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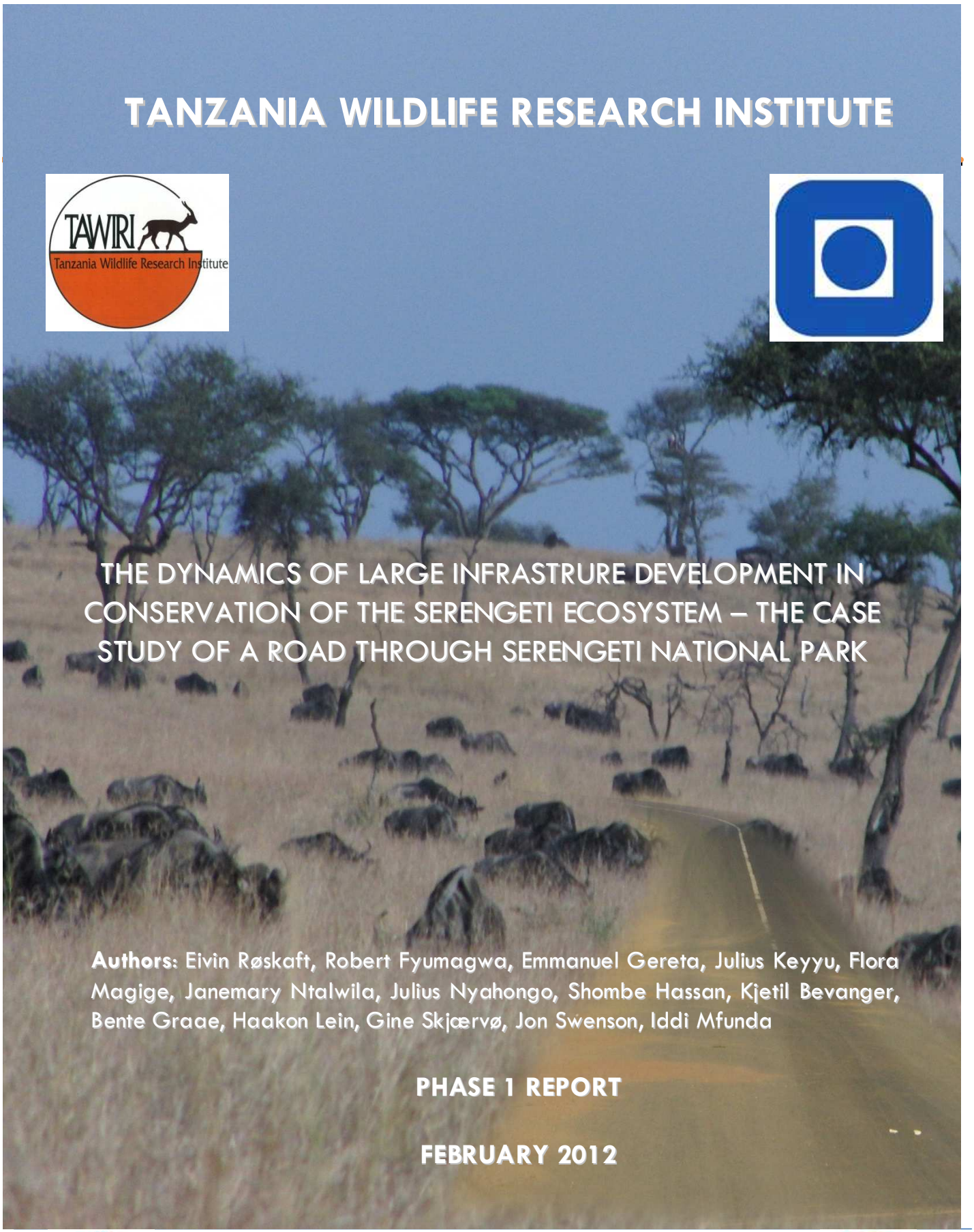

