



Conservation and economic benefits of a road around the Serengeti

J. Grant C. Hopcraft,^{*†¶} Simon A. R. Mduma,[‡] Markus Borner,^{*†} Gerald Bigurube,[†] Alain Kijazi,[§] Daniel T. Haydon,^{*} William Wakilema,[§] Dennis Rentsch,[†] A.R.E. Sinclair,^{**} Andrew Dobson,^{††} and James Daudi Lembeli^{‡‡}

^{*}Institute of Biodiversity, Animal Health and Comparative Medicine, Boyd Orr Centre for Population and Ecosystem Health, University of Glasgow, Glasgow, G12 8QQ, United Kingdom

[†]Frankfurt Zoological Society, P.O. Box 14935, Arusha, Tanzania

[‡]Tanzania Wildlife Research Institute, P.O. Box 661, Arusha, Tanzania

[§]Tanzania National Parks, P.O. Box 3134, Arusha, Tanzania

^{**}Centre for Biodiversity Research, University of British Columbia, 6270 University Boulevard, Vancouver, BC, V6T 1Z4, Canada

^{††}Eno Hall, Princeton University, Princeton, NJ 08544-1003, U.S.A.

^{‡‡}Parliamentary Committee on Land, Natural Resources and Environment, Tanzania, P.O. Box 1065, Kahama, Tanzania

Defining the balance between conservation and national development is fraught with conflicting ideals: At what point should a country prioritize new infrastructure developments above its natural heritage? In the case of Tanzania, the government has identified the need for developing a paved national transportation corridor to Lake Victoria as part of its national development strategy that would facilitate trade and alleviate poverty in the northwestern part of the country (United Republic of Tanzania 2010). Although this area is globally recognized for its protected areas, wildlife migrations, and unique biodiversity, the local communities in the region routinely face economic hardship and poor access to social services such as schools and hospitals. The promise of a highway connecting this area is welcomed; however, we argue that all potential routes must be critically evaluated and compared. Of the three possible routes that have been suggested, one in particular has generated international controversy; the Serengeti route bisects the national park and passes through the core dry season refuge of the wildebeest migration potentially separating them from the only permanent water source (Dobson et al. 2010). From a conservation perspective, this could lead to catastrophic declines in the abundance of this keystone species (Holdo et al. 2011), potentially change the entire dynamics of the ecosystem (Hopcraft et al. 2015), and threaten economic benefits from tourism. How can the

potential benefits of the road, in terms of human poverty alleviation and provisioning of socioeconomic opportunities for the people, be balanced with the protection of the Serengeti ecosystem?

A recent Diversity piece by Fyumagwa et al. (2013) suggests that the development of a road through the Serengeti National Park could reduce poverty and improve the quality of life by fuelling the local economy. Unfortunately, their analysis fails to deliver meaningful insights because they do not compare the costs and benefits among all potential routes. They base their opinions on the results of household interviews in 12 villages along one possible route. Critically, they did not consider the livelihoods of people living along any of the other more populous proposed routes or the opinions of the 11.9% of employed Tanzanians working in the accommodation and tourism sector (United Republic of Tanzania 2012a), whose livelihoods could be at stake if a road were built through Tanzania's prime tourist location (Sekar et al. 2014). (Tanzania's tourism sector contributed US\$1.279 billion, or roughly 5.5% of Tanzania's GDP in 2010 [United Republic of Tanzania 2012b].) We outline an alternative route for the road (Hopcraft et al., accepted) by which Tanzania could alleviate poverty and achieve its national infrastructure development goals more successfully and without compromising the country's natural heritage and tourism industry.

¶email grant.hopcraft@glasgow.ac.uk

Paper submitted February 10, 2014; revised manuscript accepted May 28, 2014.

