# Can Bush-Clearing, Deferred Grazing, or Camels Help Mitigate Climate-Change and Population Effects for Borana Pastoralists? An Economic Analysis of Potential Interventions

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Research Brief

*Feed the Future Innovation Lab for Collaborative Research on Adapting Livestock Systems to Climate Change*

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## Abstract

*An economic analysis of strategies to increase the resiliency of pastoral communities on the Borana Plateau is presented. Populations of people and livestock have grown in recent decades in this area. As a result of overgrazing and lack of fire, woody bush has proliferated and reduced grass forage for cattle. Droughts here are also perceived to be more frequent and severe as a result of climate change. One consequence of an increasing population and more frequent drought is that food aid has become pervasive in the system, and pastoral communities have become less resilient to drought. This analysis is based on a linear programming (LP) model, and examines possible land and livestock interventions for the Harweyu Pastoral Association that could mitigate population and climate-change effects. These include altering the mix of livestock species (introducing more browsing camels relative to grazing cattle), clearing bush, and expanding deferred grazing practices (kalo) to allow more grass forage to be available in the long dry season. Results suggest that increasing camels could yield some modest improvement to the system, but clearing bush on a large-scale (33% of the landscape) would have very positive impacts on the ability of people to sustain cattle production; it could also reduce dependence on food aid by almost 30%. However, local communities do not have the resources to take on the cost of large-scale bush clearing themselves. If an endowment of land cleared of bush was provided, the community would have the resources and economic incentive to keep the land cleared into the future, thereby promoting resiliency and sustainability of the pastoral system.*

## What Options Could Help Pastoralists Better Cope with Population Growth and Climate Change?

Communities on the Borana Plateau need options to mitigate effects of chronic overgrazing and an increasing frequency of drought. Decades of heavy grazing by livestock and lack of fire have led to bush encroachment and soil erosion. This has resulted from growing populations of people and animals that overwhelm traditional rules for proper rangeland management. Bush encroachment, in turn, dramatically reduces grass production, while soil erosion leads to permanent destruction of the rangelands as well as flooding and high rates of pond siltation that undermine vital water supplies. Drought causes many livestock to suddenly die and results in pastoralists becoming poorer and at risk of famine. When pastoralists are hungry the food aid arrives.

There are several approaches that could be considered that pertain to improved management of land and livestock. This could help make the system more sustainable. One option is to facilitate camel production because—unlike grazing cattle—browsing camels can subsist on the leaves and twigs of woody vegetation; they can consume at least part of the spreading bushland. Camels also are more reliable milk producers than cattle during drought. Another option is to clear bushland, allowing the grassland to recover to support more cattle. More cattle means more milk, and hence less food aid.

*Example of a bush-encroached site (left) and an adjacent, cleared site (right) at Harweyu PA in 2013. Note the difference in forage yields. (Photo credit: Brien E. Norton)*

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The Boran are already attempting to do some of these things themselves. For example, the percentage of camels in livestock holdings is on the increase. Pastoralists are engaging in bush clearing using simple hand tools, although this is laborious work. Pastoralists have also been creating kalo for a number of years, namely protected sites that offer deferred grazing opportunities for young or sickly animals. When kalo sites are protected, forage standing crops increase and the ratio of nutritious grasses to less desirable herbs or forbs increases.

We were interested in making an economic assessment of the value of bush clearing and multi-species livestock production. The types of questions we wanted to answer included: Is clearing bush economic—in other words, do the returns merit the costs? Given the current resource trends and productive attributes of the livestock, are camels really a viable alternative to cattle? What could be the effect of bush clearing on reducing food aid to the human population? Is deferred grazing useful in better managing forage supplies at the landscape level?

## A Model Community: Harweyu Pastoral Association

Our analysis focused on a Pastoral Association (PA) called Harweyu. Information for people living in Harweyu was gathered at the household level and then aggregated to the community level to complete the analysis. Food aid is commonly distributed to the hungry in the study area, which are the poorer households, even during normal rainfall years. The livestock numbers for 2013 are lower than what the PA can actually carry. A drought in 2011 reduced the herds, so they are currently in a rebuilding phase. Almost all (95%) of the land area at Harweyu is bush-encroached. It used to be more of a savanna with a mixture of grasses and trees several decades ago.

