Conceptualizing Pastoral Development Based on Carbon Sequestration: The Case of Yabelo District in the Southern Ethiopian Rangelands

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Abstract

Major challenges for rangeland stewardship in the developing world include how to mitigate the spread of pastoral poverty and environmental degradation. Arresting such trends requires a scale of investment, policy incentives, and institutional commitments not previously observed in pastoral development. Indeed, such a rangeland revolution requires several global events to set the stage, namely: (1) Creation of markets for diverse ecosystem services; (2) recognition that improved rangeland stewardship is vital to mitigate climate change; and (3) distribution of green climate funds in support of local projects. New approaches for pastoral development projects are also needed. Previous projects have largely focused on attempts to stimulate commercial livestock offtake, but such efforts often fail. What are the alternatives? Payments to local stakeholders in support of conservation and enhanced ecosystem services such as carbon sequestration may provide one answer, shifting the development debate from livestock (provisioning services) to resource conservation (regulatory and supporting services). Yabelo District on the Borana Plateau of southern Ethiopia provides a basis for a conceptual analysis of such a shift because it has been well-described by diverse data sets. Initial results from a synthesis of ecological and economic information suggests that efforts to promote landscape change via bush control and deferred livestock grazing could increase carbon sequestration by 18% over 10 years, and thus generate annual stipends up to US $731 per capita for a population around 103,000. This poverty-mitigating action would require a global carbon price of USD $106 per ton; similar income goals could be achieved at a carbon price of USD $53 per ton if the population eligible for payment was cut in half. Annual fluctuation in carbon prices, unreliability of local markets for food purchases, up-front costs for preparatory land management at USD $1.2 M/year, and need for resource monitoring/compliance are major project challenges.

Introduction

Drylands occupy 41 percent of the global land area and support over 2 billion people (Safriel et al. 2015). In the developing world dryland inhabitants endure poverty and degraded landscapes. Briske et al. (2020) noted that stewardship must now tackle both human and ecological problems. Drivers of dryland change include globalization, climate change, and population growth (Briske et al. 2020).

Briske (this volume) contends that a comprehensive analytical framework and stronger organizational alliances are needed to better deal with emerging dryland challenges. Briske contends that a major reason dryland development lags behind that for other biomes is the legacy of the "drylands syndrome" (Reynolds et al. 2007) where dryland socioeconomic marginalization is emphasized. Briske notes that if global drylands are credited with a broader array of ecosystem services beyond provisioning based on livestock and small-scale agriculture, the narrative could move from marginalization to one of "global value."

The challenge then becomes whether new pastoral development initiatives could be viable based on an economy based on regulating and supporting ecosystem services rather than livestock provisioning services. The objective of this paper is to provide such an example for a place that is well-studied; Yabelo District on the Borana Plateau in semi-arid, southern Ethiopia provides such a template (Coppock 1994, Coppock 2016). The main research questions include: (1) What could a carbon-sequestration project entail in terms of landscape management to optimize carbon sequestration? (2) under what conditions could ecosystem service payments to stakeholders provide sufficient means to reduce poverty and promote rangeland conservation? and (3) what challenges must be overcome to make such a project concept viable?

Study Area and Methods

Study Area

The Borana Plateau is described in detail by Coppock (1994, 2016). The plateau occurs at an elevation of 1,000 to 1,500 masl, bordered by the southern highlands to the North, Kenya (South), Rift Valley (West), and Ogaden Plains (East.) The climate is semi-arid and supports a mixed savanna dominated by perennial grasses and