THE DYNAMICS OF LARGE INFRASTRURE DEVELOPMENT IN CONSERVATION OF THE SERENGETI ECOSYSTEM – THE CASE STUDY OF A ROAD THROUGH SERENGETI NATIONAL PARK

Authors: Eivin Røskaft, Robert Fyumagwa, Emmanuel Gereta, Julius Keyyu, Flora Magige, Janemary Ntalwila, Julius Nyahongo, Shombe Hassan, Kjetil Bevanger, Bente Graae, Haakon Lein, Gine Skjærvø, Jon Swenson, Iddi Mfunda

PHASE 1 REPORT

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Funding for this work has been provided by Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) through the Norwegian Directorate for Nature Management

Cover and Photo by: ***Edward M. Kohi***

Abstract

This report presents results from the first field surveys for the five Thematic Areas – Biodiversity (Zoology and Botany), Human and Animal Health (HAH), Environmental Science, and Socio-ecology - that was conducted along the proposed Serengeti road in Serengeti and Ngorongoro Districts. The project area comprises five sections, four of which are within community areas and one inside Serengeti National Park. The study is part of the capacity building project under 'Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services' (IPBES) in Serengeti Ecosystem of Northern Tanzania. It focuses on several sub-disciplines under each Thematic Area: Zoology (large mammals, birds, small mammals, reptiles, insects), Botany (Vegetation), Human and Animal Health (Communicable diseases, non-communicable diseases, zoonotic diseases, livestock and wildlife diseases), Environmental Science (Environment and water quality and quantity (hydrology and water quality, eco-hydrology, and soil science), and Socio-Ecology (Human-wildlife interactions, natural resources management, livestock-wildlife interaction, tourism, socio-economics and livelihoods).The report highlights on background information to the study, objectives, research design and methodology, preliminary results, and important conclusions and predictions.

Keywords: *Serengeti Ecosystem, Serengeti National Park, Biodiversity, Thematic Areas, Zoology, Botany, Environmental Science, Human and animal Health, Socio-Ecology.*

Foreword

This report is part of the study on the capacity building project under the 'Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services' (IPBES) in Serengeti Ecosystem of Northern Tanzania. The aim of this report is to present: the status and trends of the natural resources and biodiversity in the portion of the proposed Serengeti Road in terms of species composition, diversity, distribution and resource abundance (biodiversity inventory); to establish the benchmark in the conservation of the ecosystem; and create an understanding of dynamics of the proposed road to the conservation of the Serengeti Ecosystem and socio-economic trade-offs. The report is based on the first fieldwork that was conducted in twelve villages, which included six villages from each side of Serengeti National Park (i.e. west and east of SNP), and within Serengeti National Park along proposed road. The research was conducted over a period of three months (November and December 2011 and early January 2012). Based on the aims of the project and inputs from respective Thematic Area, the project will publish at least five papers by the end of year 2012, and various reports.

The project has been initiated by the Tanzania Wildlife Research Institute (TAWIRI) and Norwegian University of Science and Technology (NTNU), and involves other institutions and stakeholders from Tanzania and Norway including University of Dodoma (UDOM), Sokoine University of Agriculture (SUA), University of Dar es Salaam (UDSM), Norwegian Institute for Nature Research (NINA) and Norwegian University of Life Sciences (UMB). From the set-up, the project will also involve other collaborating institutions such as Tanzania National Parks (TANAPA) and Ngorongoro Conservation Area Authority (NCAA).

Funding for this work has been provided by IPBES through the Norwegian Directorate for Nature Management. The Project acknowledges Serengeti and Ngorongoro districts and their respective village authorities for their generously support and cooperation. Despite being part of the project, the Serengeti Wildlife Research Centre (SWRC) deserves special recognition for organizing the necessary logistics, providing accommodation and assisting in the communication with the district authorities, village officials and local people involved in the study in different ways.

