriculture for their livelihood. Forty to 60% of Sub-Saharan Africa's population live in rural areas where agriculture predicates the livelihood of two-thirds of this poor rural population (HLPE, 2016). Approximately 70 percent or 150 million of the rural poor depend on livestock (LID, 1999) and poultry to sustain their livelihood. Most livestock and poultry populations in rural areas are of the indigenous or

native type, however, due to the observed and projected climate change effect and variability, within and across the region indigenous livestock and poultry rearing are now highly likely to be vulnerable (Lobell et al., 2008). The development of resilient indigenous livestock and poultry rearing systems is essential in resource poor rural communities that largely depend on the proffering ecosystem services of such systems (food and nutrition, ruminant grazing and fodder, livestock and poultry watering) for their livelihoods (Altieri, 1999). Rural communities are agrarian based economies, hence, have limited other livelihood strategies (Tilman et al., 2002) that make the system highly vulnerable to climate change. The exposure to vulnerability is precarious in rural communities because communities lack adequate resources to invest in expensive coping strategies, hence increases the vulnerability of agrarian based economies to a changing environment. Thorton et al. (2014) noted that with altered weather patterns and climatic components, there is disease and parasite build up. The rise in temperature and variability of climate patterns directly or indirectly expose livestock and poultry to pathogens, while increasing the prevalence of disease and parasites (Nardone et al., 2010). These conditions have forced resource-poor rural farmers in Sub-Saharan Africa to contend with a panoramic range of climate change risks that have adversely affected indigenous livestock and poultry production. Climate affiliated risks such as protracted dry seasons are seemly more frequent and intense with negative impacts on indigenous livestock grazing and poultry feeding and the resultant livestock and poultry performance. The climate change consequently impairs indigenous livestock and poultry productivity in the smallholder rural household entities. For that matter implementation of coping strategies to maintain current indigenous livestock and poultry productivity and to achieve production and food and nutrition security to meet rural community food demand is recommended. The goat production is a feasible climate smart micro-livestock venture and resilient livelihood strategy for resource poor rural farmers (Assan, 2014). Resilience-thinking focuses on reducing risks by increasing the adaptive capacity of the rural population and the livestock and poultry ecosystems on which they depend. Resource-poor farmers should meet their household food and nutrition is critical while coping with uncertainty of climate change (Adger, 2003). The indigenous livestock and poultry production are intricately linked to climate and thus endure the effect of climate change. The rise in ambient temperature and changes in rainfall patterns, as well as increasing seasonal livestock and poultry feed scarcity and livestock-watering challenges will adversely affect indigenous and poultry population. Climate change's negative impacts are being imposed, in the form of increasing temperatures, weather variability, shifting the agro-ecosystem limitation the prevalence of novel parasites and diseases, and more frequent extreme weather events. The major concern is on how to manage the indigenous livestock and poultry sector, so that their socio-economic and environmental benefits can be attained at a lower environmental cost. Diversification of indigenous livestock and poultry portfolios is a feasible option in fostering resilience to climate risks and thus improve the well-being outcomes of smallholder animal agriculture. This review examines climate change risks and traditional coping strategies at the household level in livestock and poultry rearing among rural resource-poor farmers in Sub Saharan Africa.

2. Relationship between climate change risks, rural farmers coping strategies and resilient indigenous livestock and poultry rearing systems

Indigenous livestock and poultry play a critical role in supporting rural households' livelihoods in most of Sub-Saharan Africa. They are key endowment that helps agrarian rural economy manage climate change shocks and stressors, especially in poor rural communities. Rural populace has put in place mechanisms to building resilience in indigenous livestock and poultry systems as a means for minimising vulnerability to climate change shocks while sustaining production at the household level. Resilience in agriculture systems is now widely used as a development framework (Frija et al., 2018) and rural farmers use a combination of coping strategies to address this issue. Figure 1 is a conceptual framework that gives an intricate relationship between climate change risks, rural farmers coping strategies and promotion of resilient indigenous livestock and poultry rearing systems. The conceptual framework illustrates how the effects of climate change on indigenous livestock and poultry production systems in rural areas impinge on the socio-economic and environmental household benefits. The indigenous livestock and poultry breeds/varieties play a significant role in rural livelihoods and economies of Sub-Saharan Africa. They are an integral part of the smallholder agricultural system providing a plethora of socio-economic and environmental benefits and alternatively act as providers of household income and employment apart from providing an important source of nourishment for billions of rural in Sub-Saharan Africa. On the other hand, indigenous livestock and poultry are a crucial asset and safety net for the poor, especially for women and children

and other disadvantaged groups. These socio-economic roles and others are becoming critical considering projected increasing human populations in rural Sub-Saharan African region.

