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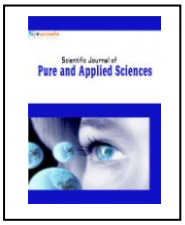

Review article

Opportunities and challenges in enhancing food production and security in the context of climate change effects in sub Saharan Africa

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ABSTRACT

This discussion explores the opportunities and challenges in enhancing food production and security in the context of climatic variability in Sub Saharan Africa. The promotion of sustainable use of plant and animal products with emphasis on satisfying basic human needs, improving people's standard of living, enhancing food security and reducing poverty have taken a center stage in Sub Saharan Africa. However, the efforts in this direction are being impacted negatively by climate change, through animal and crop production which have not been spared due to the natural disasters and environmental challenges which have affected all regions of Sub Saharan Africa indiscriminately. Climate is a particularly important driver of food production systems performance at the agriculture end of the food chain. It can affect the quantities and types of food produced as well as production-related income especially for the poor resource farmers. In order to be able to adequately address food production and security in the context of climate, there is need for the region to carry out thorough climatic vulnerability and adaptation assessments. Supporting research and training of experts to carry out vulnerability and adaptation assessments on crop and livestock production is crucial in order for respective countries to develop climate change adaptation measures to meet the obligation on food production and security. Sub Saharan Africa's agro-ecological regions are variable and need to develop specific adaptive

measures to reduce vulnerability to climate change. Due to the changing climatic conditions which the continent has already witnessed many severe climatic induced vulnerability such as decline in rainfall amounts and intensity, reduced length of rain season and increasing warm and occasionally very hot conditions has affected food production and security. Crop and livestock production systems will need to adapt to higher ambient temperatures, lower nutritional value of feed resources and new diseases and parasites occurrence. It can be seen that the present crop and livestock production systems based on pastoral or rangeland grazing husbandry systems, ecological destruction through climatic variability and overgrazing due to high stocking rates in areas where feed and water has been compromised due to high temperatures caused by climate change does not augur well for future livestock productivity. The understanding of climate change variables and their impacts is the first step in climate change research and prerequisite for defining appropriate adaptive responses by local crop and livestock farmers. Sustainable crop and livestock production supporting rural development should be compatible with the goals of curbing the effects of climate change. Production priorities should be directed towards promoting local crop and livestock genetic resources by providing comprehensive research support services on the impact of climate change. Both crops and livestock play important roles in farming systems, as they offer opportunities for risk coping, farm diversification and intensification, and provide significant livelihood benefits and food security. The chapter therefore, concludes that the effectiveness of biophysical responses of crop and livestock production systems to specific environmental challenges that are anticipated as a result of climate change, and then the range of adaptive measures that might be taken by local producers to ameliorate their effects will be the prerequisite for defining appropriate societal responses and meet food security targets.

1. Introduction

Climate change and global warming are the major concern that will define livestock and crop production systems and their productivity globally and will have even greater influence on selection of livestock breeds and crop varieties. Increased livestock and crop production are valued as the major components of food security and have enormous potential for poverty reduction. Crop and animal products have been highly dynamic globally in response to rapidly increasing demand for food due to increased human population growth. Both livestock and crops play important roles in farming systems, as they offer opportunities for risk coping, farm diversification and intensification, provide significant livelihood benefits and food security. According to Food and Agriculture Organization of the United Nations(FAO) (1996) 'Food security exists when all people, at all times have physical and economic access to sufficient, safe, and nutritious food to meet their needs and food preferences for an active and healthy life'agriculture has been given an overriding emphasis as one of the core sectors to solve the current challenges on food shortage and to bring future sustainability to the world over, however the negative impact of climate change on livestock and crop production has been considerable. It is believed that agriculture is the most susceptible sector to climate change and also predicted that climate change will have a graver effect on Africa than on any other continent and that temperatures will rise significantly (Scholtz, 2012). Climate change is expected to

alter and hence bring changes in hydrological cycle, temperature balance and rainfall patterns (Mwiturubani, 2010) which have a negative effect on productivity. Certain segments of the African continent are already experiencing considerable water stress as a result of insufficient and unreliable rainfall hence more frequent dry spells are expected to increase the likelihood of livestock and crop capacity decline.