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Executive Summary

A multi-institutional team of Tanzania, Norway, and South Africa scientists have been engaged in a scientific endeavour – studying the dynamics of the proposed Serengeti road to the conservation of the Serengeti Ecosystem, socio-economic trade-offs, and other influencing factors such as human and wildlife population increase, poverty, climate change, and natural resources management governance challenges. The most important element of the project is to improve the capacity to monitor effects of management actions; ecosystem monitoring, decision making and effectiveness by the Government authorities and institutions responsible for

natural resources management in Tanzania and elsewhere. The main partners to the project are Tanzania Wildlife Research Institute (TAWIRI) and the Norwegian University of Science and Technology (NTNU). As a collaborative project, other contributing partners are: University of Dodoma (UDOM), Sokoine University of Agriculture (SUA), University of Dar es Salaam (UDSM), Tanzania National Parks (TANAPA), Ngorongoro Conservation Area Authority (NCAA), Norwegian Institute for Nature Research (NINA), Norwegian University of Life Sciences (UMB), and University of Pretoria (South Africa).

The baseline data for the biodiversity of flora and fauna along the proposed Serengeti road has been collected from east, west, and within Serengeti National Park (SNP) along the proposed Serengeti road. The project area comprises five sections: four of which are in community areas (referred in this report as villages) and one inside SNP. The villages were randomly selected by the Socio-Ecology Group. Other Groups – Biodiversity (Zoology and Botany), Human and Animal Health, and Environment Science- applied the same selected villages. The biodiversity Groups that dealt with Zoology and Botany Thematic Areas developed additional control transects inside SNP. The six villages are from Serengeti District in the west of SNP and the other six were located in the east of SNP. The two sides are as well recognized as part of the western and eastern Serengeti. In each study section two control villages were purposively selected at a distance of 10 and 20 km perpendicular study section to the proposed Serengeti road.

The limitations in data collection across the five Thematic Areas are evident. The language barrier especially in eastern Serengeti, timing, and transportation were among the limitations encountered during the fieldwork. The use of interpreters (Maasai-Swahili) was therefore necessary in Eastern Serengeti. Inadequate number of traps and theft of set traps for small mammals in some villages were encountered in the course of the study. The project had to guard the set traps and educate the villagers, especially the youth, on the importance of research to conservation and human development aspects – and consequently making them part-and-parcel of the project. The destruction by animals like hyenas was addressed by hiding and increasing the number of traps and designing hyena threat objects – for instance toys. Finally, weather changes particularly heavy rainfalls have been affecting timely follow up of the traps due to transport difficulties. In relation to botany, it was discovered during the study that not all the three vegetation types were available in each of the study village, and that the Group under Botany Thematic Area needed more time in the field to concentrate on step-by-step procedures in plant identification. These factors made it difficult to obtain more than a basic picture of the biodiversity of flora and fauna along the proposed Serengeti road within six months of the fieldwork (Phase I).

Acronyms and Abbreviations

ESIA	Environmental and Social Impact Assessment
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
NCA	Ngorongoro Conservation Area
NCAA	Ngorongoro Conservation Area Authority
NINA	Norwegian Institute for Nature Research
NTNU	Norwegian University of Science and Technology
SNP	Serengeti National Park
SUA	Sokoine University of Agriculture
SWRC	Serengeti Wildlife Research Centre
TANAPA	Tanzania National Parks
TANROAD	Tanzania Road Agency
TAWIRI	Tanzania Wildlife Research Institute
UDOM	University of Dodoma
UDSM	University of Dar Es Salaam
UMB	Norwegian University of Life Sciences
WMA	Wildlife Management Area

1 Introduction

Tanzania is among few countries in Africa with a diverse network of Protected Areas including wildlife. The importance of wildlife cannot be overemphasized based on their biological as well as socio-economic values that are not only important to the country but also the world at large. International tourists and scientists are coming in large numbers in Tanzania to fulfil both their own interest and happiness and the obligation of international conservation paradigms. The networks of Protected Areas in Tanzania include national parks (14), Ngorongoro Conservation Area, game reserves (33) and game controlled areas (GCAs) (43). The Protected Areas network covers 233,300 km^2 of the land surface area (28%). Tanzania, like many other countries of the world has been striving to achieve biodiversity conservation and human development goals that are conflicting by their nature. One important component is the development of road infrastructures that seek to harvest the benefits of an expanding road system leading to expanding economy, creating more jobs, and better access to social services (Forman et al. 2002).