Acacia woody plants. Annual rainfall averages 550-700 mm with 60% received from March to May and 30% received from September to November. Two dry seasons prevail otherwise. Multi-year droughts are frequent and climate change is making the region warmer and drier (Funk et al. 2012). The human population is on the order of 500,000 with over a million head of livestock during inter-drought periods. Massive livestock mortality occurs during droughts, but human populations endure because of food relief and other subsidies. Human emigration from the system has been restricted due to socioeconomic barriers, so local population pressure has been increasing. It is likely that more now people reside in the dozen or so urban communities across the plateau than as pastoralists living in the bush. The rural population resides in 29 *madda* (e.g., Pastoral Associations or PAs), traditional units of resource allocation including settlements, wells, ponds, and foraging zones. A declining ratio of cattle to people has characterized system dynamics for many years, contributing to food insecurity and poverty as a result of declining milk yields and asset holdings per capita. A small minority of wealthy herders own most of the livestock (Coppock et al. 2018). Livestock marketing has occurred for decades, but cattle offtake has been low. The cash economy only replaces a small portion of the traditional livestock economy (Forrest et al. 2016). Livestock development—namely creation of an effective, equitable, and ecologically sustainable system where a reliable process of animal offtake has transformed a pastoral system in positive ways—has failed here (Coppock 2016). Other systemic changes have occurred, however, including diversification of assets among the wealthy, widespread use of mobile phones, and increased interest in formal education for pastoral children (Coppock et al. 2018). The focus for this paper is Yabelo District, located in the north-central region. One of eight districts on the plateau, Yabelo District covers about 5,523 km^2. Statistics for Yabelo District are used for this analysis below.

Methods and Data Sources

Methods used in this study involve synthesis of existing information on landscape ecology, human and livestock populations, livestock production, and socioeconomic aspects of ecosystem services as relevant to Yabelo District. There is one major town (Yabelo, population est. 30,000) and seven PAs in Yabelo District. Census data (i.e., CSA 1994, 2005, 2007, 2018) suggest a growing human population now around 147,000 with 30% urban. If we assume the urban sector, commercial crop agriculture, and a wildlife sanctuary covers 26, 20, and 2,500 km^2, respectively, this leaves 2,977 km^2 for pastoralism. With 102,900 people living as pastoralists, the overall population density in the rural area is on the order of 35/km^2. Other data from representative PAs in the locale suggest human population densities vary from 5 to 14/km^2; PAs that have more bush-encroached landscapes have fewer people; bush encroachment has transformed the region over the past 40 years (below). Ratios of Tropical Livestock Units (TLUs) per person typically average 2.3:1 (range 1.0 to 4.0; Coppock 2016). The minimum ratio of TLUs per person for 100% pastoral sustenance is 10:1 (Coppock 1994), suggesting that only one-quarter of the total calories needed for human survival is currently provided by livestock, with the other 75% covered by food aid and other sources.

Previous research based on remote sensing for 400 km^2 of Yabelo District from 1973 to 2003 shows dramatic change in land cover (Mesele 2006). Grassland declined by 86%, while bushland, bushed-grassland, and cropland increased by 44, 48, and 385%, respectively. Drivers for change were overgrazing by cattle, lack of traditional control of woody encroachment using fire, and increased cultivation by pastoralists (Coppock 2016). Research has also been conducted on carbon budgets in Yabelo District (Bikila et al. 2016). They found variation in carbon stocks among three types of grassland or bushed-grassland sites: (1) Those dominated by grasses with scattered trees that have been managed for deferred grazing over 20 years (e.g., *kalo*); (2) those similar to *kalo* that have been continuously grazed; and (3) those representing former grassland sites that were overtaken by woody encroachment, and where prescribed fire was used five years prior to clear woody vegetation and reinvigorate the herbaceous layer. These site types do not match perfectly with those of Mesele (2006)—especially with respect to bushland—but there are enough similarities, as well as insights from other studies (Birhane et al. 2017) to proceed with a preliminary analysis for Yabelo District.

There are many possible ecosystem services to select as a basis for this analysis. Carbon sequestration is the priority choice here because of the importance of carbon regulation for mitigating climate change and emerging carbon markets (Safriel et al. 2015). Reviews of carbon prices (IBRD 2019) as well as data from labor costs to implement rangeland improvements (Forrest et al. 2016) round out the approach.

