(Re) Considering Cattle Farming in Southern Africa under a Changing Climate

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ABSTRACT

Scientists in southern Africa and elsewhere focusing on climate change and agriculture are increasingly demonstrating how livestock, as a highly climate sensitive sector, may be affected by climate change. The Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) observes, for example, that "Projected increased temperature, combined with reduced precipitation in some regions (e.g., Southern Africa) would lead to increased loss of domestic herbivores during extreme events in drought-prone areas" (Easterling et al.). Response and policy discussions around climate change and agriculture in the Southern African Development Community (SADC) region have, however, thus far tended to focus far more on staple crops. The latest projected future temperatures for southern Africa show a clear increase across most models. Further, temperatures in exceedance of tested livestock comfort thresholds are indicated for the future, particularly for those months of most concern to cattle farmers. Enabling adaptation in the livestock sector should thus be a significant focus of a country's response to climate change, particularly in countries where the livestock sector is a critical component of the formal and informal economy. Although innovations are often a primary component of livestock adaptation plans under design, it is now recognized that long-standing approaches to the management of livestock may well have valuable lessons for future adaptation. Such approaches include the reintroduction of genetically diverse and resilient breeds, as well as increased support and incentives for those farmers planning and undertaking such approaches.

1. Introduction

Farming with domesticated livestock has long been a feature of livelihoods on the African continent. In southern Africa, archaeological evidence shows, for example, signs of cattle herding in rock paintings (see Manhire et al. 1986, and others). The Nguni people of eastern southern Africa (the Seswati, Zulu, and Xhosa people) may have grazed with domestic livestock for more than 10 000 yr (Palmer and Ainslie 2010); however, it is also argued that a more likely date for the event of domesticated cattle in southern Africa is 8000 yr ago, or less (Ajmone-Marsan et al. 2010). Cattle farming remains a central feature of rural populations of southern Africa; African Union statistics indicate that on the African continent, pastoralism contributes between 10% and 44% of the gross domestic product (GDP; Abdel Aziz 2011).

In recent years cattle farming in southern Africa finds itself within a vastly different environment, experiencing changes in market demand, public perception, and environmental conditions. Thornton et al. (2009) detail how the dramatically increased global demand for livestock products, such as milk and meat, has begun, inevitably, to change features of livestock production on the African continent, including southern Africa. In many countries in the Southern African Development Community (SADC) region,[1] producers have moved to more intensive types of cattle production, although extensive grazing systems remain essential to farming. In addition, cattle farming in southern Africa has seen the introduction of higher-producing breeds that are suited to farming in a more temperate climate with, in these production systems, less use of hardier, more "traditional" breeds.

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[1] Country members of the SADC community comprise Angola, Botswana, the Democratic Republic of Congo, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zambia, and Zimbabwe.

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TABLE 1. Temperature thresholds critical to cattle heat stress.

Threshold	*Relevant to*
72 THI (22°C at 100% humidity)	Comfort threshold for U.S. Holsteins heat stress (Sanchez et al. 2009; Ravagnolo et al. 2000; Freitas et al. 2006)
72 THI (22°C at 100% humidity)	Comfort threshold for high-producing dairy cows (Hernández et al. 2002); higher for *Bos indicus* breeds (which are highly adapted to heat stress)
27°C	Upper limit of comfort zone for maximum milk production in India, which is 2°C higher than for temperate countries (Sirohi and Michaelowa 2007)
28°C and high humidity	Heat stress begins in most breeds (Agricultural Information Centre, Government of Alberta)
30°C ambient temperature	Point at which *Bos taurus* and *Bos indicus* show differing response to heat stress (Hernández et al. 2002)
32°C	Accepted comfort threshold for most cattle breeds
78 THI	Critical limit for every kind of livestock

Cattle farming further faces a changing physical climate. This article details how those changes are likely to impact farming systems that themselves have undergone changes in response to changing market demands. Livestock farming is vulnerable to climatic risk, yet Thornton et al. (2009, p. 113) note that "…the intersection of climate change and livestock in developing countries is a relatively neglected research area." More broadly, the agricultural sector in Africa is likely to be significantly impacted by climate change, with diminishing options and, possibly, constrained adaptation (Archer et al. 2008; Thornton et al. 2010). The article thus concludes with proposals for enabling adaptation in the livestock sector. I suggest here that such enablement be a significant focus of a country's response to climate change, particularly in (but certainly not limited to) countries where the livestock sector is a critical component of the formal and informal economy.

2. Cattle farming and climate

This article focuses particularly on the implications of higher temperatures for cattle farming, while recognizing that a wealth of research focuses on climate change impacts on forage, and thus on livestock conditions and cattle farming–related emissions, and their role in a country's greenhouse gas inventory. McKeon et al. (2009) provide, for example, a comprehensive overview of the implications of climate change for the carrying capacity in Australian rangelands, effectively undertaking stress testing and recommending a "risk averse" approach to rangeland management based on a suite of best-estimate projections. Less research has focused on the direct impacts of higher temperatures (a consistent prediction from most downscaled models for southern Africa, as discussed below) on cattle farming, yet heat stress and risk implications for cattle have been well documented.