Elsewhere, regional and global assessments that have so far been made, including discussions of the effects of uncertainty, threshold and surprise, and the possible consequences of climate change on agricultural sustainability and food security (Thornton, 2010), may vary in their applicability to different part of Sub Saharan Africa. If the costs and even development of climate change research related to specific livestock and crop production systems are agro-ecological based, this has wide allegation for research use derived from other parts of the world as mechanism to adapt to climate change. The vulnerability to climate change impact is a function of several biophysical and socioeconomic factors as a result food production systems will be influenced by climate change in many ways which include the changes in the primary productivity of crops, forage and rangelands and the direct effects of weather and extreme events on animal health, growth and reproduction (Smit et al 1996). The challenges of climate change will call for a balanced type of animal and crop varieties which can produce in stressful environment. The use of adaptive genotypes such as the local animal genetic resources and crop varieties may sustain production in this regard. As the adverse impacts become more frequent and severe, food producers to some extent need knowledge on how to deal with climatic variability with the objective of maintaining food security. However more research on adaptive capacity related to climate change is needed in order to empower agricultural producers deal with climate change issues beyond what they have experienced previously. Livestock production can be sustainable in long term by adopting adequate adaptive measures against climate change in response to adverse environmental effects. Local animal genetic resources represent a resilient group to climate variability and should not only be conserved for future use in the event of climate change but should incorporated in main stream agricultural activities for commercial purpose to serve the increasing population. In the event that agricultural production in the low-income communities of the Sub Saharan Africa region is adversely affected by climate change, the livelihoods of large numbers of the population which much concentrated in rural areas will be put at risk and their vulnerability to food insecurity increased.

2. Use of local animal and crop genetic resources and climate change

Most Africa's local animal and crop genetic resources are well adapted to specific agro-ecological regions. They have a high degree of heat tolerance, are partly resistant to many local disease and parasites, and animal genetic resources have the ability to survive dry periods of feed scarcity and water shortage. These characteristics have become genetic for the simple reason that they have been acquired by natural selection over hundreds of generations. Genes controlling these factors have been fixed. These attributes are essential for successful livestock and crop production to meet food security in the context of climate change. Sub Saharan Africa still has an abundant local animal genetic resources pool, however the large reservoir of these are in the rural areas owned by the resource poor farmers. Sometimes due to indiscriminate crossing and frequent droughts which has depleted the feed resource base as a result of climatic variability some of these animal face the danger of being wiped out or extinction. Local animal and crop species have co-evolved in stressful environment over millennia and have adapted to different prevailing agro-ecological environment. The strategy in active animal and crop improvement through breeding should focus on the optimization of animal and crop genetic resources potential according to changes in ecological environment due to climate change. The principal focus should be to improve the overall biological and economic efficiency of local animal and crop genetic resources through provision of an optimized genetic potential in the context of climate change fulfilling the subsistence farming system where the genetic resources are numerous. The notion that the effects of climate change will be graver on the African continent than any other continent may be disputable, if only Africa intensifies the utilization of local animal and crop genetic resources which have adapted to various stressful agro-ecological conditions due to climatic variability. This points to suggest that most of the animal and crop genetic resources have over the decades managed to pull through, reproduce and produce in already stressed agro-ecological environmental conditions. Specifically under conditions of low levels of nutrition, high loads of both internal and external parasites and low water availability, while the crop varieties have produced with minimum water supply. At the level of subsistence farming which is characterised by generally low input-output system, the sustainability of livestock and crop

production efforts to improve animal production becomes a dominant factor where climate change should be taken into account.

The common multipurpose use of adapted local animal and crop genetic resources by subsistence farmers requires understanding of correlation among of economic important traits which can collectively work against climatic variability. In Sub Saharan Africa lack of information and sufficient understanding of climate change and its impact on animal and crop genetic resources are preventing progress in combating the effects of climate change to enhance food security. It would be a grave disservice endangering the local animal and crop populations and unrecoverable loss of these in the context of climate change.

