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Case study

Tourist traffic simulation as a protected area management tool. The case of Serengeti National Park in Tanzania

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ABSTRACT

The principal economic source of protected areas is tourism. However, tourism may negatively affect habitats. The growth of wildlife tourism has raised international concern regarding whether there is an equilibrium between tourism and conservation. Management actions should help provide this equilibrium. In relation to transportation management, most studies have focused on visitors' experiences and disregarded the consequences of traffic volume changes. Because tourist traffic is acknowledged as being harmful to habitats, this study develops a tool that simulates changes in traffic volume to facilitate the assessment of management actions. The tool is a simple transport model based on transport network characteristics and 2680 trip registrations in Serengeti National Park. The analyses show that a northern road through the Park may distribute tourist traffic, whereas the potential new international airport may reduce the overall tourist traffic on roads.

1. Introduction

Wildlife tourism has been increasingly growing in the past few decades (Reynolds & Braithwaite, 2001). However, recreational and tourism activities may impact wildlife habitats (Knight & Cole, 1995), affect animal behavior (He et al., 2008; Ranaweerage, Ranjeewa, & Sugimoto, 2015), facilitate the invasion of exotic species (McKinney, 2002), increase hunting (Brashares, Arcese, & Sam, 2001), and increase pollution in tourism areas (Reynolds and Braithwaite (2001); Ndibalema, Mduma, Stokke, and Røskaft (2008)). There is evidence that tourist traffic on the Ngorongoro Crater road has indirectly led to a decline in the wildebeest and gazelle populations (Estes, Atwood, & Estes, 2006). In a neighboring area, Kenya's Maasai Mara National Reserve, the large amount of tourist traffic has endangered the cheetah population (Honey, 2008). To preserve the habitats, many protected areas (PAs) have been designated. In 2016, PAs covered almost 15% of the Earth's land area (UNEP-WCMC and IUCN, 2016). Despite the tourism impacts, the revenue of PAs may be an important input for covering the high preservation costs. PAs might also benefit neighboring communities in the form of economic development (Kaltenborn, Nyahongo, Kidegesho, & Haaland, 2008; Andrade & Rhodes, 2012). However, human activities in surrounding areas might isolate PAs from other habitats (Wittemyer, Elsen, Bean, Burton, & Brashares, 2008), and the quality of visitors' experiences may be decreased due to the greater number of vehicles on the roads (Manning, Lawson, Newman, Halo, & Monz, 2014).

Given the complex relationships, understanding the dynamics of the causative processes in land use changes plays an important role in the preliminary description of management actions (Polasky, Carpenter, Folke, & Keeler, 2011). This understanding is even more important in PAs, as the consequences may be irreversible. The site management of PAs includes planning and organizing transportation (Leask, 2016). Well-designed transportation systems may improve visitors' experiences through reductions in congestion and improvements in safety, among others (Pettebone et al., 2011). Moreover, better estimations of traffic on low-volume roads might increase the efficiency of maintenance operations (Apront et al., 2013). Nevertheless, most of the previous studies on transportation in PAs have focused on environmental effects (Forman et al., 2003), visitors' experiences (Pettebone et al., 2011), and characteristics of visitors' movements (Hallo & Manning, 2009; Smallwood, Beckley, & Moore, 2012). This study aims to introduce a tool to improve the understanding of the tourist traffic changes resulting from site management actions. The tool is a simple transport model that simulates the traffic volumes on the roads in different hypothetical scenarios. Therefore, the consequences can be analyzed beforehand. Additionally, the simulated traffic volumes may be transformed into kilometers driven per vehicle unit, serving as input for measuring indirect effects of tourism, such as air pollution (Lin, 2010), noise disturbance, and wildlife road kills. The research questions of this study are

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therefore: 1) Can this tool simulate traffic changes due to different transportation management actions? 2) Can this tool complement the assessment of site management actions in PAs?

The case used to illustrate the use of this tool is Serengeti National Park (SENAPA) in Tanzania, given the important consequences that the ongoing transportation projects might have for tourism and habitats. SENAPA is a World Heritage Site in northwest Tanzania, with an area of nearly 14,750 km^2. The wildlife in the Park is world renowned. In 2013/2014, the Park attracted more than 200,000 international visitors, representing 15% of the nation's economy (Sekar et al., 2014). These sources of revenue are tourism attraction activities such as game viewings or safaris. Additionally, there are fees for tourists and vehicles entering the Park, landing fees for planes, and accommodation fees for hotels and campsites.

