Does community-based conservation curtail threats?

Using satellite imagery to monitor threats from infrastructure development and land use change

David Williams, Philip Muruthi, Daudi Sumba, Natasha Gregory-Michelman
African Wildlife Foundation, Washington DC/Nairobi

Introduction

With 65% of Kenya's wildlife living outside protected areas (Western 2009), numerous conservation organizations adopted community-based conservation (CBC) strategies to support landscape conservation programs. AWF CBC engagements featured an exchange of development–often conservation enterprises or technical assistance for livestock management—for community agreement to set aside a portion of their land for conservation management. Did these community engagements reduce threat levels on that land?

Assessments of CBC conservation impact have been hampered by a lack of quantitative analysis, practical and cost-effective tools (Salafsky 2001), or demonstrated little evidence of success (Kiss 2004). Our study used straightforward GIS techniques to assess the effectiveness of 4 Kenyan CBC projects to curtail conservation threats as measured by socio-economic infrastructure (huts, buildings, livestock pens), and settlement and cultivation areas.

Materials and methods

To determine suitable source data, we reviewed imagery from a series of sensors from 0.46m to 4m in resolution and concluded we needed imagery <=1m to detect the smallest development features. We acquired imagery from the Quickbird and Worldview-2 sensor to cover the baseline –onset of community conservation management--and the contemporary periods (Table 1). No appropriate imagery existed close to the onset period to cover 2 of the group ranches. In total, acquired imagery cost less than $3500.

We used ArcGIS and GoogleEarth to interpret the onset imagery recording infrastructure as points and land use areas as polygons; land use areas represent the human footprint including settlements and cultivation (Figure 1). We then overlaid the baseline datasets atop contemporary imagery and determined whether features persisted, were added or removed between the two time periods.

Table 1. Intervention onset, analysis imagery, and percent of group ranch covered.

Group Ranch	Intervention Onset	Baseline Imagery	Contemporary Imagery	% Coverage
Elerai	2005	2005-Quickbird	2011-Worldview-2	100
Kijabe	2001	2002-Quickbird	2011/13-Quickbird	63.7
Koija	2001	2002-Quickbird	2011/13-Quickbird	40.2
Tiamamut	2002	2002-Quickbird	2011/13-Quickbird	100

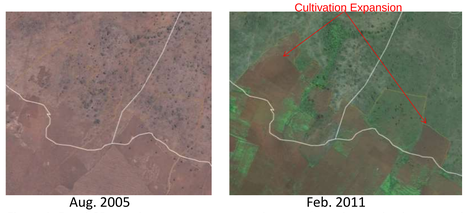

Figure 1. Elerai GR baseline and contemporary imagery featuring cultivation expansion.

Results

We observed significant changes in socio-economic infrastructure and land use using the acquired imagery.

- All infrastructure development in the Elerai and Kijabe conservation zones related to tourism (Figures 2 and 3a). Tiamamut conservation zone experienced the most infrastructure development adding 30 features (Table 2), nearly half the total for all the group ranches.
- Across the 4 group ranches, the conservation zones experienced by far the least new construction (64 features total) while the settlement-cultivation zones saw the most (253 features).
- Excluding the tourism operations, nearly all the contemporary infrastructure in Koija, Kijabe, and Tiamamut (KTK) conservation zones consists of huts and livestock pens (Figure 3b); buildings occur predominately in the settlement-cultivation areas. The only infrastructure in the Elerai conservation zone is tourism-related.
- The human footprint in KTK increased over three-fold to 2674 hectares but that was predominately in the settlement-cultivation and grazing areas (Figure 3c).
- Tiamamut also recorded the largest gain in land use in the conservation zone. Land use in the conservation zones of the other ranches expanded due to tourism (Elerai) or retreated (Koija, Kijabe).

Table 2. Infrastructure changes observed across mgt. zones.