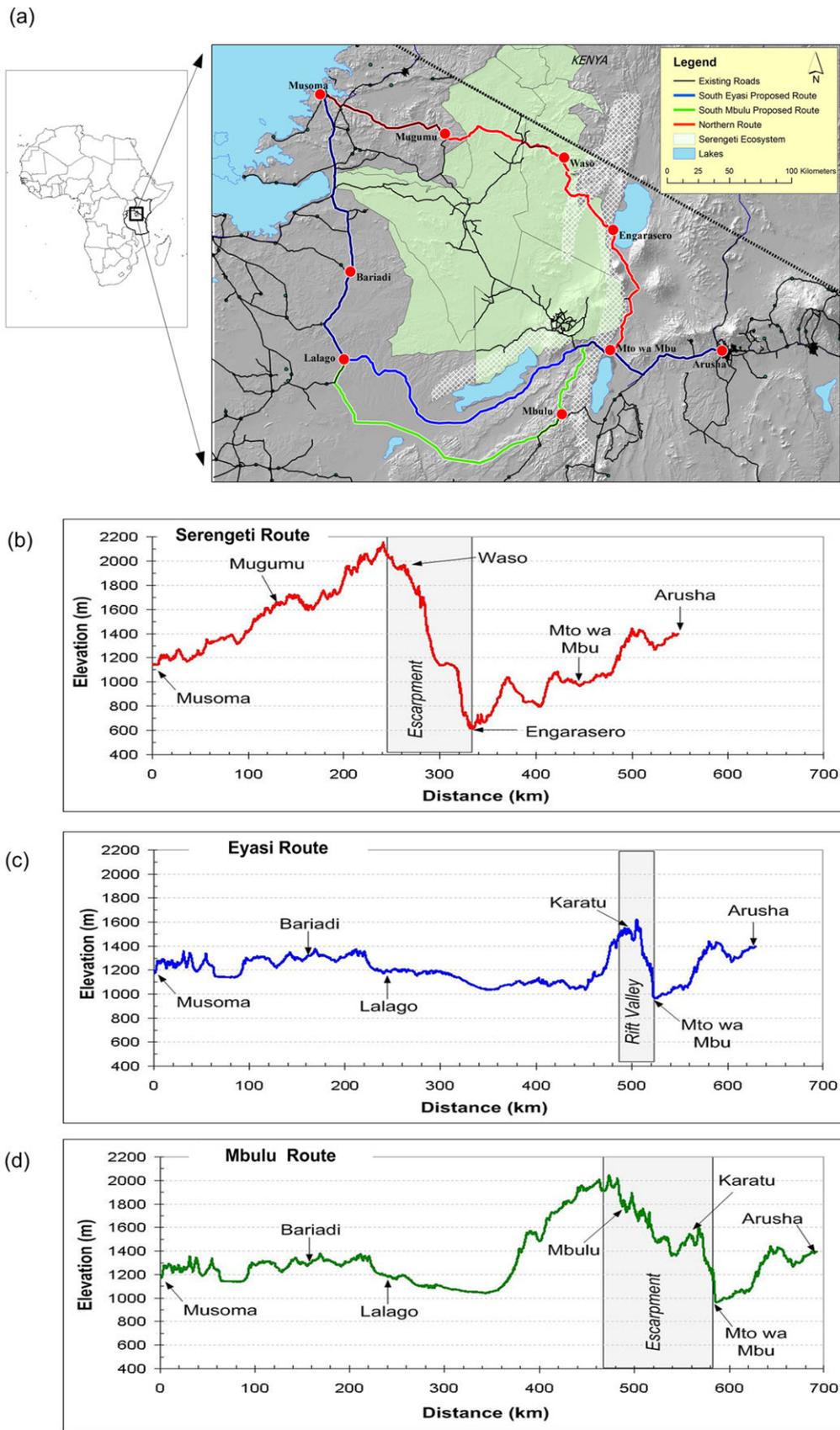


Figure 1. (a) The three possible routes for a transportation corridor connecting northern Tanzania to Lake Victoria and elevation cross-sections for (b) the Serengeti route, (c) the Eyasi route, and (d) the Mbulu route.

Table 1. A comparison of the attributes of three possible routes for a transportation corridor connecting economic centers in northern Tanzania.