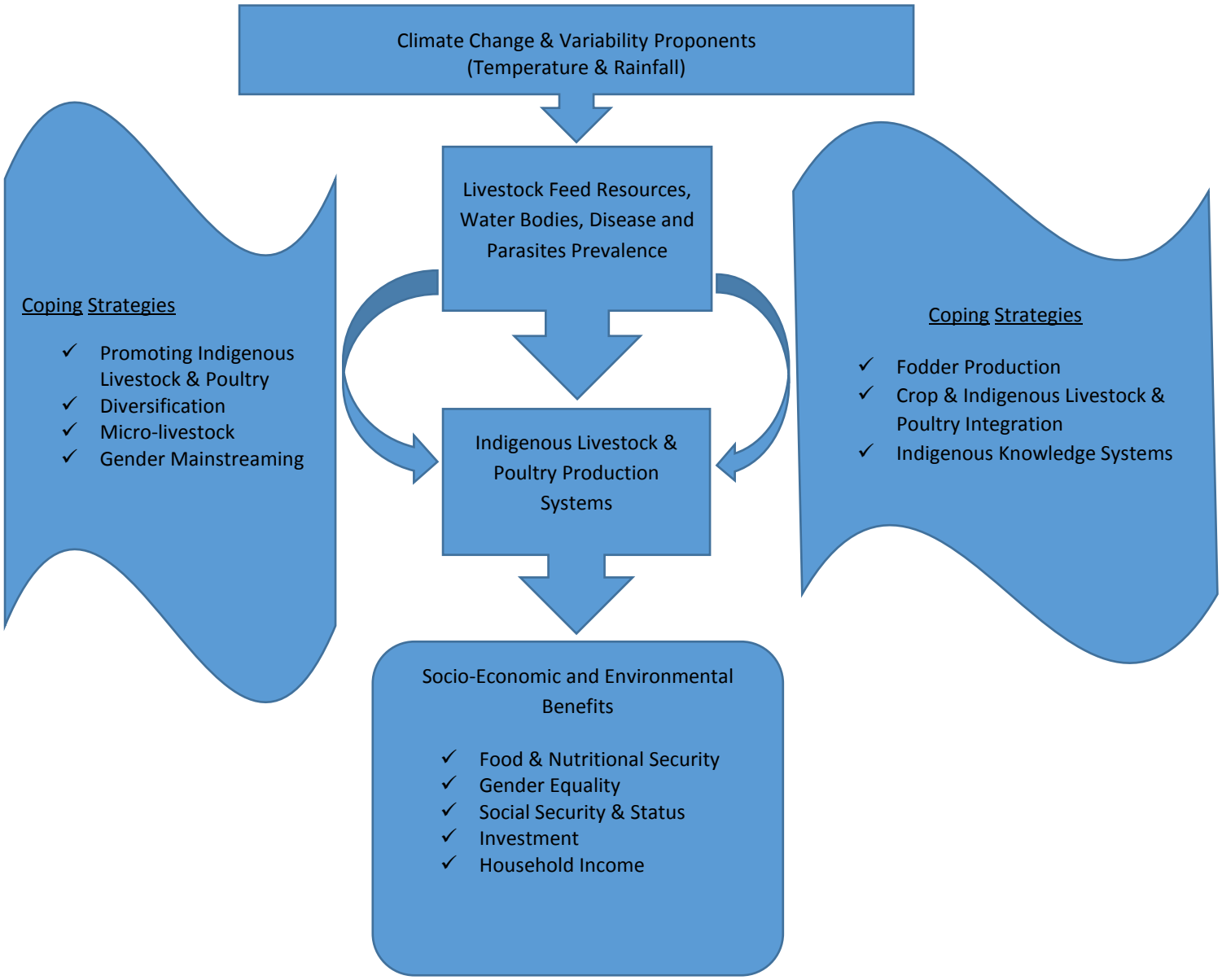

Fig. 1. Conceptual framework: The relationship between climate change risks, coping strategies and resilient indigenous livestock and poultry rearing systems (Source: Author).

To provide these benefits, the sector uses a significant amount of land, water, biomass and other resources, which makes it vulnerable to climate change. With the advent of climate change, there is concern on how to manage the indigenous livestock and poultry sector's growth, so that their socio-economic and environmental benefits can be sustained at a lower environmental cost in addition to contributing resilience to agriculture production systems. The lack of resilience in agro-based systems in rural areas will undermine the provision of food security and nutrition in addition to the many other services required to sustain rural communities and their ecosystems as a whole. However, the major challenge that befalls indigenous livestock and poultry rearing system to continue sustaining rural livelihoods is both directly and indirectly effect of climate change that has lowered performance of indigenous livestock and poultry. The direct form of climate change effects varies from ambient temperature, humidity, wind speed and other climate factors, and these influence indigenous livestock and poultry

reproduction and animal performance in general. With respect to indigenous livestock and poultry feed resources, climate change influences the quantity and quality of pasture, forage and grain, and the prevalence and distribution of indigenous livestock and poultry diseases and parasites. Changes in rainfall patterns will increase vector-borne indigenous livestock and poultry climate-sensitive diseases and parasites. The direct effects of climate change result into the accelerated spread of prevailing vector-borne diseases and parasites, coupled by the emergence and spread of novel diseases. The impacts of climate change also depend on rainfall, which affects grassland productivity, ultimately affecting indigenous ruminant livestock such as goats, sheep and cattle. Erratic rainfall results in reduced quality and quantity of natural grazing for most indigenous livestock. Climate-smart indigenous livestock and poultry systems (ICSLPS) are an approach that helps drive the actions needed to transform and reorient subsistence livestock and poultry production systems to effectively support animal product supply side development and ensure food and nutrition security in a changing climate. ICSLPS is compatible with the focus to make indigenous livestock and poultry more productive and more sustainable, and to build resilience in subsistence system to curtail climate change effects. ICSLPS approach is sustained through coping strategies employed to ensure promote indigenous livestock and poultry production, hence, ensuring food security and nutrition safety net for vulnerable rural populations. Climate change and its consequences have become highly visible affecting smallholder subsistence livestock and poultry, through its influence on rangelands and water resources (CBS, 2016). Despite the indigenous livestock and poultry production systems playing an important role in the livelihoods of many rural resource-poor farmers in Sub-Saharan Africa, the systems have not been spared from the impacts of climate change. The relationship between disease, parasites, water, feed, livestock and climate is as important as it is complex. While climate change chain reactions are anticipated to be indiscriminate and ubiquitous, it is the predetermined course of water and livestock feed resources that deserves the highest consideration, as the opulence of subsistence indigenous livestock and poultry production hangs in the balance**.** Climate change affects indigenous livestock and poultry production in smallholder-farming sector in multiple forms. Changes in ambient temperature and rainfall patterns along with weather and climate extremes are ever-impacting livestock and poultry productivity in smallholder livestock farming. Weather and climate circumstances are also determinants of the accessibility of water needed for livestock-watering practices. Climate change is anticipated to cut down indigenous livestock and poultry productivity in smallholder livestock farming sector. The number of extreme events negatively affecting livestock production is expected to increase**.** Climate change's negative impacts are being imposed, in the form of increasing temperatures, weather variability, shifting agro-ecosystem limitation, prevalence of novel parasites and diseases, and more frequent extreme weather events. The impact of climate change and variability on indigenous livestock and poultry entities is indicated by impinging on productivity through negatively influencing reproduction and animal performance. Coping strategies mechanisms will be required to maintain indigenous livestock and poultry productivity to meet the rural community food and nutritional demand. The resilience in rural animal agriculture systems is the basis of the ability of indigenous livestock and poultry to access water, feed resources and climate change diminution, and eventually affording the socio-economic and environmental livestock and poultry benefits to the rural resource poor households (Fig. 1). The direct and indirect action of climate change will influence indigenous livestock and poultry production. Among the imminent effects of climate change, the wide range is its impact on water resources, which is the basis of sustainable indigenous livestock and poultry rearing. Schilling et al. (2012) in their studies of water bodies, suggested that livestock watering will become limited because of prolonged drought due to climate change. Consequently, rural farmers are to shift to rearing smaller livestock such as goats and sheep instead of cattle as a coping strategy. Apart from the erratic rainfall pattern influencing water resources in general, it will also adversely influence the seasonal availability of grazing livestock. Climate change will disrupt the hydrological cycle; hence**,** affecting livestock watering and performance. The elevated temperature associated with climate change and variability will increase the surface water evaporation and a possible change in the patterns and intensity of rainfall that will indirectly influence indigenous and poultry rearing in rural areas. Much of the impact of climate change will be in the form of changing patterns of water availability, as a result of changing patterns of rainfall increasing the likelihood of drought and scarcity of indigenous livestock and poultry feed resources. Direct effects of changing temperatures, humidity and other factors influence general livestock and poultry performance and reproduction (Rust and Rust, 2013). An important effect of climate change, which is although indirect is scarcity of livestock and poultry feed resources. Freier et al. (2012) observed that due to climate change rangelands are prone to degradation and the constitution of forage, or grass species available to livestock will vary. It is common knowledge that indigenous livestock and poultry production can be destabilised by climate change and events such