Supporting the breeding and multiplication criteria of most animal and crop genetic resources should be more varied than the narrow production criteria of industrial countries food systems. Most populations of animal and crop species have been subjected to little or no deliberate selection for higher productivity which has compromised food security but on the other hand have managed to sustain local population in the event of catastrophes. Benefit of any organized genetic improvement for local animal genetic resources may be accrued through selection methods which take into cognisance adaptive traits preferred breeding objectives which deliberately respond to the demands of climatic variability and low input systems. This scenario may be an advantage in the sense that the animal survival traits will not be compromised, because such traits will be crucial for animals to survival in the context of climatic variability. It is suffice to say, the livestock and crop varieties which may severely succumb to the challenges of climate changes are those which have been imported from other continents into the region because this group may have not selected for genetic adaptation responses in more marginal environments. The selection of livestock and crop species should be centred on adaptation than productivity alone which augur well with the uncertainties of climate change. The recent high demand for food from both livestock and crop products have changed the focus of production to higher production targets to match their counterparts in western world. The major focus for utilizing local animal and crop genetic resources is their adaptive traits which will be more important in climate change variability and other common environmental shocks if food security is to be promoted. The challenges of both livestock and crop breeders in Sub Saharan Africa the context of climate change is to some extent improve livestock and crop productivity potential to a satisfactory level without sacrificing adaptation qualities.

What need to be acknowledged about the local animal and crop species is that they constitute an important reservoir of genetic material which has not been given adequate recognition. It is the argument in this review that with the foreseeable catastrophes of climate change the local animal and crop species on the continent need to carefully guarded. It would be a grave disservice in the long term if these are left unattended. There can be little doubt that the opportunities for utilization of local species are greater if farmers are willing to accept the challenges of climate change on livestock and crop production and realises the necessity for exploring adaptive measures in production systems. The introduction of new livestock and crop biotechnology such as genetic engineering which focus on local livestock and crop species will widen the opportunities if utilizing them. The efficiency of local livestock production should be mainly determined in terms of nutrient requirements for maintenance together with fertility, thriftiness and hardiness and on crops the need to produce. Efficiency of livestock and crop production has too often in the past been measured only in terms of their productivity, whilst the efficiency to survive and produce in stressful environment was ignored. The factors which contribute to efficiency in both animal and crop production as influenced by water stress and disease resistance should be studied further because these are the traits which will make production possible in the extremities of climate change.

The purpose of agriculture go beyond their direct output functions and include other significant economic and cultural roles. These include savings, insurance, cyclical buffering, accumulation and diversification, as well as various cultural roles related to status and the obligations of their owner (Anderson, 2003). If agriculture production is properly planned and designed has considerable economic potential as a vehicle to arrest the negative acceleration of climate change effects and enhance food security. Indeed, it has been shown that in Africa the contribution of substance farming to respective national animal protein yield is greater than that from commercial production enterprise in terms of kg protein production per hectare per year (Barret, 1992). For these reasons and others, our attention in attempting to mitigate the effects of climate change and enhance food security must be primarily focused on realignment of the subsistence farming sector, to introduce simple and climatic adaptive measures to sustain livestock and crop productivity to meet the food security targets. African governments are mostly unaware of the necessity of promoting livestock and crop species to mitigate the impacts

of climate change and apathetic in investing in such noble cause. The high level of awareness created on the effects of climate change needs to be carried a step ahead on the continent to encompass the sustainable utilization of local animal and crop genetic resources in the context of climate change. Efforts should be made to establish and characterise stable livestock and crop species that have now adapted to stressful environment, these could possess desirable qualities needed in future to enhance food security. Multiple stresses make most of Africa highly vulnerable to environmental changes, and climate change is likely to increase this vulnerability. There is variation in vulnerability taking into account the different regions of Africa (North Africa, West Africa, Central Africa, East Africa, Southern Africa) which suggest that other regions may be more vulnerable to specific impacts of climate change than others. These impacts include desertification, sea level rise, reduced freshwater availability, cyclones, coastal erosion, deforestation, loss of forest quality, woodland degradation, coral bleaching, the spread of malaria and impacts on food security.

3. Specific mitigation strategies in animal agriculture

World goat population was approximately 715 million in 2000 with over 60 percent of that found in Asia and more than 95 percent in developing countries mostly in Africa (FAO, 2001). The majority of goats in Africa are indigenous types and some are well defined as breeds and others are not. Goats comprise a considerable proportion of livestock on the African continent and are known to contribute substantially to the household economic requirement and food security of small scale farmers (Homann et al., 2007). Goat production have been recognized as the most effective livestock for promoting food security and economy on marginal and landless farmers in many developing countries (Patra et al., 2002), however their contribution has been obscured by several factors combining to give an underestimation of their true value. Goats have shown themselves to be extremely adaptable animals and they can be found at any altitude and different agro-ecological regions of Africa.