Route attribute	Mbulu route	Eyasi route	Serengeti National Park route
Total distance (km)	692	628	548
Elevation gain (m)	1099	674	1537
Fuel required to cross Rift Valley (liters of diesel)*	10.8	6.2	14.1
New pavement required (km)	402	322	428
Connections to existing road	16	14	7
Number of people	1,960,000	1,690,000	1,040,000
Number of unemployed people	904,930	768,062	458,037

*Calculation based on a 10-t transport lorry, elevation gain, standard tire friction, and 50% energy conversion efficiency of internal combustion engines (Hopcraft et al. 2011).

The Serengeti Road in a Regional Context

The objective of the new road is to connect economic centers across northwestern Tanzania (specifically Arusha and Musoma) and facilitate national growth by enhancing local economies. There are at least two other potential routes besides the Serengeti National Park option. A second alternative sweeps southeast, skirting Lake Eyasi and missing the Serengeti altogether, whereas a third option extends farther south and connects Mbulu and Lalago (Fig. 1). All three routes must cross the Rift Valley, which is a key factor in determining construction costs and fuel consumption. The basic cost of building a road in Tanzania is \$US630,000/km; however, switchbacks, bridges, and retaining walls can increase this estimate 6-fold (TanRoads, personal communication). A topographic comparison illustrates the Serengeti route has the greatest and steepest elevation gain (1537 m; Figs. 1b & 1c), which considerably inflates the costs of construction and subsequently requires 2.3 times more fuel to cross the Rift Valley than the southern Eyasi route (Table 1). Adding to this, the Serengeti route also requires the greatest amount of new tarmac even though it is the shortest overall distance (Table 1) because long sections of the Eyasi and Mbulu routes are already paved (Hopcraft et al. accepted). Furthermore, a node count of road intersections illustrates that either of the two southern routes would connect at least twice the number of existing roads and would go further toward creating a national transportation network (Table 1); the Serengeti National Park route would remain an isolated corridor with few additional synergies. These multiple lines of evidence suggest the Serengeti National Park route has the least additive effects, would be the most costly to transport goods, and would be the most expensive to build.

A Road for the People

A full comparison of the economic value of alternative routes should also consider the relative benefits each route would contribute to the socioeconomic welfare of people in the region. The prospect of any new road

undoubtedly generates large support in the rural voter community because of raised expectations for future economic opportunities (as pointed out by Fyumagwa et al. 2013), and in Tanzania's young and vibrant democracy, the issue of a road could be a critical campaign issue. Tanzanian law requires that the government demonstrate at least a 10% return from any national development project. This mandate encourages the wisest use of limited finances and the largest potential return on these investments in equitable ways for the most people. Therefore, all the potential routes should be critically compared so potential economic gains can be maximized.

The density of people and their economic status along each of the three routes provides an informative first-pass metric by which the potential socioeconomic returns of different routes can be compared. Figure 2a is based on the 2002 Tanzanian national census data and illustrates the spatial distribution of human density in the region. At the time the map was drawn, the spatial data for the 2012 census was not publically available. A comparison of the total number of people living within 10 km of each of the proposed routes categorized by employment status (Fig. 2b) illustrates that the Mbulu route connects the greatest number of people (1.96 million), followed by the Eyasi route (1.69 million). The Serengeti National Park route connects just over half the number of people (1.04 million), primarily because it passes through several protected areas where few people live. Furthermore, the number of unemployed people living along the Mbulu route alone (904,930) is almost equivalent to the total number of people along the Serengeti National Park route (Fig. 2b & Table 1). The data on unemployment (Table 1) suggest that a road to the south could open economic opportunities to 446,983 more people who urgently require income than a route through the Serengeti. In 2010, 72% of Tanzania's GDP originated from small- and medium-sized enterprises (World Bank 2012); however, these entrepreneurial activities are severely impeded in rural communities by a lack of transportation, electricity, and logistic support (Liedholm et al. 1994; Jin & Deininger 2009). Therefore, the economic spin-offs of a well-placed transportation corridor to the south of the Serengeti could potentially be realized by more people and have a greater impact on Tanzania's poverty