as an increase in disease and parasite prevalence or outbreaks. The loss of livestock and poultry assets due to disease and parasite outbreaks means a perpetuation of food and nutrition insecurity, which has long-term effects on rural communities' livelihoods. Diversification of indigenous livestock and poultry portfolios is feasible option in fostering resilience to climate risks and thus improve the well-being outcomes of smallholder animal agriculture. To cope with the effects of building greater local resilience into indigenous livestock and poultry production and food systems in resource poor rural communities, smallholder farmers have adopted specific technologies and livestock and poultry husbandry practices as coping strategies at the household level. These coping strategies are targeted at minimising the adverse effect of climate change on indigenous livestock and poultry production in turn securing food and nutrition security. The focus is on climate-smart indigenous livestock and poultry production that take the form of aggregated approach to managing animal nutrition, breeding, and general animal husbandry practices that address the interlinked challenges of livestock and poultry production in turn diminishing the effect of climate change. With signs of climate change being evident everywhere in Sub-Saharan Africa, use and conservation of livestock and poultry that are hardy and better suited to defy high temperatures should be considered. To increase resilience in smallholder animal agriculture and sustain rural livelihoods it is critical to identify livestock and poultry breeds that are climate resilient. Success in building climate change resilience for local livestock and poultry production sectors can only be achieved through promoting indigenous animal genetic resources. Indigenous livestock and poultry husbandry practices and other appropriate technologies play a key role as coping strategies in adapting to climate change and variability. The continued reliance on smallholder indigenous livestock and poultry farming system over the decades, despite multiple exposures to climate change menace, implies a capacity to respond or adapt by the rural agrarian system. With the advent of climate change, there is concern on how to develop resilience in the indigenous livestock and poultry rural farming sector, so that their socio-economic and environmental benefits can be attained at a lower environmental cost and minimizing the effects of climate change. Indigenous livestock and poultry species, which are hardy rather than exotic species should receive far more support for sustainable smallholder livestock and poultry production purposes for agrarian rural population. However, the projected severity of climate change impacts on indigenous livestock and poultry breeds/varieties seems to be overwhelming the local coping mechanisms hence there is need to co-develop resilient smallholder livestock and poultry system with assistance from agriculture policy makers in anticipation of the looming food security challenges in the midst of climate change adverse impact on agriculture. Research into perennial resilient fodder varieties meant for rural setup must be given priority by government institution that should be dramatically enhances It is imperative that national government carries out action research and policy advocacy to support the development of more sustainable, resilient and locally controlled livestock and poultry systems that can withstand climatic and economic shocks. National policies on climate change as it relates to livestock production should focus on creating awareness as well as increasing access to extension services among livestock farmers on climate risk and risk-coping strategies to mitigate the impact on smallholder livestock producers. Diversification of indigenous livestock and poultry portfolios is feasible option in fostering resilience to climate risks and thus improve the well-being outcomes of smallholder animal agriculture. From the discussion can conclude that smallholder livestock producers in Sub-Saharan Africa have not been passive in dealing with the effect of climate change on livestock production. To some extend have devised strategies, which cushion them from the adverse effects of climate change on their livestock. However, there is need to support the smallholder livestock communities in their quest to effectively deal with the adverse effects of climate change in their communities. Applied holistic policy approaches that promote the widespread adoption of appropriate climate smart technologies in livestock and poultry production are recommended.

3. Imparting resilience in smallholder agro-based economies through the promotion of indigenous livestock and poultry

Sub-Saharan Africa is abundantly endowed with huge animal genetic diversity of indigenous livestock and poultry genetic resources. Food production systems and livelihoods of resource poor rural farmers in Sub-Saharan Africa depend heavily on the use of locally adapted indigenous livestock and poultry populations. This unique animal genetic resource plays a significant socio-economic and environmental role as it imposes a huge influence on the survival and livelihood of rural resource-poor farmers. Indigenous livestock and poultry remain an integral part of rural agrarian farming systems in Sub-Saharan Africa. Often a symbol of social status and wealth in traditional farming systems, indigenous livestock and poultry ensures improved food and nutritional diversity and