Cattle farming is impacted by increased temperatures in multiple ways. Research has focused particularly on the issue of heat stress. Hansen (2009) describes heat stress as the environment that drives body temperature above a particular temperature threshold, above which key physical functions begin to be disrupted (e.g., feeding and reproductive health). Hansen (2009) also observes that mammals tend to be more tolerant of low temperatures than high temperatures, defining genetic adaptation to higher temperatures as a function of the regulation of body temperature and cellular resistance.

Of particular relevance here is the fact that different cattle breeds have different thermoregulatory capacity. Essentially, locally adapted breeds (those that are either often used or a primary component of breeding in more traditional extensive farming systems) are usually better adapted to higher temperatures. As one example, *Bos taurus* breeds tend to be more productive in temperate climates and tend to be used for their productivity, while *Bos indicus* (such as the well-known Brahman) have better thermoregulatory capacity (Hernández et al. 2002; Olson et al. 2002; Ribeiro et al. 2009).

For cattle, genetic determinants of thermoregulation have been well studied, with, by illustration, important research focused on the superior thermoregulatory capacity of Zebu cattle, including their lower metabolic rate and lesser resistance to the flow of heat from body core to body periphery, and the key role of hair coat properties [the latter also detailed, e.g., in Dikmen et al. (2008), with their analysis of the role of the slick hair gene in thermoregulatory capacity in Holstein cows, as well as Olson et al. (2002), with their analysis of the impact of hair coat differences on heat stress tolerance]. As discussed above, Hansen (2009) observes that those breeds that evolved in hotter climates (such as Brahman) simply thermoregulate better than those that evolved in more temperate environments (such as Angus and Holstein breeds).

From the range of available literature, key thresholds critical to cattle heat stress can be distilled. Selected thresholds are shown in Table 1 below.

Sanchez et al. (2009), Ravagnolo et al. (2000), and Freitas et al. (2006), among others, all indicate a 72 temperature–humidity index (THI; or 22°C at 100% humidity) as the comfort threshold for most U.S. Holstein breeds. Further, studies such as that by Hernández et al. (2002) indicate the same threshold for high-producing dairy cows.

Sirohi and Michaelowa (2007) indicate, however, that the comfort threshold for maximum milk production falls at approximately 27°C, which is 2°C higher than what has traditionally been assumed in more temperate countries. Above this point, heat stress begins to be evident in most breeds, while at 30°C, Hernández et al. (2002, p. 8) observe that this ''seems to be the critical point at which both *Bos taurus* and *Bos indicus* begin to differ in their ability to maintain near normal rectal temperatures and respiratory rates.'' Finally, 32°C appears to be the generally accepted comfort threshold for most cattle breeds.

3. Climate change projections for southern Africa

To date, all downscaled climate change projections for southern Africa indicate higher average, minimum, and maximum temperatures for most months and seasons. Using the Regional Climate Model (RCM) downscalings of the Hadley Center atmospheric general circulation model 3P (HadAM3P) GCM [fifth-generation Pennsylvania State University–National Center for Atmospheric Research Mesoscale Model (MM5) and Providing Regional Climates for Impact Studies (PRECIS) regional climate model (RCMs); see Tadross et al. (2005)], the threshold of 30°C ambient temperature was applied (see Table 1), considering the December, January, and February projected changes in average monthly temperature, and superimposed on observed average temperatures for those months to create an indication of projected future climate.

Figure 1 below shows areas that newly exceed the 30°C temperature threshold for all or at least two of the summer months considered given the projections (both RCM downscalings are taken into account). The north Northern Cape Province of South Africa, close to the border of Namibia and Botswana, is an area of particular concern, newly exceeding 30°C in all of the summer seasons, as does eastern interior Kenya (although it is recognized that the latter cannot strictly be considered as being restricted to ''summer'' months).

Recent analysis undertaken at the Council for Scientific and Industrial Research's (CSIR's) Climate Studies, Modeling and Environmental Health Group on selected updated scenarios for South Africa uses six high-resolution simulations [Conformal Cubic Atmospheric Model (CCAM) dynamic downscalings] over the southern African region for the period 1961–2100 under the A2 emission scenario. Analysis of these downscalings for critical heat stress thresholds indicates an increased likelihood of exceeding the 30°C threshold in air temperature for southern Africa, with the number of days in exceedance increasing further into the future (e.g., for the 2011–40 and 2041–70 periods versus 1961–90), particularly for the northern interior (F. Engelbrecht 2011, personal communication). Research is currently underway to incorporate future projections of humidity over the SADC region to create indications of future anomalies in THI. One outstanding complication here is the dearth of robust observed relative humidity records in many SADC countries.