Kijabe Group Ranch

Zone	Baseline	Removed '02-11/13	Added '02-11/13	Contemporary	% Change
Conservation	1	1	10	10	900%
Settlement-Cultivation	61	30	73	104	70%
Grazing	25	15	11	21	-16%
Totals	87	46	94	135	55%

Koija Group Ranch

Zone	Baseline	Removed '02-11/13	Added '02-11/13	Contemporary	% Change
Conservation-Tourism	2	0	5	7	250%
Settlement-Cultivation	68	32	100	136	100%
Grazing	13	7	29	35	169%
Totals	83	39	134	178	114%

Tiamamut Group Ranch

Zone	Baseline	Removed '02-11/13	Added '02-11/13	Contemporary	% Change
Conservation-Tourism	19	18	30	31	63%
Settlement-Cultivation	17	7	31	41	141%
Grazing	52	21	102	133	156%
Totals	88	46	163	205	133%

Elerai Group Ranch

Zone	Baseline	Removed '05-11	Added '05-11	Contemporary	% Change
Conservation-Tourism	11	0	19	30	173%
Settlement-Cultivation	36	23	49	62	72%
Grazing	44	11	77	110	150%
Totals	91	34	145	202	122%

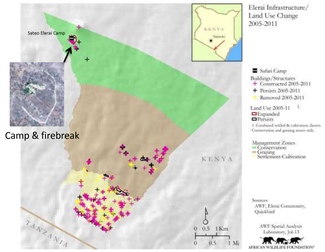

Figure 2. Infrastructure changes observed across mgt. zones.

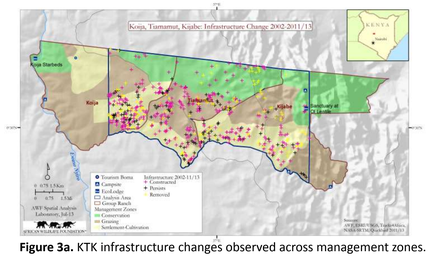

Figure 3a. KTK infrastructure changes observed across management zones.

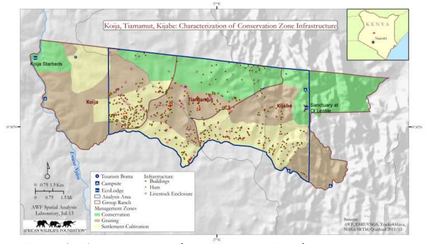

Figure 3b. Characterization of contemporary KTK infrastructure.

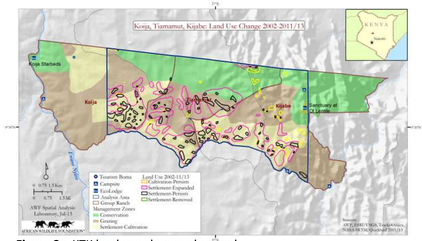

Figure 3c. KTK land use change observed.

Conclusions

With the exception of Tiamamut GR, our study suggests that management of the conservation zones helped mitigate threats related to infrastructure development and land use conversion.

- The relatively elevated level of settlement and livestock use in Tiamamut may relate to the range-rehabilitation CBC focus applied there as opposed to the ecotourism approach. The Tiamamut community appears to be using the conservation zone partly for grazing, however, they are generally refraining from more permanent structures (i.e., buildings).
- Our approach is a straightforward, readily repeatable, and cost-effective approach to monitoring development-related threats at the sub-landscape scale ; the investment in staff time and imagery is a tiny fraction of total project investment. Could we have reached the same conclusion faster with cheaper, lower resolution data?
- We recognize that non-conservation management zones are not perfect counterfactuals (Ferraro 2006) for the conservation zones. We considered using neighboring group ranches as counterfactuals but differing governance structures and preceding conservation initiatives precluded their use.

Conservation Implications

- Approach offers a reasonable ex post means of evaluating impact due to CBC project absent baseline data land use and infrastructure data collection.
- To better leverage this threat abatement, we need to understand *why* this happened through research into socio-economic drivers.

Literature cited

Ferraro, Paul J., and Subhrendu K. Pattanayak. "Money for nothing? A call for empirical evaluation of biodiversity conservation investments." *PLoS biology* 4.4 (2006): e105.

Kiss, Agnes. "Is community-based ecotourism a good use of biodiversity conservation funds?" *Trends in Ecology & Evolution* 19.5 (2004): 232-237.

Salafsky, Nick, et al. "A Systematic Test of an Enterprise Strategy for Community-Based Biodiversity Conservation." *Conservation Biology* 15.6 (2001): 1585-1595.

Western, David, Samantha Russell, and Innes Cuthill. "The status of wildlife in protected areas compared to non-protected areas of Kenya." *PLoS One* 4.7 (2009): e6140.

Acknowledgments

Funding for this work provided by the Dutch Govt. We thank the communities of the four group ranches for their input and making this possible.