security in addition to other socio-economic benefits for smallholder farmers. Each country or regional block in Sub-Saharan Africa has native or indigenous livestock and/or poultry breeds or varieties with distinct characteristics suited to local conditions. Here, there is an urgent need for smallholder farmers to devise mechanisms to build greater local resilience into indigenous livestock and poultry production and food systems to sustain production from the usage of indigenous animal genetic resources. Indigenous livestock and poultry breed and/or varieties are indispensable to rural small-holder farmers being easier to acquire and are looked after under free range system. Climate-smart livestock and poultry production enhanced resilience of indigenous livestock and poultry production systems through the implementation of coping strategies that reduce livestock and poultry vulnerability to drought, parasites, diseases, and other climate-related risks and shocks; and improve the capacity to adapt and sustain production when faced with longer-term stresses like scarce water resources and diminished livestock and poultry feed resources. These Indigenous animal genetic resources have withstood multiple generations of adaptation and genetic isolation that have led to great phenotypic variation and unique attributes ideal for sustain production in resource poor smallholder farming sector. It is true to assume that the native livestock and poultry populations act as genetic reservoir for the identification of genes important to environmental adaptation, disease resistance, and improved productivity under resource poor rural conditions. This implies that for any future sustainable development purpose in rural communities the characterization of native livestock and poultry populations should be prioritized. The advent of genomics will be a vital tool to prioritize conservation and production efforts native livestock and poultry populations and use in selective breeding programs. There is consensus within research and developmental agenda that maintenance and promotion of indigenous livestock and poultry will sustain rural livelihoods in resource poor farming communities in Sub-Saharan Africa (Assan, 2015). The call has been intensified taking into account the advent of climate change effects which are increasingly evident across the region. Ngigi et al. (2020) studying the role of livestock diversification in climate change risks management at rural household level, observed that climatic shocks are less likely to affect small ruminant and non-ruminant animals. Sub-Saharan Africa is abundantly endowed with huge animal genetic diversity of indigenous livestock and poultry genetic resources. These have proven to be sustain production due to adaptation to prevailing unfriendly production conditions as a result of climate change. It is now common knowledge that the resource-poor smallholder livestock and poultry systems are constant dependent on these indigenous domestic animal genetic resources that have demonstrated beyond doubt their resilience to adverse climate change induced conditions. Therefore, any attempt to replace indigenous animal genetic resources with exotic breeds in smallholder sector will destabilize the animal agriculture fabric consequently weighing heavily on rural poor community livelihood and survival. This on the background that climate change and variability is becoming more and more evident across Sub-Saharan Africa, hence the conservation and utilization of indigenous animal genetic resources that are hardy and better suited to defy high temperatures and feed scarcity should gain attention. Indigenous livestock and poultry breeds/varieties have a huge genetic diversity that has made them more resilient to bio-environmental menaces like parasites and disease, and elevated ambient temperatures and water scarcity.

Indigenous livestock and poultry possess several unique adaptive animal attributes that make them ideal for enhanced rural household food and nutrition security in Sub-Saharan Africa. The characterization of indigenous livestock and poultry genetic resources with the goal of increasing their contribution to the welfare and livelihoods of the rural resource-poor need to be given priority. Indigenous livestock and poultry possess adaptive characteristics that have made them sustain production in harsh environmental conditions in rural areas. These attributes include but are not limited to the ability to survive feed scarcity and to use traditionally available feed resources; the ability to withstand temperature extremes; resilience to gastro-intestinal parasites; tolerance ecto-parasites and their diseases; excellent fertility and the ability to withstand water deprivation while sustaining performance. Due to the organic form of production systems in rural areas Indigenous livestock and poultry have preferred excellent meat and milk quality. The shortage of feed in rural areas has indigenous livestock has developed superior grazing habits, which is an important characteristic for survival in limited rangeland feed resources. Their contribution to cultural and aesthetic value has not been questioned. The thorough knowledge on the production of indigenous livestock and poultry optimally enables use of this animal genetic group in rural smallholder-farming sector. The loss of this unique animal genetic resources spells doom for the resource poor rural communities, hence the need to promote their use in rural communities in order not to destabilise the food situation and household welfare. In the advent of genome science indigenous livestock and poultry can be characterized to conserve them, but at the same time to exploit them to sustain livelihoods in rural communities.

The focus of future rural animal agriculture resilience is to promote indigenous livestock and poultry to adapt to varied environments. The indigenous livestock and poultry have proved to match themselves with an environment that has sustained growth performance and production of these animals. Climate change will adversely affect agricultural production in developing countries particularly in the rural areas due to their lack of adaptive capacity. Therefore, there is a need to build climate change resilience for indigenous livestock and poultry rearing among vulnerable rural populations in Sub-Saharan Africa. Attention has focused on indigenous livestock and poultry production systems as rural resource poor indigenous livestock and poultry are considered among the most vulnerable populations in Sub-Saharan Africa. Indigenous livestock and poultry have a potential to strengthen resilience to climate change in rural areas, as these tend to be more adaptive than imported animal genetic resources. The use of indigenous livestock and poultry has been a dimension frequently ignored as climate change adaptation strategy that has a potential to strengthen resilience to climate change in rural areas. It explicitly stresses the resilience of livestock production systems to drought and the associated potential to use indigenous livestock and poultry to adapt to climate change. The matrix (Fig 1) dissects the various aspects of climate change and their impacts on the socio-economic and environmental aspects of the indigenous livestock and poultry rearing systems. In doing so, it appropriately stresses the issue of coping strategy and pays particular attention to impacts on the traditional livestock and poultry production systems in Sub-Saharan Africa. Indigenous livestock and poultry-based livelihoods in Sub-Saharan Africa are typically an example of a sector vulnerable to climate change. Due to stereotypes Sub-Saharan Africa has failed to acknowledge as an asset to many of rural poor with as yet untapped potential to adapt to climate change. The review gives an insight on the amount of indigenous livestock and poultry innovative management interventions that be considered to increase the resilience of livestock and poultry production systems to climate change. However, substantial controversy exists about the short-term and long-term effectiveness of many of them. The review provides an overview of the strategies to be taken to increase the resilience of livestock production systems and livestock-dependent livelihoods to climate change in resource poor rural communities. Overall, the review provides a synopsis of the impacts of climate change on indigenous livestock and poultry the need to address these and the management and policy options open to develop more resilient livestock production systems

