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Road around Serengeti provides greater economic development opportunities than a road through it

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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 north-western 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. in press), and threaten the economic benefits from tourism. However, how does this balance against the potential benefits of the road in terms of human poverty alleviation and provisioning socio-economic opportunities for the people?

A recent opinion article 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 between *all* potential routes (their results are only based on interviews in 12 villages along a single route). Critically, their analysis does not consider the opinions of people living along other more populous routes, nor does it consider 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 solution by which Tanzania could alleviate poverty and achieve its national infrastructure development goals more successfully, without compromising the country's natural heritage and tourism industry.

The Serengeti road in a regional context

The objective of a new road is to connect economic centres across north-western 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 would sweep south-east skirting Lake Eyasi and missing the Serengeti altogether, while a third option would extend further south and connect Mbulu and Lalago (Figure 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 $630,000US/km, however switch-backs, bridges and retaining walls can increase this estimate six-fold (pers. com., TanRoads). A topographic comparison illustrates the Serengeti route has the greatest and steepest elevation gain (1537m; Figure 1b-c), 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. 2011). 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 towards creating a national transportation network (Table 1), while 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 socio-economic 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.), 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 socio-economic returns of different routes can be compared. Figure 2a uses the 2002 Tanzanian national census data to illustrate the spatial distribution of human density in the region (at the time of the analysis the spatial data for the 2012 census was not publically available). A comparison of the total number of people living within 10km of each of the proposed routes categorized by employment status (Figure 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 (Figure 2b and Table 1). The data on unemployment (Table 1) suggests 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 (Jin & Deininger 2009; Liedholm et al. 1994). 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 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 transport developments will include high-speed railways, electricity lines, fibre-optic cables, and gas and water pipelines which will inevitably parallel the same routes as the roads. Therefore, the current developments 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 to 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 leakages 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.

Summary

A comparative approach that considers the larger geographical region around Serengeti as well as the future implications of a road, indicate that the Serengeti National Park route is: (1) the most expensive option to connect northern Tanzania, (2) would benefit the fewest people, (3) provides the least economic returns compared to any of the alternative routes, and (4) runs 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, the destruction of the critical water catchments, and climate change (Fyumagwa et al. 2013). The current data suggest that adding an expensive national transportation corridor that would benefit few people to this growing list cannot be justified; at a minimum any decision requires careful consideration of a full socio-economic 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 centres 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 socio-economic benefits of building roads where there are no people. The conclusions are straightforward - transportation corridors have the greatest socio-economic impact in locations where there are people who can benefit from them and not in uninhabited protected areas.

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Table 1. A comparison of the three routes illustrates the Serengeti National Park route is the shortest distance but has the greatest elevation gain, incurs largest haulage costs, requires the most new pavement, would contribute the least to a road national road network, and services the fewest people.

	Mbulu Route	Eyasi Route	Serengeti National Park Route
Total distance (km)	692	628	548
Elevation gain (meters)	1099	674	1537
Fuel required to cross Rift Valley (litres 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 tonne transport lorry, elevation gain, standard tyre friction, and 50% energy conversion efficiency of internal combustion engines (Hopcraft et al, 2011)

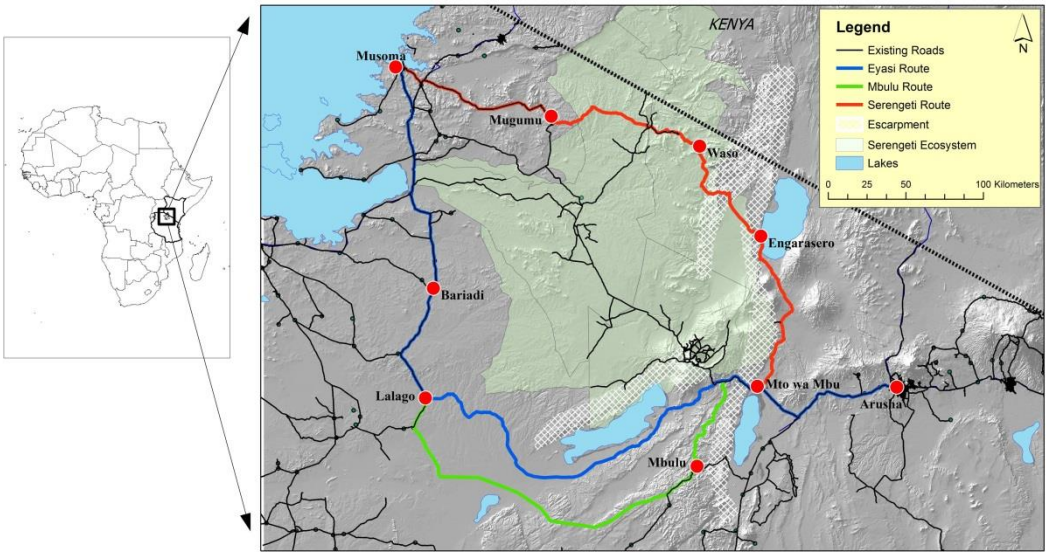
Figure Legends

Figure 1. (a) There are three possible routes for a transportation corridor connecting northern Tanzania to Lake Victoria: (b) the Serengeti route is 548km with an elevation gain of 1537m, (c) the Eyasi route is 628km and gains 674m, and (d) the Mbulu route is 692km and with an elevation change of 1099m.