## The Linear Programming Model and Explanation of How were Data Sets Constructed

A linear program (LP) was used to conduct the economic analysis. The LP assumes that members of the community maximize income from selling crops and livestock products (milk and older animals) and subtracts the cost of raising crops and livestock, household expenses (including schooling and medical), buying food, clearing bush, and developing kalo. Resource constraints in the model included the need to meet minimum nutritional needs of the human population (calories per day), the number of livestock, the land available to the community, and the labor available to the community.

*Dromedary camels on the Borana Plateau. The percentage of camels has been increasing in livestock holdings in the past 20 years.*
*(Photo credit: Brien E. Norton)*

Very large data sets were used to build the model. In addition to seasons, years of average rainfall and drought years were considered. The data sets included the human population numbers, family composition by age and gender, the diets and energy requirements of all the people in the community, the patterns of household expenses, and how family labor is allocated for all tasks. For the rangelands, data concerning forage production, wastage losses, and consumption by livestock was included. This considered the grass component, the herb (forb) component, and the browse component. For the livestock, data sets included numbers, age and sex classes for each species, body sizes and demand for feeds according to feeding habits and lactation. Market prices for local commodities and the costs of labor were also incorporated. Drought was simulated in the analysis by reducing grass, forbs, and browse production by 75%, 50%, and 20%, respectively, compared to a normal rainfall year.

## LP Scenarios

A variety of model scenarios were used in the LP exercises. These included scenarios based on whether: (1) Rainfall is normal or a drought is occurring; (2) the livestock herd is in a rebuilding phase following an earlier drought or is at full carrying capacity; (3) a certain amount of land has already been cleared or not (sunk cost creating a cleared land endowment); and (4) kalo have been developed earlier or not (sunk cost providing a kalo endowment)[1]. Considering an existing endowment of land either cleared of bush or developed with kalo is important in determining how large these endowments would need to be to reduce the long-run dependence on food aid in the area. The endowments of cleared land and kalo were considered to have only minimal maintenance costs and labor requirements. Consequently, the LP selected the number of hectares of cleared land and kalo necessary to maintain livestock numbers when these endowments were present. For drought scenarios, human caloric intake for the community is assumed to be 10% less than normal assuming that a certain level of fewer calories could sustain the human population before food aid was required.

## Results

The LP results indicated the community of Harweyu is self-sufficient, overall[2], during years of average rainfall because income (value of the objective function) is positive for all scenarios assuming normal rainfall. However, during a drought year, milk production decreases dramatically, crops fail, grain prices increase, and there is insufficient forage to support livestock numbers—all of which result in dramatic decreases in income levels and dramatic increases in food aid[3] needed during droughts.

Drought scenarios with no bush clearing or kalo endowments suggest that a severe drought will result in a loss of approximately 70% of the cattle in the system (DC in Table 1) either through off take or death loss. This seems reasonable given past research about drought effects here. Normal rainfall scenarios are the only ones selecting small ruminants (sheep and goats) to be in the system (Table 1). The reason for this is that during droughts grass and forbs production is greatly reduced and remaining herbaceous production is used for cattle. This places small ruminants in direct competition for low-level browse with camels and the LP selects camels over small ruminants when this happens because camels produce more milk (especially during dry periods) than small ruminants and are more valuable on a per head basis when they are sold. This result suggests the increasing number of camels in the Borana Plateau is a rational response in the face of frequent droughts. While there is pressure to supplant small ruminants with camels as a response to drought, small ruminants are unlikely to disappear from the Borana Plateau. Sheep and goats can easily

be sold to meet short-term household needs requiring relatively small amounts of cash. Sheep also have traditional value in rituals, but are more susceptible to disease than goats. This suggests that sheep and goats will continue to be part of the livestock mix, but the number of camels will continue to increase.

The LP suggests a staggering amount of resources would need to be devoted by the community of only 3,057 people in order to clear enough bush to maintain livestock herds at full capacity during droughts [between approximately 13,000 and 18,700 hectares (see Table 1)]. Less land would need to be cleared if kalo were developed because the forage is preserved for the long dry season, the time of year when forage is least available (Table 1). Once land is cleared, only a small amount of labor and other resources would be needed to keep the land free of bush. The analysis suggests the community could bear the costs of maintaining cleared land and kalo if there was an "endowment" and the upfront resources to establish them were not borne by the community.