There has been a worrisome trend as a result of intensified livestock and poultry production using genetically improved livestock and poultry breeds, that indispensable indigenous animal genetic resources population are dwindling. It is imperative that indigenous livestock and poultry animal genetic resources as an integral part of promoting the resilience of smallholder livestock and poultry production systems in Sub-Saharan Africa be promoted. Indigenous livestock and poultry genetic resources in Sub-Saharan Africa are a class of their own that warrant to be safeguarded under imminent climate change and variability and its adverse effect on agriculture production. However, understanding which type of animal genetic group to rear will give the highest return on sustainability factoring resilience in light of climate change. In this regard, there is a potential in use of indigenous animal and poultry genetic resources to promote sustainable rural livestock production in the face of climate change and variability. The vulnerabilities of major livestock species raised in smallholder livestock farming sector vary. The consequences of climatic change and variability is lesser fodder for the indigenous livestock and poultry, unavailability of clean water, proliferation of diseases and endo and ecto-parasites, decreased fertility and reduced livestock and poultry performance. Direct effect of climate change through raised temperature affect the physiology of imported livestock and poultry in turn adversely compromising their production and reproductive efficiency, especially if reared under the smallholder farming sector. In most cases, reproductive efficiency is impaired in both male and female imported breeds, with also high morbidity and mortality rates. The indigenous livestock and poultry breeds/varieties would be far more adaptive to the rising temperature than the imported breeds' in turn promoting resilience in the rural farming systems. With the purpose of promoting climate adaptive livestock and poultry farming and husbandry in rural farming sector there is need to promote indigenous livestock and poultry breeds. The obstacles to promotion of indigenous animal genetic resources emanate from the fact issues to do with this genetic grouping is overlooked at policy level. The value of indigenous livestock and poultry breeds is not well recognized in most Sub-Saharan countries. Due to lack of policy support some resource poor farming communities have now not putting value interest in indigenous livestock and poultry breeds, started using exotic livestock and poultry breeds, which are perceived to be superior. This is despite the overwhelming evidence that promotion of indigenous livestock and poultry breeds are a vehicle for strengthening rural agriculture resilience and livelihoods in the advent of climate change. The promotion of indigenous livestock and poultry genetic resources into the national agenda is critical if smallholder livestock sector in Sub-Saharan Africa is to be

sustainable in the face of adverse effect of climate change and variability. Precariously, in most Sub-Saharan countries the issue of livestock and poultry indigenous genetic resources does not get prominence in agricultural and related policies. There is less attention given to issues pertaining indigenous animal genetic resources as a result of agricultural policies that are focused other exotic and commercial livestock and poultry genetic species. This is despite that known fact that indigenous livestock and poultry genetic resources are able to survive under harsh climatic conditions, thus resource-poor farmers should be encouraged to farm with these resources as they require low inputs. It can be concluded that Sub-Saharan Africa's in its effort to improve livestock and poultry productivity focusing on the use of improved livestock and poultry breeds, it does not warrant to replace the local livestock and poultry genetic resources. There should be a parallel effort also to promote the local livestock and poultry genetic resources that can contribute to sustainable livelihoods and ensure that poor, subsistence and small farmers have ways to manage risk and vulnerability in the advent of climate change. The rural resource poor animal agriculture cannot sustain their livelihoods due to utilization of imported livestock and poultry genetic resources, because firstly these animals may easily succumb to the harsh environmental condition which prevail in most these rural communities. Secondly the level of management within the resource poor animal agriculture is not up to date which may result in increased mortality in exotic breeds.

4. Indigenous micro-livestock farming as a strategy in building resilience in livestock and poultry production in the rural areas

Due to population bloom in Sub-Saharan Africa seems there is a decline in rural household farm size with each new generation inheriting smaller portion of land for household farming. In this case keeping of micro-livestock such as chickens, ducks, goats, sheep etc. is an available household options to sustain household food security and nutrition. Intensification of micro livestock may be an option for some farmers but available land for keeping livestock are experiencing declining productive because of over utilization and loss of quality grazing and browsing. While micro-livestock production is often a driver of sustainable household livelihoods, future climate change will have significant impacts on micro-livestock production. The effect of climate change is only likely to make a precarious situation worse. Goat production is a feasible climate smart micro-livestock venture and resilient livelihood strategy for resource poor rural farmers. Both large and small livestock and poultry species play an important role in the livelihoods of many rural communities in Sub-Saharan Africa but there is evidence that large ruminants are likely to be more vulnerable to the adverse impacts of climate change. However, understanding which type of animal group to raise will give the highest return on sustainability factoring resilience in light of climate change.

4.1. Native chicken and resilience in rural agriculture

Resource poor rural household's poultry production contribute 70% of the total production in most low-income food deficit developing countries. Eighty percent of the world poultry production is bound in the village production system and constitute approximately 90% of poultry products in some developing countries (Besbes, 2009). Indigenous chickens are widely distributed in the rural areas of tropical and sub-tropical countries (Ajayi, 2011) and of the poultry species in the developing countries are of the indigenous type. The most popular poultry species in rural areas of Sub-Saharan Africa is the native chicken, although ducks, geese, turkey, etc. are also prominent in rural areas. These chickens are an integral part of a balanced agrarian rural system with multiple socio-cultural roles of rural communities (Padhi, 2016), and their significance for rural agrarian economy is overwhelming in different countries (Khan, 2008; Mtambo, 2000). Native chickens are a common sight in most rural areas in many developing and underdeveloped countries throughout the world (Bett et al., 2015; Magothe et al., 2012; Vali, 2008). The diversity in agro-ecology, climatic conditions and variation in the purpose of chicken rearing in different regions and production environments are the major determinants of the present high diversity in chicken genetic resources in these areas. The sustained use of native chickens in the rural household poultry production system showed the need to consider the value of native chickens. Indigenous poultry act as subsidiary income, as well as providing meat and eggs (Padhi, 2016) and food and nutrition security for the rural poor (Assan, 2014). Apart from the village poultry contributing substantially to household food and nutrition security in developing countries, they assist to diversify household income, provides high quality food and fertilizer and acts as form of household savings and insurance (Besbes, 2009). Through the decades impacted by natural selection and partly artificial selection native chicken breeds/varieties have evolved genetic adaptations to their diverse