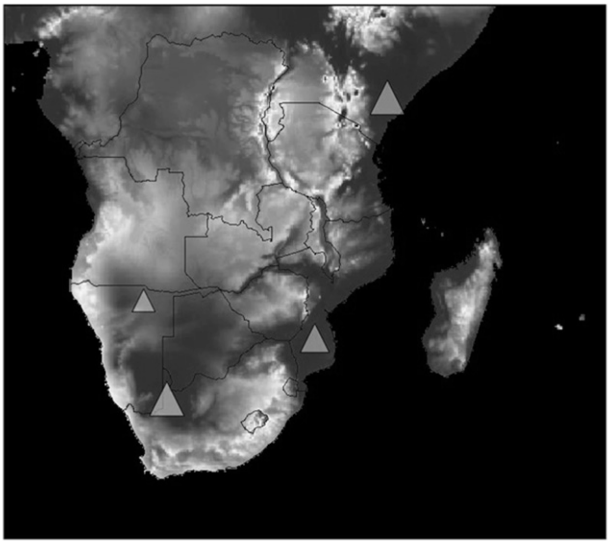

FIG. 1. Areas newly exceeding the 30°C threshold for at least two summer months.

4. Adapting cattle farming in a changing climate

It is evident that cattle farming in southern Africa will almost certainly experience a higher risk of heat stress in the future, along with other projected climate changes of concern detailed elsewhere. Clearly, as shown above, more extensive and, under certain circumstances, more traditional livestock management systems may hold critical tools for adapting to increased future climate risk.

For example, Moonga and Chitambo (2010, p. 1) observe that ''well adapted traditional livestock breeds will, most likely, play a very significant role in adaptation to climate risk.'' Blümmel et al. (2010) consider traditional breeds and higher genetic diversity to be critical for increased resilience of livestock production systems. They indicate that the improvement of breeding programs needs to be a priority, with particular support provided to research that provides improved matching of appropriate genetic resources. These authors propose that ''conservation needs to be considered as an important component of a broad-based strategy to conserve critical adaptive genes and genetic traits'' (Blümmel et al. 2010, p. 139).

What remains unclear, however, is how to provide effective policy and marketing incentives to promote the use of more appropriate breeds as part of more resilient cattle farming systems. From the policy perspective, while Kenya's National Climate Change Response Strategy (Government of Kenya 2010) prioritizes livestock as an area for policy support, by including the recommendation to create special livestock insurance schemes to either spread or transfer climate risk impacts on the livestock sector (with a particular focus on northern Kenya), the South African Green Paper on Climate Change Response (Department of Environmental Affairs 2011), for example, focuses far more on staple grain and high-value crops than on livestock. Although agriculture, in the South African context, is considered a priority area for targeted adaptation support in the short to medium term (together with water and human health), only a few of the highlighted impacts refer to livestock, and identified adaptive responses (Department of Environmental Affairs 2011, p. 11) focus mainly on crops. Finally, in Mozambique, the study ''Impacts of climate change on disaster risk in Mozambique'' (Phase I; INGC 2009), completed in May 2009 by the National Institute for Disaster Management (INGC), focuses on the implications of climate change for the country, with agricultural studies focusing purely on crop modeling (a continuing focus in phase 2 of the program).

Considering the SADC as a whole, in the SADC Science and Technology Implementation Framework to Support Climate Change Response currently in preparation, participants from all SADC member states were asked to indicate priority needs for four key areas—systematic observation and monitoring; impacts, vulnerability, and risks; mitigation; and adaptation—as well as cross cutting needs. Livestock features very little explicit mention in the emerging documents.

The key question facing the livestock sector thus entails what would be required to create a supportive policy and market environment for enabling adaptation. First, national (and regional) policy and strategy specifically addressing climate change and the agricultural sector in southern Africa need to accord higher priority to livestock sector support. This should include increased attention to the feasibility of livestock insurance schemes, tested elsewhere on the continent, as well as substantively increased funding for research and development in the livestock sector, matching that committed to staple crops.

One key focus would be on livestock breeding for higher temperatures and breed–site matching. A focus on impact modeling for staple crops and on livestock impacts need not be at odds, however. In fact, research on climate change impacts on the agricultural sector in southern Africa should rather look at synergies between the approaches and initiate studies of a more ambitious scope in this regard. Further, although this article has focused particularly on heat stress impacts on cattle, other stressors interact with heat stress and should be considered (such a focus was, however, beyond the scope of this article). In both humans and livestock, water supply and quality challenges diminish thermoregulatory capacity, as does poor fodder quality and the presence of disease. All of these factors are likely to be affected by climate changes in southern Africa, and future research that focuses on their interactions, as well as the relative resilience of different types of livestock production systems facing these multiple stressors, would be welcomed.

Second, both policy and market environments need to effectively incentivize adaptation in the livestock sector, such as supporting the choice to use less productive but more resilient so-called ''traditional'' breeds. Increased attention has long been paid to how prices paid for agricultural commodities may better reflect producer choices and incentivize more resilient types of production. The extension of such schemes to the livestock industry in southern Africa is still very much in its infancy. Increased government support, whether at the provincial, national, or SADC level, is essential, and would greatly facilitate this process. The debate on so-called traditional breeds is, however, more complex, as acknowledged in a number of studies; tradeoffs for production, performance, and reproductive rates would have to be carefully assessed. More attention to the issue would, however, make such debates better informed and more accessible to both land managers and policy makers.

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