The infrastructure development such as road constructions may become threats to natural resources and environment promoted by climate change, including air and water pollution. Moreover, destruction of wildlife habitat, loss of species, killing the individual animals, unsustainable use such as illegal hunting, and encroachment on villages closer and within protected areas may increase as a result of road construction through the protected area. There is much concern that the loss of living organisms will reduce our ecosystems functioning (Chapin et al. 2000). A particular concern is that the consequences of species extinction on ecosystems may be undetected until conditions deteriorate beyond our ability to restore the situation (Sinclair et al. 2002). Some ecosystems respond to human induced changes by losing species leading into changes in species richness, diversity and abundance (Holling 1986). Mitigation measures are most likely to be effective during the period of initial slow change, if such change could be detected. Change in species richness and abundance can be monitored over time in different areas. To determine these changes we need to characterize the baseline data occurring in current land uses that will be used for monitoring purposes. For instance, birds and small mammals have been extensively used as indicator species since they are among the most sensitive species and sometimes act as an early warning to biologists.

Thus following up the construction of Serengeti road, before (planning), during (impact) and after the construction (consequences) will create an understanding of the dynamics of the Serengeti road to the conservation of the Serengeti Ecosystem, socio-economic trade-offs, and other influencing factors such as governance challenges. The project will improve the capacity to monitor effects of management actions; ecosystem monitoring, decision making and effectiveness by the government and institutions responsible for natural resources management in Tanzania and elsewhere.

2 Objectives

This is the first fieldwork report about TAWIRI-IPBES Project which aims to strengthen the capacity of Tanzanian institutions to develop good Environmental and Social Impact Assessment (ESIA) in relation to large infrastructure development. The report presents some descriptive results of the status and trends of the natural resources and the biodiversity in the portion of the Serengeti road in terms of species composition, distribution and resource abundance (biodiversity inventory); the benchmark in the conservation of the Serengeti Ecosystem; and an understanding of the dynamics of the proposed Serengeti road to the conservation of the Serengeti Ecosystem and socio-economic trade-offs. The

report is based on the fieldwork which was conducted within and in villages along the western and eastern parts of Serengeti National Park (SNP). The descriptive results presented here deals with five Thematic Areas (TAs) - Biodiversity (zoology and botany), Human and Animal Health, environmental science, and socio ecology - covered in the fieldwork. The Thematic Areas details theoretical and empirical issues related to the conservation and human development aspects in the Serengeti Ecosystem. The objectives are:

i. To determine the status and trends of the natural resources and the biodiversity in this segment of the Serengeti Ecosystem – as a barrier - in terms of species composition, distribution and resource abundance (biodiversity inventory).
ii. To improve the capacity to monitor effects of management actions; ecosystem monitoring, decision making and effectiveness by the government and institutions responsible for natural resources management.
iii. To establish the benchmark in the conservation of the ecosystem, and allow the decision making body and local experts to make a better informed decision for the benefit of the ecosystem and Community.
iv. To create an understanding of the dynamics of the proposed Serengeti road to the conservation of the Serengeti Ecosystem and socio-economic trade-offs governance challenges, and other influencing factors.