local but unfriendly environmental conditions (Lawal et al., 2018; Wang et al., 2015). In view of the current and future global effects of climate change, the genetic basis of adaptation to hot or arid climates in native chickens is of practical value for building resilient livelihood strategy for resource poor rural farmers in Sub-Saharan Africa. There are so many attributes that makes indigenous chicken an ideal group for rearing in resource poor rural communities that is under the influence of a plethora of climate change challenges. Native chicken through time have proved to be well adapted to the harsh tropical condition and are normally reared under a free-range system. Indigenous chickens are known to possess superior merits with reference to important adaptative attributes namely disease resistance, tolerance to cold and heat, ability to escape from predators, scavenging and brooding behaviors and hatchability of eggs. These traits are ideal for adaptation to the resource poor village environment which is also characterized by mediocre husbandry practices. Despite their low output indigenous chicken can thrive and produce with erratic supply of feed and water and with minimum bird health care. The minimum health care involve mainly the use of local herds at low cost focusing on use indigenous knowledge systems. Dessie et al. (2011) acknowledged the desirability of the small body size of native chickens in tropical and subtropical environment. The most important attributes are their ability to withstand the harsh environmental condition and mediocrity husbandry practices without much loss in intended production. Tadelle (2013) observed that the native chickens are have ideal maternal instinct a good mother and sitters. Despite being poor layers as indicated by their small sized eggs their efficiently incubate the few eggs they lay. Their feeding behavior is well adapted to scarce feed resources, characterised by being excellent foragers. Naturally native chickens are hardy (Dessie et al., 2011) and are tolerant to most local specific diseases (Mtambo, 2000). The native chicken rearing system in Sub-Saharan Africa is characterized by extensive scavenging management, no immunization programs, increased risk of exposure of birds to disease and predators, and reproduction entirely based on uncontrolled natural mating and hatching of eggs using broody hens, where there is no or minimum intervention to maximize their production and reproductive performance. The native chicken production in the rural areas should be revitalized and popularized in order to sustain their livelihoods.

4.2. Indigenous goats' functional adaptation and climate change and resilience in animal agriculture in rural areas

Thirty-five percent of world's goat population, as of 2012 was found in Africa which constituted the largest proportion of livestock species on the continent (FAO, 2014), and the greater percentage of these are indigenous type. Strengthening resilience in indigenous livestock and poultry rearing systems in response to climate change in rural resource-poor farming areas in Sub-Saharan Africa will call for an animal/birds with an efficient physiological response to heat stress due to rise in temperature, and also the response to deterioration of feed resources quality and quantity and scarce water resources. These factors have been attributed to the uncertainties associate with climate change and variability. The proposed rearing of goats in this case is based on the premise that use of adaptive animal species may continue to sustain production, while at the same time reproducing in climate change stressful environment. It's now common knowledge that the rural areas in Sub-Saharan Africa that are known to heavily depend on agriculture are the most vulnerable to climate change. The impact of climate change is now evident to be more frequent and severe than before, hence knowledge on how to minimise its effect is critical, especially in rural areas. The solution to climate change in resource poor rural areas is promoting the use of indigenous animal genetic resources such as goats, because of their small body size and proven to have an efficient reproductive system. The small body is associated with low maintenance and also facilitate an easy adjustment of flock size to match the scarce feed resources due to climate change. Crop and livestock integration is easy with goats in rural areas because of their small body size. The proliferation of goats in diverse harsh environmental conditions that characterizes arid and semi-arid regions is an indication of the capacity of this species to adjust to climate change. Peacock (2005) described the multiple roles played by goats in Africa and the reasons for the current interest as an integral of rural agrarian development agenda. An appropriate model of good practice in smallholder indigenous goat rearing systems which, if scaled-up, could have considerable impact on rural household poverty and food and nutrition insecurity. In comparison with sheep and cattle, goats have proven tolerant to heat stress and water scarcity induced by climate change, hence their proliferation in diverse agro-climatic ecological regions (Azizi, 2012). Campbell (1998) explained how goats will survive in diverse harsh environmental conditions as an indication of their superior adaptability. The same sentiments were echoed by (Devendra, 1990) that goat are found mostly in the harsh arid and semi-arid regions of the tropics, which are characterized with 6 to 8 months of dry conditions as a result of erratic rains, which negatively influence forage

production. The adaptability of goats to arid and semi-arid regions is due to multi-factorial features such low body mass and low metabolic requirements. These factors makes goats ideal for rearing in the resource poor farming systems in rural areas. Due to low body mass goat maintenance and water requirements are low, especially where water sources are scarcely distributed and feed resources have been adversely affected in terms of quantity and quality. Water availability due to erratic rains is a predominant feature in semi-arid regions. In most cases, there is water scarcity that adversely affect livestock production (FAO, 1989). Erratic rainfall is associated with water scarcity and limited rangeland biomass production which affect livestock production (Ngigi, 2009). Ambient temperature, humidity, wind speed and other climate factors, affect livestock reproduction and production (Houghton et al., 2001). Goats have withstood the harsh environment making it an adaptable livestock species at various altitude and different agro-ecological regions (Devendra, 1999). King (1983) and Shkolnik and Silanikove (1981) suggested that goat due to their feeding behavior are ideal species for the tropics and have sustained production as compared to other livestock species. However, in addition to feeding behavior goats have other functional attribute that make them survive in harsh environment. Geographical wide representation of goats habits in harsh tropical environments is an indication of its capacity to tolerate such areas (Van Thanh, 2006), associated with poor quality feed resources, and in most cases limited water supply. Physiological adaptive mechanisms enshrined in goats tend to favour them for survival in unfavorable condition and sustain production in the context of climate change. Adedeji (2012) suggested that some goat breeds possess oversized appendages that physiologically enhancing body surface area, which promote body heat loss. Goat can adjust their behavior to respond to the day ambient temperatures through minimizing travel while resting more during the hottest and drier hours of the day. The extension of the tongue outwardly is a physiological mechanism to deal with high temperatures therefore enhancing evaporative cooling. Accompanied by other behaviors such as feeding, watering goats have an efficient thermoregulatory system to deal with high ambient temperatures. Split upper lip, narrower muzzle and long legs have been some of the attributes enhance their survival as they climb difficult terrain and tolerate poor forages (Mc Gregor, 2000).