Goats make a very valuable contribution, especially to the resource poor farmers in Africa. However, the importance of this valuable animal genetic resource is underestimated and its extent of contribution to food security of the resource poor farmers is inadequately understood. Goats are animals which will survive the increased temperatures, feed resource scarcity. The serves to point to the fact that intensification of goat production would be a viable option in the context of climate change where other species production may be vulnerable to climate change. There is need to set new livestock standards for sustainability. The nucleus type of breeding or elite breeding may not work for the future. Some of the livestock attributes which are not considered in these breeding situation such as outstanding adaptability, disease resistance and low maintenance cost may be valuable to mitigate the effects of climate change. importance in future. The ability to graze and browse a wide range of forage species which may be unpalatable will be a necessary adaptive characteristic in livestock. Water shortage is one of the major components of climate change hence animals will need to walk for long distances to look for water and feed. Goats are smaller animals which have less maintenance requirement which will be paramount in the event of scarce feed resources. Despite the large numbers of goats in Africa, information on goat research related to climate change is scarce and often unavailable. The goats are an important component of household livelihoods and with the pending uncertainties of effects of climate change it is wise for government to promote goat sector to enter the mainstream livestock production system, as recognised breeds. Climate change taking the centre stage goats in this sector can play a major role in livestock production. The merit of the indigenous goats apart from their ability to adapt to stressful environment are a valuable asset to the smallholder farmers as they provide their basic needs. Largely as a result of prejudice and ignorance of the importance of goats to farmers in the smallholder farming sector, there had been little research on goats related to climate change. On performance alone it is difficult to understand why goats has not reached a position of importance in livestock production. The choice of goat production may increase the adaptive capacity of resource poor livestock farmers because the goat has a greater effect on the ecosystem than other animal species. They are numerous in Zimbabwe and could provide substantial quantities of animal protein. However their production is based on age-old husbandry system which need to be gradually modified in order to actual respond to crisis that is associated with climate change. Given the considerable hardy characteristics of goats their promotion will go a long way to facilitate livestock production coping with stressful environment as a result of climate change. Situation is changing with education locally it has shown that it is often best to promote the local animal genetic resources indigenous species and systems than imported exotic species or breeds from overseas (Assan, 2013).

Natural disasters caused by climate change have resulted in loss of valuable indigenous genetic resources, breeding tracts and mixing of genetic characteristics of various genetic grouping. Indigenous livestock production systems should encompass changes in climate and attitude of smallholder livestock producers from the present consideration of climate variability to more important objectives of higher productivity and socioeconomic benefits that are business oriented in the context of climate change. Goats are going to be more important source to enhance food security for the majority of the resource poor farmers in the context of climate variability and, thus, they deserve greater attention at both the micro and macro levels. Now, it is the time to consider and pay attention to the value and capacity of goats for producing food and enhance food security.

4. Climate change influencing rangeland productivity, water availability and animal health

The climatic change induced interactions of humidity, temperatures and rainfall are likely to influence the distribution of grass and legumes species on which livestock production rely on for productivity. The local livestock production system is mainly rangeland based and is associated with different types of animal species and types. Grasses, legumes and shrub composition in rangeland are important determinant of livestock productivity. There is marked seasonality in feed quantity and quality on rangelands in some of the ecological regions on the continent. The frequent dry spells or floods that are now common in certain segments of Africa, have resulted in the deterioration of animal feed resources on rangeland resulting in the loss of livestock In southern Africa lack of high quality feed throughout the year on rangeland has been cited as the major constraint in livestock production in smallholder farming sector which has made smallholder livestock based production system unsustainable in long term (Masikati, 2010). Grass and legume plants dynamics is bound to change in some areas that the grazing capacity on rangeland may be expected to decline. As temperature increases and rainfall decreases due to climatic variability the grasses and legumes species on rangelands will change and rangeland productivity is likely to be negatively affected. To avoid such a scenario superior grasses and legumes species must exhibit good adaptation to different agro-ecological regions for both biotic and abiotic constraints to survive. Vegetation should have wide spread adaptation to environmental stresses, ease of management and acceptability by livestock farmers. The optimal growth for different grasses and legumes species will change in the context of climate change, species which will alter their competition dynamics and diversity of mixed species definitely will change. Such changes could have enormous consequences on livestock production systems which is mainly dependent on these rangelands through the numbers of animals that are kept, livestock productivity itself and potential loss of animals during the dry spells.