3 Research Design and Methodology

3.1 Study Area

The study area is located in Serengeti and Ngorongoro Districts on the west and east of Serengeti National Park (SNP). The national park (14,763 km^2) is a World Heritage Site, Biosphere Reserve, and forms the heart of the Serengeti Maasai-Mara Migratory Ecosystem of north-western Tanzania and south-western Kenya (Mfunda & Røskaft 2010). SNP borders the Ngorongoro Conservation Area, a multiple land use area and also a biosphere reserve and world heritage site. SNP borders the Ikorongo, Grumeti and Maswa Game Reserves, Ikona Wildlife Management Area (WMA), and the Loliondo Game Controlled Area. Seven districts, including the Serengeti and Ngorongoro, share administrative boundaries with the national park. The national park contains a very high diversity and concentrations of ungulates, large carnivores, and birds (Sinclair & Arcese 1995). The wildlife of Serengeti is migratory in nature and dominated by wildebeest (*Connochaetes taurinus*), zebra (*Equus burchelli*), Thomson gazelle (*Gazella thomsoni*) and other threatened or endangered species like African elephant (*Loxodanta africana*) (Sinclair & Arcese 1995; Thirgood et al. 2004). The Serengeti Ecosystem contains grasslands in the north, woodlands in the centre, and forests in the western corridor (Herlocker 1976). According to Fryxel (1995), the Serengeti Ecosystem can be divided into two main regions; the southern short grasslands with low annual rainfall and the wooded northern grassland with higher rainfall (Fryxell 1995).

The study area for the Serengeti Capacity Building Project along the proposed northern Serengeti road consists of five segments, four of which are within villages (in other words, the community areas) and one inside SNP including Isenye-Mugumu, Mugumu- Tabora B, Tabora B-Kleins Gate, Kleins Gate-Wasso and Wasso-Mto wa Mbu respectively. Each study segment in community areas has three study villages at a distance of 0 km, 10 km and 20 km from the proposed main road. A total of 12 villages

six from western Serengeti (Serengeti district) and six were in eastern Serengeti (Ngorongoro district) along the Serengeti road (Figure 1).

The selected villages included Nyiberekera, Masongo and Maburi (Makutano-Mugumu segment), Mbirikiri, Koreri and Nyamirama (Mugumu- Tabora B segment), Ololosokwan, Oloipiri and Enguserosambu (Kleins Gate-Wasso segment), Maaloni, Losoito and Digodigo (Wasso-Mto wa Mbu segment). Kleins Gate-Wasso and Wasso-Mto wa Mbu segments are in Ngorongoro district which is inhabited mainly by two major tribes; the Maasai pastoralits and Sonjo agro-pastoralits. Isenye-Mugumu and Mugumu-Tabora B segments are in Serengeti district and are inhabited mainly by multi-ethnic agro-pastoral communities.