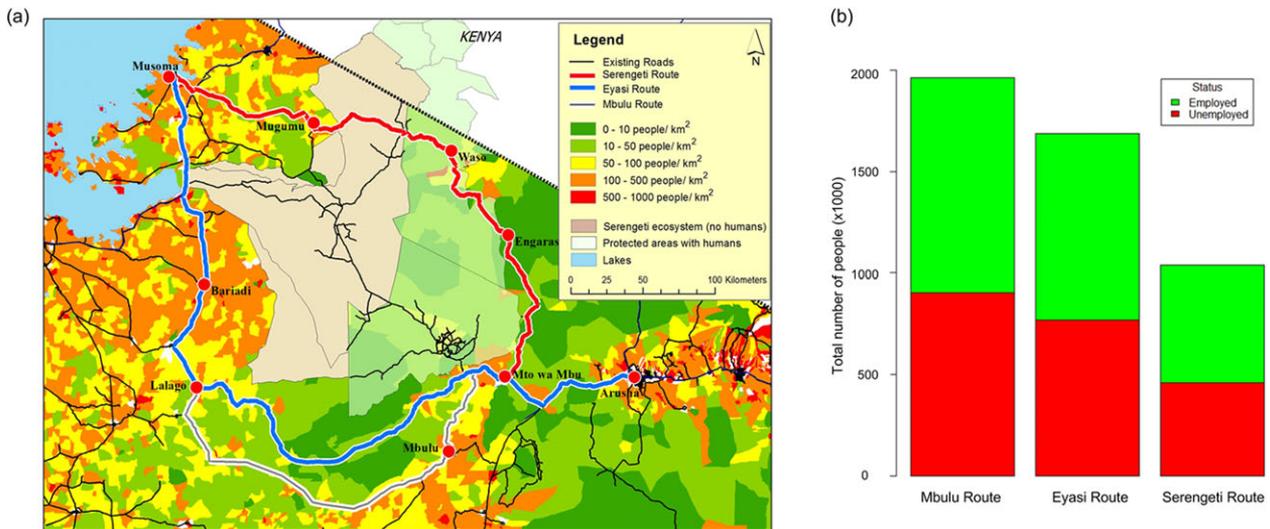


Figure 2. A comparison of the human demographics of the three possible routes: (a) the spatial distribution of people in the region by density and (b) the total number of people within 10 km of each route by employment status (totals are 1.96 million people along the Mbulu route, 1.69 million along the Eyasi route, and 1.04 million along the Serengeti National Park route) (adapted from Hopcraft et al. 2011).

alleviation strategy (United Republic of Tanzania 2010) than a road through the park, regardless of construction costs or the conservation implications.

Ultimately, Tanzania's long-term communication and transportation developments will include high-speed railways, electricity lines, fiber-optic cables, and gas and water pipelines, which will inevitably parallel the same routes as the roads. Therefore, current development must anticipate the infrastructure demands of the people for the next 50 years at least. The geography of the Rift Valley requires the Serengeti National Park road to climb gradients of 7–10%, which automatically precludes the construction of a cost-efficient railway through Serengeti (typically a locomotive is capable of pulling half its capacity on gradients of 1%). Moreover, oil and gas pipelines are notoriously prone to bursts and catastrophic leaks when the gradient exceeds 0.8% (Government of Alberta 2010). The logistics of developing complimentary infrastructure along the Serengeti route in the future would be exceedingly challenging and would not meet the long-term demands of the nation.

A comparative approach that considers the larger geographical region around the Serengeti and the country's future development indicates that a road through the Serengeti National Park is the most expensive option to connect northern Tanzania; benefits the fewest people; provides the least economic returns relative to the alternative routes; and poses the greatest risk of destroying an ecosystem that is currently under huge stress yet still generates over \$80 million in tourism revenue per annum. The Serengeti ecosystem already faces many threats such as human population growth, poverty, resource extraction, destruction of critical water catchments, and climate change (Fyumagwa et al. 2013). Adding an expensive

national transportation corridor that benefits only a few people to this growing list cannot be justified; at a minimum any decision requires a full socioeconomic study.