Even clearing bush and establishing kalo will not eliminate the need for food aid during droughts (Table 1). But, food aid assistance could be reduced by almost 30% if large-scale bush clearing is undertaken (compare DC to DCK in Table 1). However, our calculation of the costs to clear enough bush and establish enough kalo to support livestock numbers at full capacity is over $1,600 per person in the community per year for five years while food aid costs per recipient are estimated to not exceed $500 per person during a drought. This suggests that the cost of bush clearing and/or kalo development cannot be justified solely by savings in food aid costs.

However, further simulation of conditions (income) for the community over a 10-year period revealed that the introduction of bush clearing and kalo development increase average community income and reduce the standard deviation of income compared to a scenario where no large-scale bush clearing and/or kalo development is undertaken. This suggests that clearing bush and/or developing kalo is an effective method to increase the resiliency of the community. However, costs for clearing bush and developing kalo are high and may not allow for the large-scale implementation of such an intervention.

## Conclusions

Increasing average income and reducing risk for this pastoralist community would have many positive outcomes. Doing so elevates the livelihoods of the people in the study area because boom-and-bust cycles related to drought effects on livestock are extremely disruptive. These disruptions make it challenging to plan for the efficient use of resources and, perhaps most importantly in terms of the future, make it difficult for the people to accumulate wealth. Our results suggest the resiliency and future of the Harweyu community would be greatly enhanced if a significant amount of land were cleared of bush and/or developed into kalo. However, this would need to be done at a significant cost and on a very large scale relative to the size of the community (3,057 people). External investments in bush clearing and kalo development cannot be justified by savings in food aid expenditures (Table 1) because food aid will continue to be required to meet the nutritional needs of the people living in the community during drought years even if a large amount of bush is cleared and kalo are developed. The greatest benefit to the community, and the one that increases its resilience, is that community members will be able to quickly recover from drought since livestock numbers will be maintained as a result of the land being cleared of bush and the development of kalo.

Our results also support the idea that changing the livestock complement to include more camels helps the resiliency of the community during drought. Female camels lactate longer than female cattle, thus providing the community milk during the driest months of the year. Camels also can consume a small portion of the browse provided by the heavy bush encroachment in the study area, while cattle require grass to survive. However, it is important to note that most of the major bush species have little forage value for camels. Our results also suggest that the number of camels in the study area will probably continue to increase while sheep and goats—the competitors with camels for browse at the lower levels of the bush canopy—may decrease. However, if large-scale land clearing and kalo development is undertaken, less browse will be available but more grass will be produced with the result being that cattle will be increasingly selected over camels. Cattle are the true "economic engine" of the system, and enhancing the sustainable productivity for cattle is the wisest course of action.

*Table 1. Summary of expenses and revenue (Birr) for Harweyu PA for various LP scenarios. (Source: Forrest 2014)*

| | Scenarios | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Variable** | **NC [a]** | **NR** | **DC** | **DR** | **DCB** | **DRB** | **DCK** | **DRK** |
| Objective Function [b] | 1.98E+07 | 5.41E+06 | (1.40E+07) | (1.42E+07) | (1.08E+07) | (1.30E+07) | (1.00E+07) | (1.26E+07) |
| Implied Cost of Food Aid [c] | - | - | 2.80E+07 | 2.84E+07 | 2.16E+07 | 2.60E+07 | 2.00E+07 | 2.52E+07 |
| Implied Tonnes of Food Aid [d] | - | - | 1,400 | 1,420 | 1,080 | 1,300 | 1,000 | 1.260 |
| Hectares Bush Cleared [e] | - | - | - | - | 18,721 | 5,869 | 12,890 | 2,744 |
| Hectares Kalo Developed [e] | - | - | - | - | - | - | 2,273 | 1,218 |
| Cattle [f] | 16,700 | 8,700 | 5,045 | 5,048 | 16,700 | 8,700 | 16,700 | 8,700 |
| Camels | 1,583 | 900 | 1,266 | 900 | 796 | 900 | 942 | 900 |
| Goats | 7,583 | 6,200 | - | - | - | - | - | - |
| Sheep | 5,384 | 4,200 | - | - | - | - | - | - |
| Equines | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 |