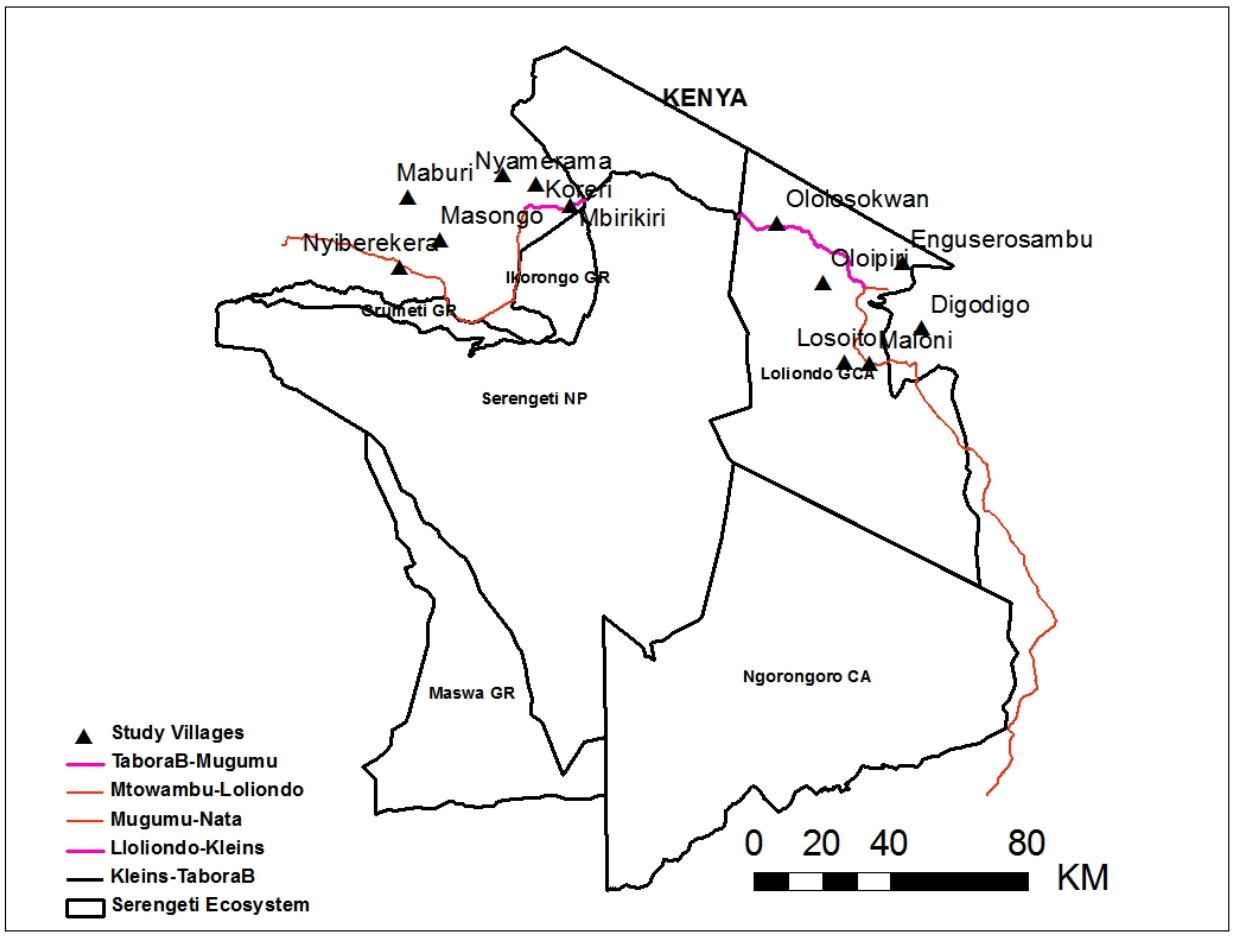

Figure 1: *The map of Serengeti ecosystem showing study sites for the Serengeti capacity building project (SCBP)*

3.2 Sample and Data Collection

During this study we obtained different sets of data and information needed to address the study objectives to the five thematic Areas using a multi-method approach. The research was conducted from October 2011 to January 2012. The villages were randomly selected by the Socio-Ecology Thematic Area. All the other Thematic Areas – biodiversity, human and animal health, and environment - used the same villages. The biodiversity Thematic Areas consisting of Zoology and

Botany developed additional control transects inside SNP. The twelve study villages consisting six villages from Serengeti District in west of SNP and the other six villages from Ngorongoro District, east of SNP. The two areas of SNP are referred in this report as to western and eastern Serengeti. In each study section one control village was purposively selected at a distance of 10-20 km perpendicular study section to the proposed Serengeti road:-

3.2.1 Socio-Ecology

(Nyahongo, J. W., Lein, H., Kideghesho, J. R., Ntalwila, J., Malugu, L., Alfred, A., Mwakatobe, A., Runyoro, V. & Dallu, R.)