These physiological mechanisms make goats able to thrive in extreme temperatures and limited water (Cain et al., 2005). Giger Reverdin and Gihad (1991) reported that the water requirement for maintenance of goats in temperate climates is 107 ml/kg BW0.75 and indicated that water requirement under different ambient temperatures based on previous work ranged between 3.15 kg/kg DM at 230 C to 4.71 kg/kg DM at 350 C. Coat color had a significant influence on heat tolerance traits which include rectal temperature, pulse rate, respiratory rate and heat stress index (Adedeji, 2012). Of the number of proponents of climate change which has an effect on livestock production in the smallholder farming areas in the rise in temperature. Heat is a major challenge which adversely affect livestock production, especially in semi-arid areas (Silanikove, 1992). Silanikove (2000) opined that the amount of heat absorbed by an object from direct (solar) radiated heat depends not only on the temperature of the object, but on its color and texture with dark surfaces radiating and or absorbing more heat than light colored surfaces at the same temperature. The arid and semi-arid areas where most goats are found they suffer from thermal load on the animal feeding during the day. The extent of heat load is determined by the animals' coat color, length and condition of its hair (Acharya et al., 1995). Pelt color and hair structure for goats have been a contributing factor for efficient thermoregulation (Hetem, 2010) and adaptability to various ecological zones (Banerji, 1984). Bilaterally wattled white and swiss marked goats were reported experience the lowest rectal temperature and heat stress index. In this case, coloration and hair structure seemed to be important features in minimizing heat stress, as a result goat which were light colored were more tolerant to solar radiation. The explanation for this is that the lighter coat absorbs less solar radiation hence prone to less heat load. Hair structure showed an inclination to environmental conditions where goats are found. This makes goats well adapted to extreme temperatures, with their lighter coat and hair structure acting as an insulated layer that protects them from cold and heat. The propensity towards Multicoat coloration is a common adaptation feature in goats that makes them withstand various intensity and duration of light, heat and cold in the semi-arid tropics (Katongole et al., 1996). On a different physiological mechanism goats tend to increase their respiratory rate as an immediate response to environmental heat stress (Hales and Brown, 1974). They are known to succeed in tropical rain forests, being the domesticated animal with the largest ecological distribution (Epstein, 1965). Goats inhabiting hot, humid environments have small bodies (dwarfs), while those living in dry environments or in areas with a wide diurnal temperature range usually have larger bodies (Horst, 1984).

Goats feeding behavior of browsing is a major feature in their ecological adaptation. Goats in the tropics, when possible, eat a diet composed of tree-leaves and shrubs (browse), which ensure a reliable and steady supply

of food all year around, albeit, from a low to medium quality food. The narrow muzzle gives goats an advantage if the pasture is very short. The combined effect of appropriate body size and feeding behavior enables goats to withstand environmental stress. Goats can be easily recover from feed shortages emanating from drought situations as a result of their efficient reproductive propensity and small maintenance body size (Horst, 1984). One of the impacts of climate change on animal production is availability of forage in terms of quantity and quality (Rotter and Van de Geijn, 1999). Goats have survived erratic nutritional conditions and subsequently maintaining their production (Aziz, 2010). Goats are intermediate and fixed feeders that can use browse that can utilize grasses in addition to shrubs (Hofmann, 1989). The browsing as an underlying morphological digestive capacity accompanied with profuse saliva production may assist in efficiently process their feed (Holechek, 1984). Goats are merited with a more flexible feeding behavior inclined to alter their feed resources preference quite quickly. This makes them more adaptive and selective feeders with reference to either sheep or cattle. Lechner-Doll et al. (1995) reported that goats have the propensity to choose high quality feed during the dry season, on the other hand, goats can feed on many plants that are regarded as weeds (Mc Gregory, 2000). While other animal species such as sheep and cattle show less selectivity to high quality feed, the browsing feature of goats promote the consumption of nutritious feed resources from shrubs and grasses. Their choice of feeding behavior allows a wider choice of browse from trees and shrubs. In most cases have developed the ability to browse and to eat poor quality forage/herbage than other ruminants. The ability to eat forage with high level of anti-nutritional factors have been reported in goats (Provenza, 1992; 1997).

5. Integrated crop-indigenous livestock and poultry system build resilience in rural communities

Embracing integrated crop-indigenous livestock and poultry systems at the household level is a proven and highly reliable way to make our agriculture resilient to increasingly unpredictable changes in the climate. Mixed farming systems in which farmers rear both indigenous livestock and poultry and crops, although it is recognized that livestock in such systems may also rely on rangelands unlike poultry fed from household leftovers. Smallholder indigenous livestock and poultry rearing usually on mixed crop-livestock rural household setup has remained a dominant feature in Sub-Saharan Africa (Jayne et al., 2003). Frija et al. (2018) reported that mixed crops-livestock systems had a considerable high resilience indexes. Since time immemorial integrated crop-livestock system has been practiced in rural areas, however it has now evolved and adjusted as a response to climate uncertainty. It is acting as an appropriate resilient livelihood mechanism for indigenous livestock and poultry coping with the harsh environment facilitating optimizing animal agriculture opportunities within variable and unpredictable rangeland ecosystems. Rural farmers can benefit in integrated crop-indigenous livestock and poultry system in another way so is the stream of income and providing security in uncertain times. In response to dwindling feed resources smallholder farmers has adopted control of the number of livestock and poultry which each family householder keeps. This has been necessitated by also the pressure on community grazing land which has reduced in size because of expansion of arable land for cultivating crops. Controlled herd size: the production objectives of pastoralists and agro-pastoralists, why herd size matters in mitigating the effects of increasingly frequent and severe droughts, and practical steps (other than mobility) that could be taken to control herd size in order to adapt to the impact of climate change**.**

6. Fodder and browse conservation and utilization to sustain indigenous livestock and poultry rearing in rural areas

Seasonal variation in rangeland and fodder availability due to erratic rainfall patterns is a widespread problem affecting rural areas and it has been implicated as a major contributor of reduction in indigenous livestock and poultry performance. To a certain extent the sustainability of the indigenous livestock and poultry sectors in rural areas is adversely affected by limited access to high-quality fodder in satisfactory quantities. Therefore, there is a need to adopt feasible environmental and cost-effective strategies for improving the year-round feed supply in rural areas as a means of developing resilient indigenous livestock and poultry system. The effects of climate change have worsened the availability of livestock and poultry feed resources in rural areas. The expanded rural population which has forced portioning of grazing land into crop farming has exacerbated the scarcity of animal feed resources in rural areas. More land has been allocated to crop production on the expense of grazing land. The livestock and poultry farmers have responded by shifting from rearing larger animals to micro-livestock such as

goats and sheep or indigenous chicks, ducks and guinea fowl. To assist smallholder farmers some research institution has developed improved planted forages recommended as one of the strategies of alleviating feed scarcity, especially in drier agro-ecological zones (Maina et al., 2020). Where there is abundance of land in rural areas, it is highly likely that increasing the land area allocated to fodder production will equally enhance indigenous and poultry production seems to increase in animal products, resulting in higher income and alleviating poverty.

