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Impacts of climate change and variability on cattle production in southern Ethiopia: Perceptions and empirical evidence

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ABSTRACT

Climate change and variability can severely constrain the productivity of pastoral herds by reducing water availability, forage production and quality, and hence the carrying capacity of rangelands. In particular, the risk of heavy livestock losses suffered during recurrent severe droughts associated with climate change and variability presents one of the most serious threats to pastoral livestock keepers. To generate insights into how climate change and variability adversely affect cattle production in the Borana of southern Ethiopia, we analyzed perceptions of herders and long-term changes in cattle numbers and climate data. A total of 242 households were surveyed to generate data on perceived trends in climate, rangeland condition and livestock production. Socio-demographic characteristics of households and cattle mortality due to the 2010/2011 drought were also recorded. Using a local time calendar, cattle herd history was reconstructed for a period spanning five major droughts to portray the linkage between changes in cattle numbers and changes in rainfall and temperature. Most of the herders perceived that rainfall has become more unpredictable, less in amount and shorter in duration, while drought recurrence and temperature have increased. Similarly, the majority perceived a decreasing trend in cattle herd sizes and their production performances. The 2010/2011 drought was associated with a substantial decline in cattle herd sizes due to increased mortality (26%) and forced off-take (19%). Death occurrences and mortality rates varied significantly by district, herd size and feed supplementation. Spectral density analysis revealed a quasi-periodic pattern in the annual rainfall with an approximate cycle period of 8.4 years, suggesting that droughts recur approximately every 8.4 years. A downward trend in cattle population mirrored a similar underlying trend in the interannual rainfall variation. Accordingly, changes in cattle number were significantly linked with changes in rainfall. In conclusion, perceptions corroborated by empirical evidences showed that climate change and variability were associated with declining cattle numbers, portending a precarious future to the sustainability of cattle pastoralism in southern Ethiopia and other pastoral systems.

1. Introduction

Traditional pastoral cattle production is the major livelihood strategy for the Borana community of East Africa (Cossins and Upton, 1987; Coppock, 1994). The possession of cattle, therefore, constitutes an integral part of the social, economic and ritual life of the people. An individual without cattle may not qualify to fulfill the requirements of certain social standards or to execute certain social obligations (Tache and Sjaastad, 2010). In comparison to other pastoral livestock, the Borana cattle herd productivity was found to be higher due to their remarkable production and reproductive performances, low mortality rates, and suitability for arid environments (Cossins and Upton, 1988b). At present, however, the Borana production system is coming under increasing pressure from various stressors, including human population growth, degrading and shrinking rangelands, insecure communal land

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rights, market failures, and recurrent climatic shocks (Desta and Coppock, 2004; Angassa and Oba, 2007; Homann et al., 2008; Tache and Sjaastad, 2010). Climate change, especially increasing frequency and intensity of droughts, accentuates the impacts of these stressors and thus, undermines the traditional coping strategies and deepens the vulnerability of the Borana pastoralists. Cattle are the livestock species most susceptible to water and feed shortages engendered by climate change (Seo et al., 2010). As a result, the Borana herders, who have historically been cattle pastoralists, are reportedly responding to environmental changes by adjusting their herd composition, i.e., keeping more tolerant species such as camels and goats (Zander, 2011).

Long-term changes in regional or global climate, in particular increasing temperatures, declining and changing precipitation patterns are typically used to assess climate change and its associated impacts (IPCC, 2007). For Africa, the available evidence highlights a greater importance of the trends and variability in precipitation (Funk and Verdin, 2009; Williams and Funk, 2010, 2011; Omondi et al., 2012; Viste et al., 2013; Williams et al., 2012) over similar changes in temperature (Collins, 2011). This stems from the immediate detrimental effects of droughts on livelihoods that are dependent on rain-fed cultivation or pastoralism. Accordingly, climate change has already brought about observable changes in East Africa, such as declines in rainfall, changing rainfall seasonality, and increasing frequency of droughts (Funk and Verdin, 2009; Williams and Funk, 2010, 2011). There is also documented evidence of declining rainfall in Ethiopia (Cheung et al., 2008; Viste et al., 2013) with a significant decrease in the long rains (March–May) in the southern part of the country (Viste et al., 2013). East African rainfall is characteristically bimodal, and is largely influenced by atmospheric and oceanic forcing through rising sea surface temperatures and the El Niño-Southern Oscillation (Omondi et al., 2012). Williams and Funk (2011) suggested a strong link between recurrent droughts in East Africa and rising Indian Ocean temperatures caused by anthropogenic warming. Consequently, the downward trend in the long rains (March–June) that observed over the past 30 years in Ethiopia and Kenya has been attributed to climate change (Funk and Verdin, 2009; Williams and Funk, 2010).