The data on socio-ecology was collected through questionnaire surveys in twelve villages from Serengeti and Ngorongoro districts. The interviews covered 429 households. The group interviewed household heads or any adult person (≥ 18 years) who have been living within the household for 12 consecutive months. The villages were obtained from a list of villages in each district. The list was split into three categories based on the distance from the road; zero distance, 10 km and 20 km. Then using random numbers generated from a scientific calculator, the villages to sample were then randomly selected. The households to be interviewed were randomly selected from the village and sub-village registers where the first household was randomly selected and then every fifth name of household were picked from either direction in the list until 30 household were obtained. The villages sampled were Mbirikiri, Nyiberekera, Koreri, Nyamerama, Masongo and Maburi in Serengeti District, and Maloni, Digodigo, Loosoito, Enguserosambu, Oloipiri and Ololosokwan in Ngorongoro District. The data were collected by the senior researchers and field assistants conversant with the village and households. The language barrier, timing, and transport were among the limitations encountered during the data collection. The use of interpreters (Maasai-Swahili) in Eastern Serengeti was necessary to obtain good results. The survey aimed at gathering baseline information on socio-ecological issues focusing on Human-wildlife interactions, natural resources management, tourism, socio-economics and livelihood prior to the road construction in all the major identified segments in the west and east of SNP.

3.2.2 Human and Animal Health

(Fyumagwa, R., Skjærvø, G., Keyyu, J., Mdaki, M., Kimera, J. & Eblate, E.)

Data collection for the human and animal health group was divided into two phases. Phase I of the study dealt with qualitative data whereby two sets of questionnaires were administered. One set was for human health and another set was for animal health. In each of the 12 sampling villages, at least 30 respondents were interviewed for human health and 30 respondents for animal health respectively. A total of 790 respondents (311 (39.4%) females and 479 (60.6%) males) were interviewed including 398 respondents for Human Health and 392 respondents for Animal Health respectively. The number of male respondents was higher compared to females because both agro-pastoralists and pastoralists in Ngorongoro and Serengeti districts where the study was conducted are male dominated societies. The village leaders and at least one teacher were purposively interviewed because of their acquired knowledge on human and animal health issues. Phase II of the study will deal with quantitative data sampling that will involve clinical examination of humans, domestic and wild animals by collecting

samples of blood, faecal sputum, urine, and parasites. Because of limited time it was not possible to procure all laboratory consumables and submit the application for ethical clearance to the National Institute for Medical Research (NIMR) for access to human samples. The priority for the diseases to be studied will depend on results from questionnaire survey that have an indication of major diseases for humans and domestic animals.

3.2.3 Zoology

(Magige, F., Kohi, E., Mwakalebe, G., Nkwabi, A., Kalumbwa, E, Makongoro, N., Jackson, C., Fossøy, F. & Røskaft, E.)

For each of the 5 established segments along the proposed highway, two points were selected for sampling of both small mammals and birds: the point close to the road was 150-200 meters away from the roads and second point was about 10 km away from the road. The 10 km point was set as a control. A Capture-Mark-Recapture (CMR) method was used. A total of 50 Sherman traps were set in each segment - 25 traps in each point. The traps were set 10 m apart from each other. The traps were located by red or orange flagging tape so that they could be easily spotted in subsequent visits. Traps were covered with grass during hot periods to reduce mortality from heat stress. In addition 10 pitfall traps (20L) were set in each trapping point. The pitfall traps were set 5 meters from each other. Point count method was used simultaneously to record birds in the same points. The recording and counting of birds and trapping of small mammals were conducted for 4 consecutive days for each point. Because of small sample sizes data was pooled and therefore analyses were done basing on segments and not point wise.

3.2.4 Botany

(Hassan, S., Bukombe, J., Lyamuya, R., Mwita, M., Mayemba, E. & Graae, B. J.)

Data on Botany were gathered from each of the study villages with three sites per village corresponding to three vegetation types - grassland, woodland and shrub land. The villages in each section of the proposed Serengeti road were distributed at a distance of approximately 0, 10, and 20 km. The vegetation and environmental recording were done in 1x1 m plots at distances 0, 5, 10, 25 and 50 m for the herb layer and in 10x10 m plots at 10, 30, 50, 70 and 90 m for the trees and shrub layers (Figure 2). Vegetation cover was estimated first for the entire plot and then for a species as visual cover in percentage. Lopping scores per individual were recorded at 5 levels: 1 = rudimentary signs of lopping; 2= up to half of the main branches lopped; 3= more than half of the main branches lopped; 4 = tree reduced to a stump; 5 = some or all roots harvested. Light and soil measurements were recorded in the centre of each plot with a VG-meter. Next to each of the herb plots, two 0.25 x 0.25 m quadrants (at north east and south-west corners) were selected, and from each, all herb material were clipped at ground level and put in a bag for later sorting into 3 compartments (leaves, stem and standing dead) for structure analysis and later on for analyses of Pb in the lab. The beginning of each transect was marked using a wooden peg driven into the ground.

