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Review article

Potential consequences of climate change and mitigation options in livestock production in Zimbabwe

N. Assan

Zimbabwe Open University, Faculty of Science and Technology, Department of Agriculture Management, Bulawayo Region, Box 3550, Bulawayo, Zimbabwe.

*Corresponding author; Zimbabwe Open University, Faculty of Science and Technology, Department of Agriculture Management, Bulawayo Region, Box 3550, Bulawayo, Zimbabwe.

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ABSTRACT

This is a review paper that looks at the potential consequences of climate change and mitigation options in livestock production in Zimbabwe. The local environmental policy objectives highlights related to climate change cite the promotion of sustainable use of natural resources with emphasis on satisfying basic needs, improving people's standard of living, enhancing food security and reducing poverty as the major issues. These efforts are being impacted by climate change through livestock production which has not been spared due to the natural disasters and environmental challenges likely to affect all sectors of the country and all layers of the population indiscriminately. In order to be able to adequately address climate change in a sustainable development context, there is need for the country to carry out vulnerability and adaptation assessments. Research and training of experts to carry out vulnerability and adaptation assessments on livestock production is crucial in order for the country to develop climate change adaptation measures. Societies are dynamic and they develop all possible adaptive measures to reduce vulnerability to climate change. Due to the changing climatic conditions Zimbabwe has already witnessed much 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. 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 livestock production system based on 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 livestock farmers. Increasingly local strategies for livestock production must consider the impact of climate change. Improved livestock production supporting economic development should be compatible with the goals of curbing the effects of climate change. Livestock production priorities should be directed towards promoting indigenous livestock genetic resources by providing comprehensive livestock research support services on the impact of climate change. Livestock play an important role in farming systems, as they offer opportunities for risk coping, farm diversification and intensification, and provide significant livelihood benefits. The review paper therefore, concludes that the effectiveness of biophysical responses of livestock production to specific environmental challenges those are anticipated as a result of climate change, and then at the range of adaptive measures that might be taken by livestock producers to ameliorate their effects will be the prerequisite for defining appropriate societal responses.

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1. Introduction

Livestock production is valued as one of the main global drivers of agriculture as well as one of the sectors having enormous potential for poverty reduction (FAO 2006). It has been highly dynamic globally in response to rapidly increasing demand for livestock products (Thornton, 2010). Livestock plays an important role in farming systems, as they offer opportunities for risk coping, farm diversification and intensification, and provide significant livelihood benefits.

Livestock production 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 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). Zimbabwe is 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 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 not be applicable to certain parts of the globe. If the costs and even development of climate change research related to specific livestock production systems are context based, this has wide allegation for research use derived from other parts of the world as mechanism to adapt to climate change in a different environment. The vulnerability to climate change impact is a function of several biophysical and socioeconomic factors. Livestock production 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 which can produce in a stressful environment. The use of adaptive genotypes such as the local animal genetic resources may sustain production in this regard. As the adverse impacts become more frequent and severe, livestock farmers to some extent have 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 livestock farmers to deal with climate change issues beyond what they have experienced previously.

It is estimated that about seventy five percent (75%) of Zimbabwean population depend on agriculture as means of support (Moran and Nyamapfende, 1986). Livestock production can be sustainable in long term by adopting adequate adaptive measures against climate change in response to adverse environmental effects. Indigenous livestock represent a genetic resource which is resilient to climate variability and should not only be conserved for future use in the event of climate change but should also be fully utilized to serve the increasing population.

2. Use of indigenous livestock and supporting the smallholder livestock sector to mitigate the negative effects of climate change

Indigenous livestock are well adapted to semi arid conditions of Zimbabwe. They have a high degree of heat tolerance, are partly resistant to many of the disease and parasites, and 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. In my opinion these characteristics are essential for successful livestock production in the context of climate change. Zimbabwe still has an abundant indigenous livestock genetic pool; however the large reserve of indigenous livestock in the smallholder sector face the danger of being wiped out by the frequent droughts as a result of climatic variability. Indigenous livestock which have co-evolved in stressful environment over millennia and have adapted to the prevalent climatic and disease environment will be essential in future (Baker and Rege, 1994). 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 the indigenous livestock on the continent. This is so because most of the livestock indigenous to Africa have over the decades managed to survive, reproduce and produce in already stressed environmental conditions. The indigenous breeds are adapted to produce under conditions of low levels of nutrition, high loads of both internal and external parasites and low water availability (Khombe, 1994). At the level of subsistence livestock farming which is characterised by generally low input-output system, the sustainability of livestock production efforts to improve animal production becomes a dominant factor where climate change should be taken into account. The common multipurpose use of indigenous livestock by communal farmers requires that correlation among the different livestock traits with climatic variability be understood. In Africa lack of insufficient understanding of climate change and its impact on livestock production and characterisation of indigenous populations are preventing progress in combating the effects of climate change. It would be a grave disservice endangering the indigenous livestock populations and unrecoverable loss of animal genetic material in the context of climate change.