Results

Baseline Statistics

Hypothetical baseline statistics for Yabelo District in 2020 are shown in Table 1. Of special note are the spatial dominance of bushed-grassland (BG) and bushland (B) sites covering 75% of the area, more people per unit area in grassland sites, fewer cattle per person in woody encroached locales due to less grass, and the highest carbon stocks per hectare in the protected Grassland-*Kalo* (GK). The latter occurs because carbon stocks in top soils result from improved dominance of grass cover from deferred grazing; stocks held in woody plants are less impressive (Bikila et al. 2016). The ideal scenario for rapidly enhancing carbon sequestration would be to develop more GK directly from G, and then a sequential process from BG to G and then to GK. Restoring B to GK would be the slowest of the three processes (Forrest et al. 2016).

Table 1. Statistics for site types representing pastoral areas in Yabelo District, 2020.

Site Type	Percent of Area[1]	Area[2]	People/ km^2	People	TLUs/ Person	TLUs	Carbon tons/ha	Carbon tons
Grassland (G)	10%	298	10	2,980	4	11,920	142	4.2 M
Grassland-*Kalo GK)*	1%	30	10	300	4	1,200	300	0.9 M
Bushed-Grassland (BG)	50%	1,489	7	10,423	2	20,846	185	27.5 M
Bushland (B)	25%	744	5	3,720	1	3,720	100[3]	7.4 M[3]
Cropland (C)	14%	416	14	5,824	3	17,472	---	---
All	100%	2,977	8	23,247	2.4	55,158	---	40.0M

[1]Extrapolated over space and time for Yabelo District based on data in Mesele (2006).
[2]Based on a total area of 2,977 km^2 for Yabelo District (see Methods).
[3]Place-holder estimate based on information in Birhane et al (2017) and Forrest et al. (2016). All other figures in the carbon columns are derived from Bikila et al. (2016).

Scenario for Project Implementation

Again, the objective is to see to what extent the local livestock economy could transition to another economy focused on carbon storage. Project implementation would need to be gradual. One activity could be to shift BG to GK at a rate of 50 km^2 per year. An important priority could be to simultaneously shift B to BG at a rate of 25 km^2 per year. It is assumed that G and C sites would remain static with no additional resource degradation. Change in carbon stocks for BG→GK and B→BG under deferred grazing is assumed for to be stepwise over 5-year transitions. Table 2 illustrates an overall increase in GK area by 16-fold by year 10 with 12 and 44% decreases in BG and B, respectively. Carbon stocks increase by 7% after 5 years and 18% after 10 years.

Table 2. Temporal statistics for five site types in Yabelo District with annual conversions of 50 km^2 (BG→GK) and 25 km^2 (B→BG). Top figures per cell are km^2 and bottom figures are millions of tons of carbon stocks (data derived from Table 1.)

Site Type	Baseline	Year 5	Year 10
Grassland (G)	298 4.2	298 4.2	298 4.2
Grassland-*Kalo* (GK)	30 0.9	280 7.2	530 14.8
Bushed-Grassland (BG)	1,489 27.5	1,389 25.3	1,314 23.9
Bushland (B)	744 7.4	594 5.9	419 4.2
Cropland (C)	416 ---	416 ---	416 ---
All	2,977 40.0	2,977 42.6	2,977 47.1

Discussion

Assuming assumptions and calculations are accurate, prospects for poverty mitigation based on carbon sequestration here would be greatly influenced by global carbon prices and human population density. With a rural population of 102,900 across 2,977 km^2 surviving at an income level of US $2/person/day (Forrest et al. 2016), an average carbon price of USD $106 per ton could double incomes by year 10, and hence marginally mitigate poverty. A similar income objective could be met with an average carbon price of USD $53 per ton if the eligible population was reduced by half to 51,477. This could be rationalized to cover those people who are the primary managers and users of key landscapes that are altered. Given these scenarios, it would be most likely that income from carbon sequestration could only supplement livestock income (in cash and in kind). Annually variable carbon prices would add significant risk to household budgets; prices per ton used here are consistent with 2030 global targets needed to meet criteria of the Paris Accords (IBRD 2019). The analysis also illustrates the importance of sunk costs (i.e., non-recoverable investments) and time in creating viable carbon-sequestration projects to benefit pastoralists. In this model, it would take at least 5 years of considerable effort to provide a foundation for change; labor costs for bush clearing and *kalo* establishment (i.e., 75 km^2 per year at US \$15,600/km^2) would be around US \$1.2 M per year, not including site maintenance and opportunity costs of reduced stocking rates (Forrest et al. 2016). Once a project was underway, resource monitoring systems would be needed to ensure resource use compliance. Flux in global carbon prices and unreliable local markets for food purchase add risks for pastoral households. An equitable mix of top-down and bottom-up participatory engagement among key stakeholders would be required to promote project buy-in (Coppock 2019). Other ecosystem-service provisions (i.e., water, biodiversity, etc.) could be added to the effort once the base carbon component was well-managed. Other project benefits from bush clearing, however, would include marked improvements in food security from increased livestock production (Forrest et al. 2016).