[a] NC= normal rainfall with livestock at capacity; NR = normal rainfall with livestock numbers in rebuilding phase; DC = drought with livestock at capacity; DR = drought with livestock in rebuilding phase; DCB = drought with livestock at capacity and an endowment of land cleared of bush; DRB = drought with livestock in rebuilding phase and an endowment of land cleared of bush; DCK = drought with livestock at capacity and an endowment of land cleared of bush and kalo developed; and DRK = drought with livestock in rebuilding phase and an endowment of land cleared of bush and kalos developed;
[b] Numbers reported in parentheses are negative.
[c] The implied cost of food aid is estimated assuming the cost for agencies to purchase, deliver and distribute food aid would be double the cost of what community residents would pay for food if it were available in the local community. This means for scenarios with negative values for the objective function that the cost of food aid was estimated by multiplying the objective function by two.
[d] The implied physical quantity of food aid was calculated by dividing the cost of food aid by $1,000 (approximate average cost of a metric tonne of food aid delivered by USAID (US House of Representatives 2014) and then dividing by 20 to convert Ethiopian Birr to USD (XE.com 2014).
[e] Figures reported for amount of land cleared of bush and kalo developed were selected by the LP assuming only maintenance costs for these activities and also assuming the number of livestock that needed to be maintained through a drought.
[e] Maximum livestock numbers depended on whether the livestock complement was considered to be at current numbers or at capacity (see Table 1). However, the numbers reported in this table were selected by the LP and do not necessarily need to equal the numbers for livestock reported in Table 1.

## Footnotes

[1] Early LP analysis showed that bush clearing and kalo development would not be selected by the community if the community needed to shoulder the full costs of these activities. Consequently, only scenarios assuming endowments of land cleared of bush and with kalo developed are considered.

[2] Not all households may be self-sufficient even in "good" times.

[3] If the LP's objective function is negative it indicates insufficient income in the community to meet human nutritional needs. This deficit is assumed to be met by food aid but is a conservative estimate because it prices the cost of food aid at local food market prices during droughts, i.e., does not account for administration and distribution costs of food aid.

## Further Reading


Coppock, D. L. 1994. The Borana Plateau of Southern Ethiopia: Synthesis of Pastoral Research, Development, and Change, 1980-91 (Systems Study No. 5). International Livestock Center for Africa, Addis Ababa, Ethiopia. 370 pp.

Coppock, D.L., S. Tezera, B. Eba, J. Doyo, D. Tadele, D. Teshome, N. Husein, and M. Guru. 2014. Sustainable pastoralism in Ethiopia: Preliminary results from participatory community assessment on the north-central Borana Plateau. Research Brief-16-2014, Feed the Future—Adapting Livestock Systems to Climate Change, Colorado State University, Fort Collins, CO USA. 4 pp. http://lcccrsp.org/wp-content/uploads/2011/02/RB-16-2014.pdf

Desta, S., and D. L. Coppock. 2002. Cattle population dynamics in the southern Ethiopian rangelands, 1980-97. Journal of Range Management, 55:439-451.

Forrest, B. 2014. Analysis of Building Resiliency in an Ethiopian Pastoral System: Mitigating the Effects of Population and Climate Change on Food Insecurity. MS thesis. Department of Applied Economics, Utah State University, Logan.



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*Sustainable Pastoralism on the Borana Plateau: An Innovation Systems Approach*

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*The Borana pastoral system has endured several decades of decline. The climate is drier, human populations have increased, rangelands are degraded, herders are poverty-stricken and food-insecure, and livestock productivity – typically based on cattle – has dropped. The old system is unsustainable. Many pastoralists recognize these trends and are responding with innovative coping strategies. This study will work to reveal the best-bet land and livestock interventions that will move the pastoral system back towards sustainability. The research team will do this primarily via a participatory framework that creates community action plans. An innovation system team of research and development stakeholders will be assembled to help pastoralists implement their action plans within a year of project initiation. A period of monitoring and evaluation will follow. Interventions will include pilot tests of promising innovations. Associated capacity building will involve local researchers and pastoralists, with the latter including a special focus on women and the poorest households. A review of system dynamics indicates that priority research will include: (1) how to diversify livestock holdings to include more browsing camels and small ruminants; (2) how to improve rangeland productivity via changes in common property regimes and forage innovations; and (3) how to promote livelihood diversification to reduce excessive stocking rates and encourage faster marketed turnover of livestock. Research approaches will include use of interdisciplinary methods, including public engagement, household surveys, and technical trials and studies. Linear programming will clarify policy relevant issues regarding land use and climate change. Research results will be important locally and throughout the Greater Horn of Africa.*


**Feed the Future Innovation Lab for Collaborative Research on Adapting Livestock Systems to Climate Change is dedicated to catalyzing and coordinating research that improves the livelihoods of livestock producers affected by climate change by reducing vulnerability and increasing adaptive capacity.**


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