The breeding criteria of most indigenous livestock were often many more varied than the narrow production criteria of industrial systems. Most populations of indigenous livestock have been subjected to little or no deliberate selection for higher productivity. They had been no benefit of any organized genetic improvement although they had established methods of selection for their locally preferred breeding objectives which unknowingly responded to the demands of climatic variability and low input system. This itself may have been an advantage in the sense that the survival traits were not compromised. It is suffice to say on contrary, the livestock which may severely succumb to the challenges of climate changes are those which have been imported from other continents. Indigenous livestock have been selected for livestock genetic adaptation responses in more marginal environments since time immemorial. The selection of indigenous livestock was centred on adaptation than productivity which augurs well with the uncertainties of climate change. The recent high demands for livestock products have changed the focus of indigenous livestock to higher production targets to match their counterparts in western world. The major concern for using indigenous livestock is their adaptive traits which will be more important in climate change variability and other common environmental shocks. The challenges of livestock

breeders in the context of climate change are to some extent improve livestock productivity potential to a satisfactory level without sacrificing adaptational qualities of indigenous livestock.

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

Livestock numbers in the communal areas have generally increased over the last four decade. In the year 2000, communal farmers owned 68% of all cattle, 98 of goats, 84% of sheep, and 60% of pigs in Zimbabwe (Agrisystems, 2000). Livestock scoping study confirmed great opportunity for livestock production to improve livelihoods among the rural households, provided that livestock productivity is enhanced and appropriate input and services can be availed (Homann, 2007). The country has 4.4 million goats mostly kept by small scale farmers (van Rooyen et. al., 2007) compared to 5.3 million cattle and 0.3 million sheep both declining (CSO, 2000). Poultry and pigs are estimated at 11 million and 11,795, respectively, (Hagreveas et al., 2004). The purposes of livestock production goes 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). Indigenous livestock production if properly planned and designed has considerable economic potential as a vehicle to arrest the negative acceleration of climate change effects. Indeed, it has been shown that in Zimbabwe the contribution of communal livestock production to the national animal protein yield is greater than that from commercial ranching 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 must be primarily focused on realignment of the smallholder livestock sector, to introduce simple and climatic adaptive measures to sustain productivity. African governments are mostly unaware of the necessity of promoting indigenous livestock 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 in developing countries to encompass the sustainable utilization of indigenous livestock in the context of climate change. Efforts should be made to establish and characterise stable indigenous livestock that have now adapted to stressful environment, these could possess desirable qualities needed in future. Multiple stresses make most of Africa highly vulnerable to environmental changes, and climate change is likely to increase this vulnerability. This graphic shows which of the regions of Africa (North Africa, West Africa, Central Africa, East Africa, Southern Africa and the Western Indian Ocean Islands) are most vulnerable to specific impacts of climate change. 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. Smallholder goat production impact of and response to climate change

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). Small ruminant especially goats comprise a considerable proportion of livestock in Zimbabwe and they contribute substantially to the economic requirement 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.

The country has 4.4 million goats mostly kept by small scale farmers (van Rooyen et. al., 2007) compared to 5.3 million cattle and 0.3 million sheep (both declining)(according to CSO, 2000). The majority of goats in smallholder sector are indigenous types and some are well defined as breeds and others are not. 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 merits 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.

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 situations 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 Zimbabwe, information on goat research related to climate change is scarce and often unavailable. 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 a goat 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.

4. Status of rangeland, water availability and animal health in the context of climate change

4.1. Rangeland dynamics

The climatic change induced interactions of humidity; temperatures and rainfall are likely to influence the distribution of plant diversity on rangelands. 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 Zimbabwe. The frequent dry spells, that are now common, have resulted in the deterioration of rangeland resulting in the loss of over 1 million cattle in the smallholder farming areas (Madzima, 1993). 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). The vegetation 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 both biotic and abiotic constraints to survive. They 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 system 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 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 have been observed in smallholder livestock sector (Masikati, 2012). Severity of shortages worsened during the dry season which has been exacerbated by erratic rainfall patterns.