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References

Bikila, N.G., Tessema, Z.K., and Abule, E.G. 2016. Carbon sequestration potentials of semi-arid rangelands under traditional management practices in Borana, southern Ethiopia. *Agr. Ecosyt. Envir.*, 223:108-114.

Birhane, E., Treydte, A., Eshete, A., Solomon, N., and Hailemariam, M. 2017. Can rangelands gain from bush encroachment? Carbon stocks of communal grazing lands invaded by *Prosopis juliflora*. *J. Arid Envir.*, 141: 60-67.

Briske, D. 2021. Rangelands support the Earth system and global human well-being. In: ____ (eds.) Proceedings of the Joint XXIV IGC and XI IRC Congress, ____________Nairobi. pp.____

Briske, D., Coppock, D.L., Illius, A. and Fuhlendorf, S. 2020. Strategies for global rangeland stewardship: Assessment through the lends of the equilibrium-nonequilibrium debate. *J. Appl. Ecol.*, DOI 0.1111/1364-2664.13610

CSA (Central Statistical Agency of Ethiopia). 1994, 2005, 2007, 2018. *National Census*. www.csa.gov.et

Coppock, D.L. 1994. *The Borana plateau of southern Ethiopia: Synthesis of pastoral research, development, and change.* International Livestock Center for Africa, Addis Ababa.

Coppock, D.L. 2016. Pastoral system dynamics and environmental change on Ethiopia's north-central Borana Plateau—influences of livestock development and policy. In: Behnke, R., and Mortimore, M., (eds.) *The end of desertification? Disputing environmental change in the drylands.* Springer Berlin-Heidelberg, pp. 327-362.

Coppock, D.L., Bailey D., Ibrahim, M., and Tezera, S. 2018. Diversified investments of wealthy Ethiopian pastoralists include livestock and urban assets that better manage risk. *Rangel. Ecol. Manage.,* 71: 138-148.

Coppock, D.L. 2019. Public participation methods for a new era in dryland science and stewardship in the Global South. In: Lucatello, S., Huber-Sannwald, E., Espejel, I., and Martinez-Tagüeña, N., (eds.) *Stewardship of future drylands and climate change in the global south: challenges and opportunities for agenda 2030*. Springer Climate Series, Berlin, pp. 113-127.

Forrest, B., Coppock, D.L., Bailey, D., and Ward, R. 2016. Economic analysis of land and livestock management interventions to improve resilience of a pastoral community in southern Ethiopia. *J. Afr. Econ*., 25: 233-266.

Funk, C., Rowland, J., Eilerts, G., Kebede, E., Biru, N, White, L., and Galu, G. 2012. *A climate trend analysis of Ethiopia.* Fact sheet 2012-3053. United States Geological Survey and Rolla Publishing Service Center, Rolla, MO. 6 pp.

IBRD (World Bank). 2019. *State and Trends of Carbon Pricing 2019.* Washington, DC. 95 pp.

Mesele, S. 2006. *Land use dynamics and impact on selected physiochemical properties of soils in Yabelo woreda of the Borana lowlands, southern Ethiopia.* Master's thesis, Faculty of Rangeland Management, Alemaya University, Harar, Ethiopia.

Reynolds, J.F., et al. 2007. Global desertification: Building a science for dryland development. *Science,* 316: 847-851.

Safriel, U., et al. 2015. Dryland systems. Chapter 22 (pages 623-662) in Millennum Ecosystem Assessment. https://www.millenniumassessment.org/documents/document.291.aspx.pdf