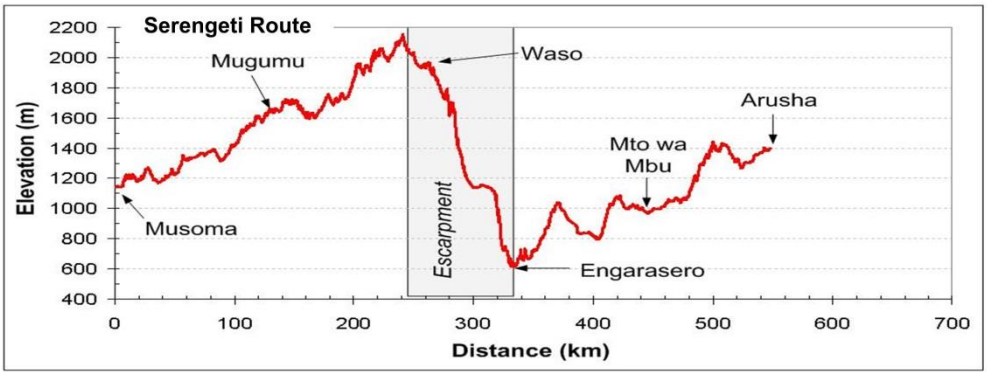
Figure 2. A comparison of the human demographics of the three possible routes: (a) the spatial distribution of people in the region by density and (b) the total number of people within 10km of each route and split by employment status (totals are 1.96 million people along the Mbulu rout, 1.69 million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

Figure 1

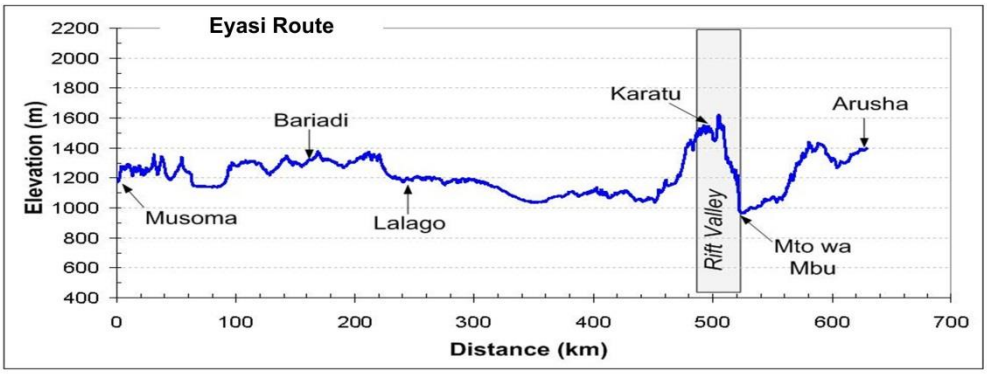
(a)



(b)



(c)



(d)