An alternative to a road through the Serengeti National Park is to build a transportation corridor to the south. The spatial analyses of national data consistently indicate that a southern route would be less expensive to build and benefit twice the number of people. Furthermore, the evidence also suggests that a southern route would provide faster and more direct connections to all the economic centers in the lake and central regions of Tanzania. Tanzanian law requires both economic and environmental assessments for any project; however, the results of these processes are often diametrically opposed, which epitomizes the “infrastructure versus conservation” conflict that developing countries face. Pristine protected areas are becoming more valuable because of their global scarcity, and therefore the economic returns of maintaining their integrity are likely to outweigh the limited socioeconomic benefits of building roads where there are no people. The conclusions are straightforward—transportation corridors have the greatest socioeconomic impact in locations where there are people who can benefit from them rather than through uninhabited protected areas.

Acknowledgments

We thank T. Caro and an anonymous reviewer for comments and improvements, the Government of the United Republic of Tanzania for availing the 2002 census data, and the Lord Kelvin Adam Smith Fellowship for supporting J.G.C.H.

Literature Cited

- Dobson, AP, et al. 2010. Road will ruin Serengeti. *Nature* **467**:272–273.
- Fyumagwa R, et al. 2013. Roads as a threat to the Serengeti ecosystem. *Conservation Biology* **27**:1122–1125.
- Government of Alberta. 2010. Application procedures for placement of underground oil and high pressure gas pipelines in the vicinity of transportation facilities. Edmonton, Alberta.
- Holdo RM, Fryxell JM, Sinclair ARE, Dobson A, Holt RD. 2011. Predicted impact of barriers to migration on the Serengeti wildebeest population. *PLOS ONE* **6**:e16370. DOI: 10.1371/journal.pone.0016370.
- Hopcraft JGC, Bigurube G, Lembeli JD, Borner M. Accepted. Alternatives to the Serengeti highway: finding solutions that benefit both socio-economic development and conservation. *PLOS ONE*.
- Hopcraft JGC, Borner M, Bigurube G. 2011. Connecting northern Tanzania: a socio-economic comparison of the alternative routes for a highway from Arusha to Musoma. Frankfurt Zoological Society, Frankfurt.
- Hopcraft JGC, Holdo RM, Mwangomo E, Mduma SAR, Thirgood S, Borner M, Fryxell JM, Olf H, Sinclair ARE. 2015. Why are wildebeest the most abundant herbivore in the Serengeti? Pages 125–174 in Sinclair ARE, Metzger K, Mduma SAR, Fryxell JM, editors. *Serengeti IV*. University of Chicago Press, Chicago.
- Jin SQ, Deininger K. 2009. Key constraints for rural non-farm activity in Tanzania: combining investment climate and household surveys. *Journal of African Economies* **18**:319–361.
- Liedholm C, McPherson M, Chuta E. 1994. Small enterprise employment growth in rural Africa. *American Journal of Agricultural Economics* **76**:1177–1182.
- Sekar N, Weiss JM, Dobson AP. 2014. Willingness-to-pay and the perfect safari: valuation and cultural evaluation of safari package attributes in the Serengeti and Tanzanian Northern Circuit. *Ecological Economics* **97**:34–41.
- United Republic of Tanzania. 2010. MKUKUTA II: national strategy for growth and reduction of poverty. President's Office, Government of the United Republic of Tanzania, Dodoma.
- United Republic of Tanzania. 2012a. Employment and earnings survey 2012 Analytical report. National Bureau of Statistics, Government of the United Republic of Tanzania, Dodoma.
- United Republic of Tanzania. 2012b. Tanzania tourism sector survey: the 2010 international visitors' exit survey report. National Bureau of Statistics, Government of the United Republic of Tanzania, Dodoma.
- World Bank. 2012. World development indicators. Page 463. World Bank, Washington, D.C.