During the dry season, low protein levels and high fibre content may limit livestock production and may cause weight loss. This scenario may worsen in the event of decline in precipitation in future due to climatic variability. Need for new adapted animal feed resources in the context of climate change such as legumes and fodder shrubs could improve the nutritive value of rangelands to support livestock production. However in the event that temperatures rise there is a tendency of plants accumulating high levels of anti-nutritional substances which may affect digestion or health. There is need to continue to evaluate forage legumes for the effects of anti-nutritional factors to improve their use in livestock production. Particular attention should be given to identification and use of native pasture plants and forage shrubs for use in degraded environments as a result of climatic variability. Matching feed resources to livestock requirement in adverse condition will be a grave task. Challenges associated with feed availability has been observed in most smallholder livestock sector on the continent. Severity of shortages worsened during the dry season which has been exacerbated by erratic rainfall patterns in semi arid Africa.

Population pressure and emerging new markets created by urbanisation have caused an increase in land under cultivation, at the expense of grazing land (Morton and Matthewman 1996) further exacerbating the problem of seasonal fluctuations in forage quality and quantity. According to Amenu et al (2011), grazing land is restricted to waste land, roadsides, edges of cropping fields and river banks, as well as fallow land during the wet season and crop residues during the dry season associated with land competition for cropping. Elsewhere, farmers reported a seasonal fluctuation in livestock feed availability with the greatest feed scarcity being felt during the dry season in Rwanda, Uganda and Kenya (Lukuyu et al 2009). Coping strategies to climate change by majority smallholder livestock farmers have been adopted, such as collection and storing crop residues for use as feed supplements during the dry season and paddocks close to crop fields for use as graze but this is mainly in response to shortage of grazing land.

Lack of knowledge on adaptation measures and coping strategies due to inadequate extension services and sometimes ignorance, leads to serious problems related to feed shortages. The rate of adoption of coping strategies in livestock-related technologies in smallholder crop-livestock systems in Africa is consistently low. Farmers fail to take advantage of proven technologies aimed at improving feed quality and feed low quality roughage in the form of dried maize stover (Svotwa et al 2007) among other crop residues (Lukuyu et al 2009), yet poor nutrition results in low growth rates and low reproductive performance in livestock (Pen et al 2009). Opportunities for improving the nutrition of livestock do exist, for instance, multipurpose legume trees adapted to local environment can provide high-quality feed and improve soil fertility (Lenné and Thomas 2006). Research institutions should start producing forage varieties that are well adapted to stressful environmental conditions. The efforts of new approaches such as marker assisted selection on forages could be exploited to produce grasses and legumes varieties which can sustainably support livestock production in the predicted uncertainties of climatic variability. Forage varieties with multiple attributes to overcome a range of biotic and abiotic constraints induced by climate change are needed.

Water resources are inextricably linked with climate change, so the prospect of climatic variability has serious implications for water resources and development on the continent. This is attributed to the fact that climate change affects the two most important direct agricultural production inputs, precipitation and temperature. Climate change and variability have the potential to impact negatively on water availability and access to and demand for water in most countries, but particularly in Africa (IPCC, 2007). This is so through a multiplier effects on other factors affecting water resources (Tadesse, 2010). In most African countries the impact of climate change has lead to additional pressure on water availability, accessibility, supply and on demand for livestock sustainable production to enhance food security. The continent is already experiencing considerable water stress in some parts of its agro-ecological regions as a result of insufficient and unreliable rainfall hence more frequent dry spells are expected to increase the likelihood of livestock capacity decline. Flooding as a result of rise in sea levels on coastal countries has periodically affected these countries and a lot of livestock have been lost in the process. Climate change can often exacerbate water problems for instance where climate change has led to overgrazing in some areas which then suffer rapid runoff and flooding.