Droughts have been anticipated to occur every five to six years in the Borana rangeland (Desta and Coppock, 2002), but both their frequency and severity may be rising. Droughts deplete cattle population through heightening mortalities and forced off-takes. Warming and drying trends in climate negatively affect the rangeland productivity by lowering the quantity and nutritional quality of forages besides causing water scarcity (Thornton et al., 2009; Nardone et al., 2010). Rising temperatures aggravate the influence of moisture stress on plant growth and thermal stress on animals. Increasing drought frequencies may unevenly affect plant communities, lowering the herbaceous biomass while potentially facilitating the invasion of vigorous woody plants (Hiernaux et al., 2009). Decreasing precipitation reduces the primary production and forage quality. It lowers soil moisture, which in turn affects nitrogen (N) cycle and reduces the amount of nitrogen available for plant uptake (Beier et al., 2008). Moreover, soil N content is already deficient in moisture-stressed arid environments (Delgado-Baquerizo et al., 2013). Projected drier and warmer conditions as a consequence of climate change are therefore likely to worsen N deficiency and to adversely affect the growth and nutritional quality of plants. Likewise, Craine et al. (2010) have demonstrated that declining precipitation and rising temperatures decrease the crude protein and digestible organic matter contents of plants. Consequently, low levels of N along with reduced levels of fermentable energy contents of forages can be expected to adversely affect rumen microflora and impair microbial protein synthesis (Calsamiglia et al., 2010). These conditions hamper the production and reproduction performances of cattle, and hence their population growth.

Previous studies have either focused mainly on assessing effects of droughts on cattle mortality (Cossins and Upton, 1988a) or on relating long-term rainfall variability and grazing pressure to cattle mortalities (Desta and Coppock, 2002; Angassa and Oba, 2007). These studies have documented a strong influence of rainfall variability on changes in cattle numbers, but have produced mixed results regarding the effect of grazing pressure on variation in cattle numbers. However, the relationship between trends in precipitation and temperature, and contemporaneous trends in cattle numbers have attracted relatively little attention thus far. Hence, understanding the relationship between changing trends in climate and cattle numbers would advance our knowledge regarding the impacts of local climate changes on animal breed (species) biodiversity and pastoral livelihoods (Thornton et al., 2009). Documenting herders' perceptions of the changes in climate, rangeland and livestock productivity over time could reinforce the available empirical evidences. This study therefore aimed at investigating the linkages between temporal changes in precipitation and temperature and concurrent changes in cattle numbers in southern Ethiopia.

2. Methods

2.1. Study area

The study was conducted in Dire and Yabelo districts in the Borana zone of Oromia Regional State, southern Ethiopia (Fig. 1). The Borana zone is predominantly inhabited by the Borana Oromo, and borders Kenya to the south, Somali Region to the south-east, the Southern Region to the west and north, and the Guji zone to the north-east. The climate is generally semi-arid with an average annual rainfall ranging from 300 mm to 600 mm and average daily temperature ranging from 19 °C to 26 °C (Coppock, 1994). The area has a bimodal rainfall distribution, with the long rains "*Ganna*" extending from March to May and the short rains "*Hagaya*" from September to November. A cool dry period "*Adoolessa*" (June to August) bridges the two rainy seasons, while a warm dry season (major dry season) "*Bona Hagaya*" runs from December to February (Coppock, 1994; Angassa and Oba, 2007).

Droughts have frequently hit the Borana area, causing heavy livestock mortalities, particularly of cattle (Desta and Coppock, 2002; Angassa and Oba, 2007). Drought is an extreme weather event, which results when rainfall is far below average (failure of rainfall). In Borana area, droughts occur either due to failure of the long rains or below-average values of both the short and the long rains. Failure of the short rains alone may not result in drought if the long rains resume timely and traditional coping strategies are properly implemented. A range of strategies have been developed by Borana herders to cope with feed and water shortages, and to reduce risks related to droughts. These include moving herds between seasonal grazing areas, splitting herds into mobile and homestead milk herds, and reserving grazing areas for calves and weak animals. Veterinary treatments (e.g., parasite treatments) also increase during the dry periods because animals lose their body conditions due to heightened water and food shortages, and become more susceptible to diseases. Diversification of herd species compositions, i.e. keeping camels, sheep and goats along with cattle, is also increasingly being practiced in response to changing environmental conditions (Homann et al., 2008; Zander, 2011). The traditional social security system "*Busa gonofa*", which obliges the clan members to redistribute animals to those clan mates who lose their livestock, is also a notable local ex-post risk management strategy (Tache and Sjaastad, 2010).