



## Research article

# Indigenous ecological knowledge as the basis for adaptive environmental management: Evidence from pastoralist communities in the Horn of Africa



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## ABSTRACT

The proliferation of woody plants has been observed on rangelands globally and has significant impacts on subsistence livestock production. However, adaptation strategies to such environmental changes remain largely unexamined. This paper investigates pastoralists' adaptations to such environmental changes in the Borana zone of southern Ethiopia by integrating pastoralists' ecological knowledge, surveys of plant species composition, and census data on livestock holdings. The results indicated that a proliferation of woody plants and corresponding decline in herbaceous species would have negative impact on forage values for cattle and sheep, whereas goats would remain relatively unaffected, and camels would benefit. While census data showed declines in household herd size from 2000 to 2014, pastoralists have been adapting to the proliferation of woody plants by doubling their goat holdings, and wealthier households are investing in camels. These changes in livestock holdings based on indigenous ecological knowledge will mitigate the negative impacts of vegetation shifts on livestock production, and facilitate adaptive environmental management in the pastoral systems.

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## 1. Introduction

Savanna ecosystems, which are characterized by an open canopy of trees and shrubs with an unbroken layer of herbaceous plants, cover one-fifth of the world's land surface and are ecologically and socioculturally important (Riginos, 2009). These lands support millions of pastoralists whose livelihoods depend primarily on their forage resources (Wiegand et al., 2006). In recent decades, the species composition and physiognomic structure of savannas throughout the world have experienced significant changes for a variety of reasons, including suppression of fires, increased livestock density, and climatic changes (Anadón et al., 2014; Briggs et al., 2005; Buitenwerf et al., 2012; Gartzia et al., 2014; Gillson and Hoffman, 2007; Naito and Cairns, 2011). It is widely accepted by both herders (Angassa and Oba, 2008) and ecologists (Gemedo-Dalle et al., 2006) that pastoral livelihoods are affected when

woody plants replace graminoids and forbs on rangelands (Kgosikoma et al., 2012; Solomon et al., 2007). In places where cattle are the dominant livestock type, a reduction in the amount of palatable herbaceous forage species results in a shortage of food to meet animals' nutritional demands, thus negatively affecting subsistence herding communities. Addressing this problem is important to the food security of pastoralists, particularly those who keep cattle-dominated herds.

Pastoralism has long been considered a livelihood strategy that is well adapted to the disequilibrium inherent to rangeland ecosystems (Behnke et al., 1993). Pastoralists have developed a wide range of adaptive strategies to respond to socio-environmental change, which are summarized in terms of five broad categories: mobility, storage, livelihood diversification, communal pooling, and market exchange. These strategies allow risk to be spread across space, time, and asset sectors (Agrawal, 2010). Indigenous herding systems emphasize flexibility over stability, so that the entire pastoral system can maintain functionality while recovering from socio-environmental shocks (Leslie and McCabe, 2013). However, many pastoralists are reporting unprecedented rates and

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magnitudes of rangeland vegetation shift toward a woody plant-dominated regime, which has severe impacts on the fundamental resource base for livestock production (Angassa and Oba, 2008). Therefore, it is imperative to search for alternative adaptation strategies that would bear similarities to traditional pastoralism while involving novel elements to address the challenges of rangeland vegetation regime shifts.

Indigenous ecological knowledge is an essential component of adaptive environmental management (Berkes, 1998; Kassam, 2009; Turner and Clifton, 2009). Pastoralists' decisions regarding the movement and diversification of livestock are based primarily on their ecological knowledge (Knapp and Fernandez-Gimenez, 2008). Given the depth of pastoralists' knowledge of their rangelands, they can make critical contributions to policies related to rangeland management. Specifically, pastoralists hold a rich body of knowledge on forage plant species and rangeland vegetation dynamics (Kaye-Zwiebel and King, 2014; Kgosikoma et al., 2012). Documentation and analysis of pastoralists' ethnobotanical knowledge and perception of rangeland vegetation regime shift can provide context-specific and empirically-grounded recommendations for policies that will facilitate adaptation to woody plant proliferation, and thereby enhance the resilience of both human communities and the savanna ecosystems of which they are part.

Boran pastoralists, who herd livestock on the savannas of southern Ethiopia, have developed rich ethnobotanical knowledge based on subsistence livestock production and rangeland management (Gemedo-Dalle et al., 2005). This knowledge, including an awareness of the palatability of forage species for their different livestock types (cattle, camels, sheep, and goats), is the basis for context-specific adaptation to the proliferation of woody species in their rangelands (Angassa and Oba, 2008). Unfortunately, previous investigations of Boran knowledge related to the palatability of forage plants have been far too generalized to provide insights for adaptation (Angassa and Oba, 2010). For example, the first comprehensive ethnobotanical study in Borana documented 327 plants (Gemedo-Dalle et al., 2005), including 188 with reported forage values for livestock, but did not report differences in palatability between domestic animal species. Lack of animal-specific data on forage palatability is a barrier to the development of effective policies to guide pastoralists' livestock management.