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, and 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 worldwide 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

4.2. Climate change and water availability

Water resources are inextricably linked with climate change, so the prospect of global climate change has serious implications for water resources and regional development. 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). Locally the impact of climate change has lead to additional pressure on water availability, accessibility, supply and demand for livestock. Zimbabwe is already experiencing considerable water stress in some parts of the country 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 in Mozambique has periodically affected the eastern highlands which the country share a common border 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.

Local sources of water for communal 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.

4.3. Climate change influencing emergence and distribution of livestock disease and parasites

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); IPCC, 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 Zimbabwe. Most smallholder livestock farmers have acknowledged that diseases posed the worst threat to herd growth. 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 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 indigenous 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 indigenous livestock and take a risk on an epizootic not occurring within an economic cycle. It is seems sometimes that advocates of the conservation of indigenous livestock biodiversity 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. Adoption of appropriate research and extension strategies to reduce the vulnerability to climate change

Assessment of climate change constraints to livestock production for the purpose of setting sound research priorities is required. Livestock production issues related to climate change has not been reasonably researched and simply not known locally. Research on indentifying adaptive measures and estimating the determinants of adaptation strategies to climate change in livestock production is scarce in Zimbabwe. Definition of comprehensive livestock production strategies incorporating specific, immediate and long term ecological constraints as a result of climate change was found lacking in most livestock projects that has failed. Specific or targeted research related to climate changes which give solutions to ensure sustenance of individual ecosystems and its herbage and tree shrubs cover and of grazing livestock species for the future taking into account the climatic variability are

necessary. The events in terms of livestock research in Africa have been compromising adaptational traits on the expense of livestock productivity, as a result many livestock species will be unable to cope with the effects of climate change in future if the breeding objectives are not changed. Livestock research should be redirected to consolidate the already adaptational traits which indigenous livestock species possess. The focus of livestock research should change to encompass the animals' ability to survive in stressful environment. Indigenous livestock research locally has been driven by the desire that the local livestock species should match their counterpart in Europe in terms of productivity. With climate change events taking the centre stage such research focus may be counter productive. Indigenous livestock 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 indigenous livestock 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 adaptive measures and capacity need conservable attention to reduce vulnerability especially in smallholder livestock sector. Research geared at development of collaborative work by all stakeholders to support the adaptation of livestock systems to better cope with the negative impact of climate change will be critical. However it is not possible drastically to change the livestock production culture of the livestock producers especially the smallholder farmers for at least for decades to come. To achieve success in livestock research in the context of the uncertainties of climate change it is necessary to look at livestock production system holistically and involve smallholder livestock producers at every stage in the planning and integrating the traditional values on climate change. It is also important that livestock research should have a component of subjecting animals to simulated impacts of climate change. This will assist in substantiating the responses of livestock to nutritional stress, water deprivation and increase in environmental temperatures.

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). Livestock farmers need to be exposed to extension services for awareness creation and climate change innovation adoption to mitigate its effects on livestock production. It seems that commercial livestock producers have access to extension information concerning climate change forecasting, adaptation options and livestock management practices to mitigate the effects of climate change. It is highly unlikely or decrease the probability that smallholder livestock farmers may take up adaptation measures to ameliorate the effects of climate change because of poor flow of information from extension to farmers.

6. Final comment

Livestock production systems need to change through adoption of possible strategies to reduce vulnerability to climate change. Livestock production systems vary widely between different parts of the world and differ substantially in their use of the environment hence the extent of their response to climate change may also differ. The livestock production system 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 livestock producers if adaptive measures are not put in place. Decline in livestock 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 production systems. Research prioritisation should be guided by demands from livestock farmers to curb the negative effects of climate change on production. From climate change centred viewpoint, it is now apparent that there are several adaptation options by which livestock production can survive the negative effects of climate change. These will include choice of adapted livestock species to promote production and appropriate climate change research which are location specific. In future any proposed research on livestock production should consider testing in stressful environment, these calls for simulation studies which will limit loss of adaptive traits in indigenous livestock 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 production. Evaluation of factors that influence livestock farmers to adopt new adaptive technologies to climate change is imperative. Demand for livestock products are projected to increase in Zimbabwe 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 indigenous have stimulated a recent reorientation of livestock production in tropical 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 developing countries suffer inconsistency political support and thus funding, as well as differing scientific capacity. The international community should assist to raise the profile of climate change research in developing countries 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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