Sources of water for poor communities for livestock include rivers, dams/ponds, bore-holes, wells and springs (Amenu et al 2011). With climatic variability challenges associated with watering animals are the long distances to water sources, steep slope and poor water quality especially following the rains (muddy) or long after (smelly). The longest distance that farmers and herds would walk during the dry season was 14 km (Masikati 2010) in Nkayi District of Zimbabwe. Elsewhere, distances covered were relatively shorter ranging from 5 – 8 km, however cases of water scarcity were reported in other African countries such as Rwanda, Uganda and some parts of Kenya (Lukuyu et al 2009). Svotwa and co-workers (2007) reported similar problems including inadequacy of watering points as the major constraints in a study conducted in Tanda ward in Manicaland province of Zimbabwe. Walking long distances could lead to weight loss while smelly and/muddy water leads to a reduction in intake to the detriment of livestock affected. Charlotte and Mandsen (1998) as well as Lukuyu et al (2009) in a study on water availability for livestock reported that lack of fresh water caused a reduction in feed intake imposing a limit on milk yield and growth rate.

Bacterial, viral disease and parasitic infestation will be greatly influenced by changes in rise in temperature and humidity. Climate change could indirectly affect agriculture by influencing the emergence and distribution of livestock disease and parasites, exacerbating the frequency and distribution of adverse weather conditions (Waston et al 1998); IPPC, 2001). Heat related mortality and morbidity will take its toll on livestock production as a result of climatic variability. Temperature sensitive diseases will be on the increase which may be considerable in semi arid areas of Africa. Most resource poor livestock farmers have acknowledged that diseases posed the worst threat to animal production. In southern Africa this appears to be a common observation among communal livestock producers with findings by other researchers generally making similar revelations (Masimba et al 2011) adding that disease challenges are a major constraint to the improvement of the livestock industry in the tropics (Devendra et al 2000). This was attributed to the effect of diseases of reducing production and increasing morbidity and mortality (Mwacharo and Drucker 2005). According to Masikati (2010), the major constraint for cattle production in the smallholder farming systems is the high animal mortality through diseases. In a study carried out by Amenu et al (2011), farmers indicated shortage of feed, shortage of water and livestock diseases as the top ranked constraints for livestock production in Lume district in Ethiopia. Elsewhere, in south-east Asia, the

farmers in the studied sites rated the lack of feed and disease as the most important constraints to cattle production (Pen et al 2009).

The responsibility for maintaining diverse indigenous livestock as a strategy against serial disease mutation may fall increasingly to individual national governments. Diseases are adapting ever faster to new drugs and strains of related infections, arising ever more rapidly with clear parallel in livestock production. In this case the native livestock will have a range of tolerance of disease pathogens and the unadapted livestock, especially imported ones, will suffer more mortality. With the uncertainty of climate change disease cycle will be unpredictable and sporadic outbreaks may occur and the most viable strategy in the context of climate change is to retain more of the adapted native livestock species and take a risk on an epizootic not occurring within an economic cycle. It seems sometimes that advocates of the conservation of local animal genetic resources take up a fundamentalist position that propose the elimination of all high input-high output livestock. This view emanate from the realisation of the future consequences of climate change, despite the high input-high output livestock feeding the globe.

5. Climate change mitigation strategies through appropriate research and extension

Assessment of climate change constraints to livestock and crop production for the purpose of setting sound research priorities is required. Production issues related to climate change have not been reasonably researched and simply not known and appreciated in Africa. Research on indentifying adaptive measures and estimating the determinants of adaptation strategies to climate change in livestock and crop varieties has been scarce on the continent. Definition of comprehensive production strategies incorporating specific, immediate and long term ecological constraints as a result of climate change was found lacking in most livestock and crop production projects that have failed. Specific or targeted research related to climate change which give solutions to ensure sustenance of individual ecosystems and its herbage and tree shrubs cover and of grazing livestock species and crop varieties for the future taking into account the climatic variability are necessary. The events in terms of research in Africa have been compromising adaptational traits on the expense of both livestock and crop productivity, as a result many livestock and crop species will be unable to cope with the effects of climate change in future if the breeding objectives are not changed. Research should be redirected to consolidate the already adaptational traits which native animal and crop genetic resources posses. The focus of research should change to encompass the animals and crops ability to survive in stressful environment. The livestock and crop research on the continent has been driven by the desire that the local livestock and crops species should match their counterpart in the first world in terms of productivity. With climate change events taking the centre stage such research focus may be counter productive. Native animal and crop species which are adapted to the harsh environmental conditions have unfortunately been crossed with imported genotypes which are less tolerant to local diseases and less well adapted to the changing environmental conditions but produce better than local animal and crops genetic resources only when the management is modified. It is reasonable to suggest that this research trend imposed on Africa does not take cognisance of the unforeseeable negative effects of climate change on the continent which has been predicted to be graver than on any other continent. Research on livestock and crops adaptive measures and capacity need conservable attention to reduce vulnerability especially in resource poor farmers who are the majority on the continent. Research geared at development of collaborative work by all stakeholders to support the adaptation of production systems to better cope with the negative impact of climate change will be critical. However it is not possible drastically to change the African production culture of the livestock and crop producers especially the resource poor farmers for at least for decades to come. To achieve success in livestock and crop research in the context of the uncertainties of climate change it is necessary to look at production systems holistically and involve resource poor producers at every stage in the planning and integrating the traditional values on climate change. It is also important that research should have a component of subjecting animals and crops to simulated impacts of climate change. This will assist in substantiating the responses of nutritional stress in livestock, water deprivation and increase in environmental temperatures on crop production.