The actual traffic volumes on some SENAPA roads are currently approximately 650 vehicles per day on average in the high tourist season. These traffic volumes might not seem high compared with other roads, but they tend to be concentrated around the same hours. This situation, along with the poor road standards, might quickly reduce the comfort of the road conditions and compromise the safety of road users. The forecasts indicate an increase in tourism at the Park. Sekar et al. (2014) argued that more research is needed to control the consequences of this increase. A potential transportation management action to reduce the harmful effects of the growing tourist traffic volumes and to provide better experiences to visitors would be to improve the infrastructure to access SENAPA. This might lead to reductions in travel time and travel costs, the expansion of the agriculture markets, and the generation of new economic activities (Haule, 2005). Moreover, it may improve access to social services (TANROADS, 2010). Accessibility to good roads may reduce local poverty (Haule, 2005) and increase the attractiveness of the tourist accommodations in the Park and surrounding areas (Bayliss et al., 2014). Spurred by several national and international discussions on potential infrastructure development, plans for constructing a new international airport closer to the Park have already started. This approach may considerably reduce the amount of road travel from the current international airport to SENAPA (approximately 400 km). Additionally, a new road crossing the northern part of the Park from east to west (approximately 50 km) is being built. The consequences of this road were evaluated by Røskaft et al. (2012), who conducted interviews in the area and concluded that it would benefit more than 80% of inhabitants in the north. On the other hand, Dobson et al. (2010) argued that it might cause habitat fragmentation due to its location within the migration path for wildebeests. TANROADS (2010) evaluated the road impacts but disregarded the traffic volumes of the transport network; i.e., the traffic was analyzed only on new roads. According to Fyumagwa et al. (2013), this road might spread the traffic effects to the inside of the Park; thus, the traffic volumes of the whole network should have been analyzed.

The tool developed in this study was a simple transport model based on the transport network characteristics and 2680 trip registrations at the road and air entrances to SENAPA in 2013. 31 zones in northwest Tanzania functioned as origins and destinations of the registered trips. The model assigned the traffic volumes from the trips to the different roads. To better illustrate the consequence of the management actions for tourists, the traffic volumes were classified into international tourist traffic and local traffic. The tool aimed to simulate traffic volume changes for the two ongoing transportation projects mentioned above. Therefore, two main scenarios were modelled. In the first scenario, the road improvement through northern Serengeti was implemented in the actual transportation network. In the second scenario, the Mugumu airport was additionally included. Both scenarios were compared with one another and with a basis scenario for the years 2013 and 2020.

The study area is described in more detail in Section 2, along with the description of the data and the transport model developed. The results from the transport model are analyzed in Section 3. Section 4 includes the discussion and implications of this study, and the conclusions are summarized in Section 5.

2. Method

2.1. Study area

Fig. 1 shows the zones and the road network of northwest Tanzania. These zones are areas with similar characteristics. Six of these zones are inside SENAPA, so more detailed data were included within the area. In this study, the airports and airstrips (with data) are also considered zones, as these may represent the origin or destination of a trip. In total, 31 zones were considered in this study. Tanzanian roads are hierarchically classified according to the towns/cities they connect. These classifications are national, regional, district, feeder, and urban roads. The first two have similar characteristics, as they could be paved or unpaved (approximately 50%), while the rest of the roads are mainly unpaved (TANROADS, 2009). This results in several kilometers of gravel roads and costly maintenance work, which is especially problematic during the rainy season, as large volumes of water might erode the roads.

The road between Kilimanjaro International Airport and central Serengeti, which is one of the worst geometrically designed roads, is also the most popular road between the Lake District (Musoma/Mwanza) and the Arusha/Kilimanjaro region. The long travel times by vehicle, approximately 8 h, might explain the increase in air traffic to access SENAPA. The roads within the Park consist of approximately 500 km of regional roads and more than 1200 km of safari roads (not represented in the figure). All roads within the Park are unpaved and have generally low standards. The main road between Naabi Gate and Ikoma is the only one designed for heavy vehicles (up to 7.5 tons) within the Park. Nevertheless, road maintenance and construction vehicles up to 20 tons are allowed.

SENAPA can be accessed by road by any of the four road gates: Ndabaga, Ikoma, Kleins or Naabi. International tourists pay a one-time fee of 50€ to enter Serengeti, in addition to a daily fee of approximately 50€, whereas the fee for locals is 1.50€. Naabi gate is the most popular entrance, as it is located on the access road from Kilimanjaro International Airport. The Park is also accessible through any of the 12 airstrips located within or in surrounding areas. Nevertheless, less than 20% of tourists accessing the Park travelled by air in 2013/2014, potentially due to the high price of plane tickets in the tourist packages (Sekar et al., 2014). The trips from the international airport or any of the airstrips to the accommodations are mainly done by safari vehicles. Most of these accommodations are within central Serengeti. Therefore, the road traffic is mainly concentrated in that area. Moreover, in the dry, season wildebeests are in the short grass plains in central and south Serengeti, which is a major attraction for the tourism market.

This study developed a tool to simulate the effects of two ongoing transportation projects. The first one was the new northern road. This road, currently under construction, will connect Ngorongoro to Klein's Gate and to Mugumu. The road will be paved outside the Park and unpaved within its limits. Moreover, the road between Mugumu and Musoma is being updated to a paved road. The second project modelled was the new international airport at Mugumu, already approved for construction.

2.2. Data source

All vehicles driving into SENAPA stop at either the gates or the airstrips to pay the corresponding fees to the Park. They also have to complete a questionnaire providing details about their destination inside the Park, the number of days overnighting, and the number and nationality of visitors in the vehicle, among other things. The complete list of questions in the manual registration and the Naabi gate is shown in Fig. 2.