Furthermore, there is a clear disconnection between studies of rangeland vegetation dynamics and those of livestock holdings. On the one hand, substantial research has focused on changes in rangeland vegetation and provided strong ecological evidence for the proliferation of woody plants in Borana (Angassa and Oba, 2008; Tefera et al., 2007). On the other hand, surveys of livestock holdings have found fluctuations over time and a general shift from grazers towards browsers (Homann et al., 2008; Megersa et al., 2014b). However, studies of woody plant proliferation are yet to be integrated with those of changes in livestock holdings so as to determine if the changes in vegetation referred to as 'bush encroachment' are a significant threat to pastoralists' livelihoods, or if these pastoral communities are adapting to these environmental changes by shifting their livestock holdings. Building on pastoralists' knowledge of the palatability of forage species, as well as their perceptions of vegetation change, we can simulate the effects of woody plant proliferation on each livestock species and determine if outputs correspond with pastoralists' ongoing adaptation strategies in terms of the composition of their herds.

Thus, the overarching goal of this paper is to investigate the implications of rangeland vegetation shifts on livestock production in the Borana Zone of southern Ethiopia, and to assess the connection between shifts in herd composition and environmental changes on the rangelands. We began by asking pastoralists about

forage plant species and their palatability to cattle, sheep, goats and camels. Next, we conducted a vegetation survey to measure current species composition. We used pastoralists' assessments of forage value and our own measurements of plant abundance to simulate change in species composition, and measure the impacts on palatability for the four livestock species. After that, we compared these projections with data on livestock holdings between 2000 and 2014 to determine if the trends in our simulation align with pastoralists' own decisions regarding herd composition. In closing, we consider the implications of our research findings for adaptive environmental management.

## 2. Study area

The Borana Zone is located in southern Ethiopia at elevations ranging from 500 to 2500 m above sea level. The terrain varies from rugged highlands to plains dissected by seasonal river and lake beds in the lowlands (Fig. 1). Approximately 43,000 km<sup>2</sup> in size, Borana is home to over 350,000 people with a livestock population around one million (Coppock, 2010). The climate is semi-arid with relatively cool average annual temperatures (19–24 °C) and a mean annual rainfall ranging from 300 mm in the lowlands to 1000 mm in the highlands. The annual precipitation distribution is bimodal, with 60% occurring during the long-rain season (April to May) and 30% during the short-rain season (September to November) (Desta and Coppock, 2002; Vrieling et al., 2016). Drought typically strikes the grazing system every five to ten years (Coppock, 1994); however, in recent decades, the frequency and intensity of droughts are increasing (Funk et al., 2008); in general, weather conditions are becoming more extreme and unpredictable (Abule et al., 2005).

Livestock herding is the primary livelihood strategy for the Boran. There are four major livestock species (cattle, camel, goat and sheep) in the Borana Zone, which are used for various purposes including milk/meat production, cash revenues from sales of live animals, socio-cultural functions (e.g., gifts, dowry, ceremonial slaughtering), draught power and manure. Comparing to cattle and camels that are more commonly kept for milk, sheep and goats are more generally raised for meat (Megersa et al., 2014a). According to Cossins and Upton (1987), the Borana rangelands before the 1980s were very suited for cattle grazing. Consequently, livestock herding largely revolves around cattle husbandry (Homewood, 2008), and the local culture and social institutions are closely related to cattle herding (Legesse, 2000). Specifically, cattle herding is generally practiced in two forms. One form is *worra* (home-based herding), which involves the herding of lactating cows, calves, and small ruminants close to settlements. The other form is *forra* (satellite herding), where temporary camps are used to graze bulls and non-lactating cows at substantial distances from base camps. *Forra* herding allows livestock to range more widely and have access to better forage than what might be available near settlements (Homewood, 2008). These two forms of herding are not mutually exclusive, as one household can practice both simultaneously.

Boran pastoralists have been using fire as an important tool for rangeland management. When the woody plant layer becomes denser and suppresses herbaceous plant growth, pastoralists set fires to reduce woody plant cover. However, the Ethiopian government implemented a bush burning ban in the 1970s for rangeland conservation purposes. Not surprisingly, a proliferation of woody plants in Borana was reported by scientists around the same time (Coppock, 1994). By the 1990s, in some parts of Borana, woody plant cover exceeded 60%, with densities approaching 2000 woody plant individuals per hectare. The species that tended to increase the most after fire suppression included *Acacia mellifera*, *Acacia reficiens*, and *Commiphora* spp. (Angassa and Oba, 2008).

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