7. Indigenous livestock and poultry diversification for improved resilience and welfare outcomes under climate risks in Sub-Saharan Africa

Smallholder on-farm agro-based diversity assists rural farmers in spreading risk across time, and space, building long term resilience into agricultural systems (Martin and Magne, 2015). Diversification of indigenous livestock and poultry portfolios is a feasible option in fostering resilience to climate risks and thus improve the well-being outcomes of smallholder animal agriculture. The mix of livestock and poultry species and breeds that would better adapt to hotter conditions due to genetic components or other reasons is one of the fundamental strategies for local resilience of livestock and poultry systems in the rural areas. Multispecies rearing in rural communities as established as the dominant local adaptation strategy, with high chances of building resilience of households to climate and rangeland ecosystem changes by adding to a broader existing strategies. Ngigi et al. (2020) studying the role of livestock diversification in climate change risks management at rural household level, observed that climatic shocks are less likely to affect small ruminant and non-ruminant than large ruminant. In this case rural resource poor households tend to count on diversification of indigenous livestock and poultry holdings and borrow from social groups to sustain their consumption level and bring up resilience. Indigenous livestock and poultry species diversification differ considerable with family size and economic household status, because it is dependent on the availability of household labour and economic factors at disposal. Venturing into indigenous livestock diversification in rural livestock farming sector could effectively contribute to poverty alleviation (Otte et al., 2005) as it plays a part in building resilient and sustain production in smallholder livestock production. The nonexistence and/or limited non-farm prospects in the rural areas of Sub-Saharan Africa, accompanied by rural population expansion, implies livestock and crop farming will continue to play a major food and nutrition role in rural areas. Thus, while rural food and nutrition security has dominated recent literature as a way of improving welfare through increased food production, diversifying agricultural activities, improving indigenous and poultry productivity and resilience to shocks in rural farming sector cannot be overlooked. This is important given the changing climatic conditions influencing both crop and indigenous livestock and poultry production, and thus impinging on many livelihoods in rural areas. Diversification is a feasible strategy for creating resilience against climatic shocks in indigenous livestock and poultry production. Agricultural activity and livelihood diversification have continued to be perceived as a risk management strategy and source of resilience. However, diversification of agriculture activities may not so great as compared to diversification of risk. Diversifying indigenous livestock and poultry rearing risks within resource poor communities can be achieved through several approaches at the household level. Within the range of livestock and poultry species their vulnerability to climate change is different, hence keeping one or two of these species diversify livelihood risks in different ways. Rearing different indigenous livestock and poultry species farmers will be engaging in agriculture activities with different risk profiles. It is also possible to complement indigenous livestock and poultry-based livelihoods through other activities related to agriculture/livestock. Households that are highly diversified in both crop and livestock activities attain the highest food security outcomes (Mulwa and Visser, 2020). Different indigenous livestock and poultry species are reared to discharge diverse livelihood priorities with subsistence purposes that most cases predominate production goals of the resource's poor rural farmers. In ruminant production the major determinants of livestock diversification are periodic droughts, bush encroachment, greater vulnerability of cattle that has forced smallholder rural farmers shifting to rearing adaptive species such as goats. Diversification of indigenous livestock and poultry rearing might dovetail with the explanation of Vandermeer et al. (1998) on the linkage between the role of diversity in agro-ecosystems to functional capacity and resilience. Biodiversity support ecosystem function as a result of various livestock and poultry species or genotypes occupy different niches are dependent on their role in the ecosystem. The linkage between livestock and poultry diversity and function may be useful for the long-term maintenance of sustainable agricultural systems. Mixed livestock and poultry rearing take advantage of the feeding behaviour of various animals' groups hence improving the efficiency of limited feed resource. Cattle grazed together with goats and sheep will utilize range at all biomass levels because cattle are mostly grazers and goats are browsers.

8. Implications

Discussion concludes that indigenous livestock and poultry play a crucial role in enhancing rural agricultural systems resilience in turn sustaining livelihoods in Sub-Saharan Africa. This proposition is critical with the understanding that the majority of the population in the region resides in rural areas, hence there is need to safeguard the rural animal genetic resources to protect rural livelihood. The promotion of indigenous livestock and poultry would build resilience in livestock and poultry production systems in the rural areas. Indigenous livestock and poultry species and breeds have better differentially vulnerability to temperature increases and rainfall reduction as compared to imported animal genetic resources in the smallholder farming sector. This discussion gives an overview on the traditional coping strategies as a means of strengthening resilience in indigenous livestock and poultry rearing systems in response to climate change among rural resource-poor farmers in Sub-Saharan Africa. In Sub-Saharan Africa, a basic and fundamental precondition for food and nutrition security and overall smallholder animal agriculture development is dynamic indigenous livestock and poultry sectors brought about both by sustainable production and by greater efforts in imparting resilience, to enable rural farm households to exploit the opportunities and to minimize the negative impacts of climate change. Despite the enormous potential of indigenous livestock and poultry rearing in support of livelihoods in rural communities, it comes under a specific climate vulnerable agricultural sub-sector and exceptional attention to alleviate the negative impact on rural communities is desired. The development of resilient of indigenous livestock and poultry rearing systems is essential in resource poor rural communities that largely depend on the proffering ecosystem services of such systems (food and nutrition, ruminant grazing and fodder, livestock and poultry watering) for their livelihoods. For resource-poor rural farmers to cope with climate change, farmers use several appropriate livestock technologies and strategies. Fodder banks, crop and indigenous livestock and poultry integration and rearing the indigenous livestock and poultry varieties, on-farm diversification livestock and poultry diversification and, micro-livestock farming are among the most commonly used coping livestock and poultry husbandry practices and strategies. In some cases, resource poor farmers use a combination of these coping technologies and practices to enhance livestock and poultry productivity. Rural communities are agrarian based economies hence have limited other livelihood strategies which makes the system highly vulnerable to climate change. The exposure to vulnerability is precarious in rural communities because communities lack adequate resources to invest in expensive coping strategies, hence increases the vulnerability of agrarian based economies to a changing environment. Helping decision makers understand and deal with current levels of climate can provide one entry point to the problems posed by increasing variability in the future and the options that may be needed to build resilience in rural agriculture systems. However, the effectiveness of biophysical resilience responses of indigenous livestock and poultry subsistence systems to specific climate change effects are anticipated which require a range of coping strategies appropriate for rural areas to sustain their livelihoods. Continued promotion of adapted livestock and poultry is crucial in sustainable livestock and poultry production in the light of harsh environmental conditions associate with climate change.

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