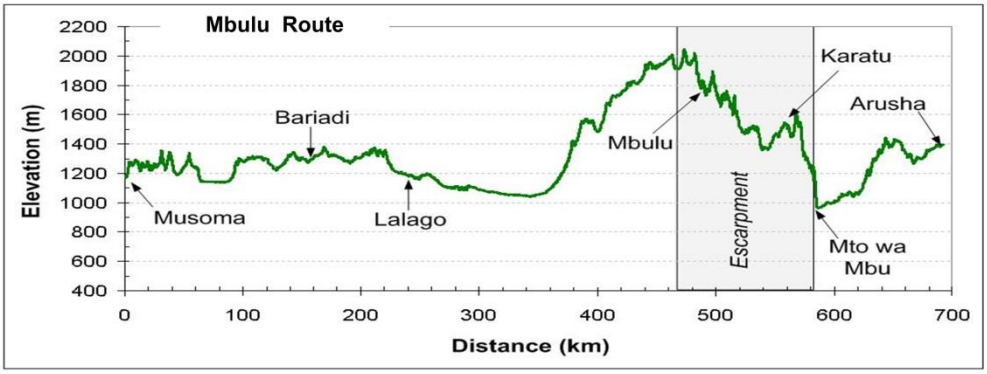
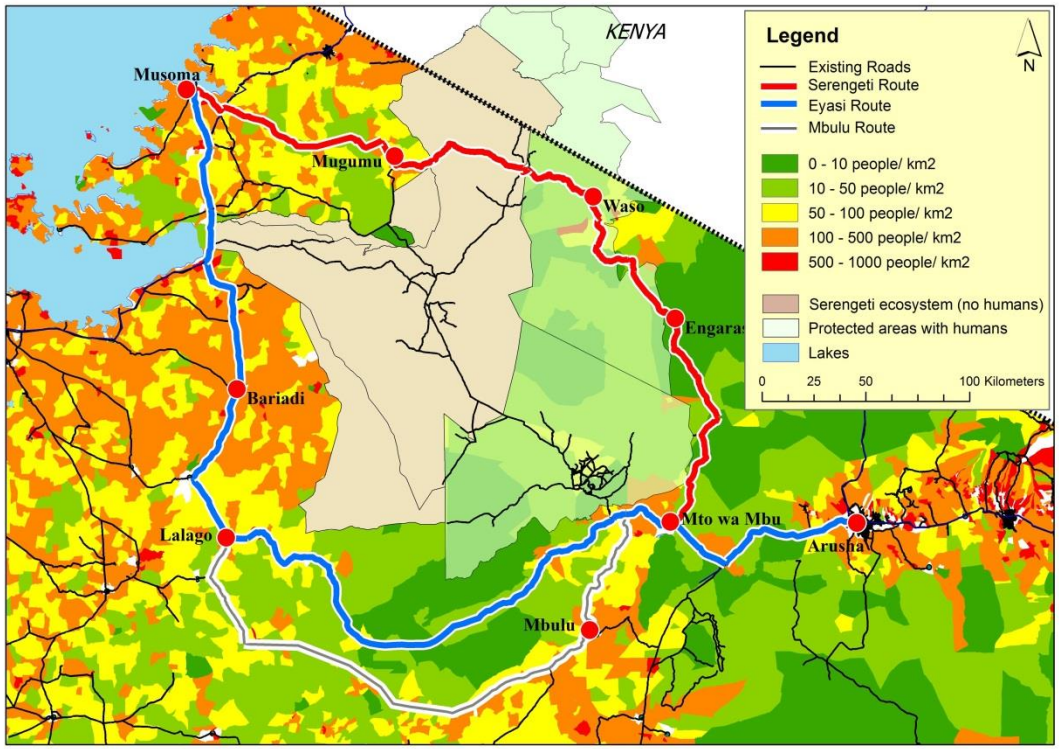
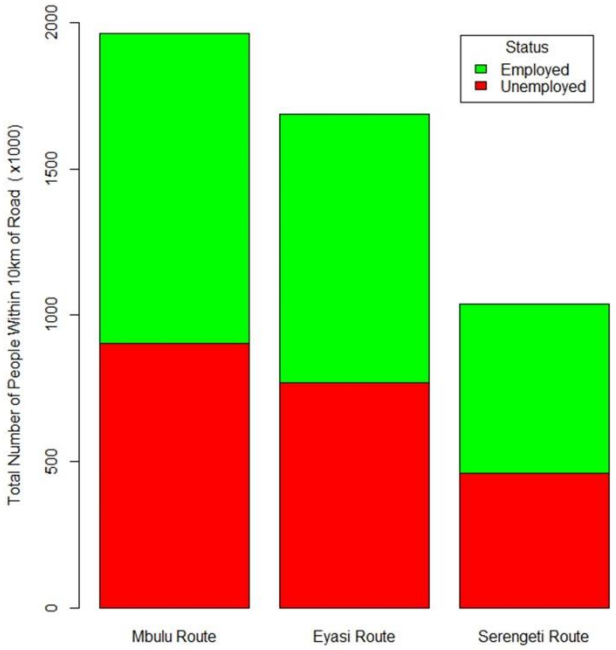


Figure 2.

(a)


KENYA
Musoma
Mugumu
Waso
Bariadi
Lalago
Mto wa Mbu
Arusha
Mbulu
Legend
Existing Roads
Serengeti Route
Eyasi Route
Mbulu Route
0 - 10 people/ km2
10 - 50 people/ km2
50 - 100 people/ km2
100 - 500 people/ km2
500 - 1000 people/ km2
Serengeti ecosystem (no humans)
Protected areas with humans
Lakes
0 25 50 100 Kilometers
N

(b)


Total Number of People Within 10km of Road (x1000)
0
500
1000
1500
2000
Status
Employed
Unemployed
Mbulu Route
Eyasi Route
Serengeti Route