Extension contact increases adaptation to climate change which implies that extension services are important for reducing the negative effects of climate change on farmers by disseminating climatic information as well as agricultural management practices (Nkeme and Ndaeyo, 2013). Farmers need to be exposed to extension services for awareness creation and climate change innovation adoption to mitigate its effects on production. It seems that

commercial producers have access to extension information concerning climate change forecasting, adaptation options and livestock and crop management practices to mitigate the effects of climate change. It is highly unlikely or decrease the probability that resource poor farmers may take up adaptation measures to ameliorate the effects of climate change because of poor flow of information from extension to farmers. Research and development investments to improve the relatively low level of livestock and crops' productivity do not match their potential importance, resulting in many livestock species and crop varieties that are not genetically explored.

6. Implications

Livestock and crop production systems need to change through adoption of possible strategies to reduce vulnerability to climate change and enhance food security. In fact, climatic variability characteristics such as ambient temperature and rainfall patterns have great influence on pasture and food resources availability cycle throughout the year, and types of disease and parasite outbreaks among animal populations and also the crop varieties to be produced.

In the literature, its acknowledged that production systems vary widely between different agro-ecological regions of Africa and vary substantially on their impact on the environment hence the extent of their response to climate change may also differ. Livestock and crop production systems will be influenced by the location specific climate induced factors such as regime of rainfall and temperatures. Climate change is set to worsen the environmental conditions faced by both livestock and crop producers if adaptive measures are not put in place hence their bearing on food security. Decline in productivity of livestock and crop production will be attributed to cumulative causation of climatic variability. Biophysical factors that perpetuate environmental stress will have implications for the long term sustainability of livestock and crop production systems. Research prioritisation should be guided by demands from livestock and crop farmers to curb the negative effects of climate change to sustain animal and crop production to enhance food security. From climate change centred viewpoint, it is now apparent that there are several adaptation options by which livestock and crop production can survive the negative effects of climate change. These will include choice of adapted livestock and crop species to enhance productivity and appropriate climate change research which are location specific. In future any proposed research on livestock and crop in Africa should consider testing in stressful environment, this calls for simulation studies which will limit loss of adaptive traits in native livestock and crop genetic resources, through selection under improved management production systems. There is need for an integrated approach to assess the impact and develop adaptive measures to curb the effects of climate change on livestock and crop production. Evaluation of factors that influence livestock and crop producers to adopt new adaptive technologies to climate change is imperative. Demand for livestock and crop products are projected to increase on the continent due to urbanization and prospects for meeting this demand are highly unlikely, unless serious investment is done to create knowledge on how to deal with the vagaries of climate change. The large scale genotyping of domesticated animal species globally without taking into account the impacts of climate change is likely to result only in wasteful expenditure without real improvements. Dismal performance of programs involving substitution of exotic for local animals have stimulated a recent reorientation of livestock production in African countries to utilize local animal genetic resources and success in some livestock production programs involving the use of local breeds has been encouraging. National programs on climate change are highly variable between countries and in most African countries suffer inconsistence political support and thus funding, as well as differing scientific capacity. The international community should assist to raise the profile of climate change research on the continent through extensive networking. Develop a smooth relationship between the investigation and publication of results on climate change and their integration into international data base for individual countries to use when necessary.

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