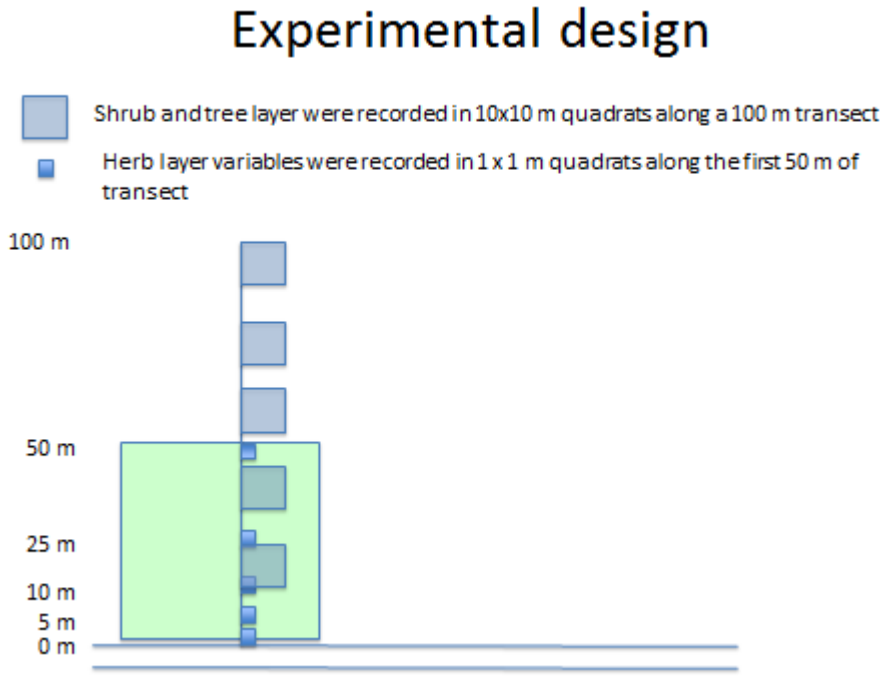

Figure 2: *Layout of plots along distance gradients from road*

Table 1: *Current work status of the Botany Thematic Area: Number of herb, shrub and trees species and current work status of the Botany Thematic Area (Work completed/pending: 1 = site selection; 2 = vegetation sampling; 3 = questionnaires ;) Vegetation types encountered: G = Grassland; W = woodland; S = shrubland)*

S/N	Road section	Sampling Village/location	Work completed	Work pending	Vegetation types	Number of herb species counted	Number of tree and shrub species counted	Number of Alien species counted
1	Mto/Mbu-Loliondo	Maloni	1 & 2	3	G,W,S	50	25	7
2	Mto/Mbu-Loliondo	Losoito	1 & 2	3	G,W,S	55	17	2
3	Mto/Mbu-Loliondo	Digodigo	1 & 2	3	GW	52	18	7
4	Loliondo-Kleins	Ololosokwan	1 & 2	3	G,W,S	48	21	3
5	Loliondo-Kleins	Oloipili	1 & 2	3	G,W	49	13	1
6	Loliondo-Kleins	Enguserosambu	1 & 2	3	G,S	20	5	7
7	Kleins-Tabora B	SNP		**all**				
8	Tabora B-Mugumu	Mbirikiri	1 & 2	3	G,W,S	74	13	12
9	Tabora B-Mugumu	Koreri	1 & 2	3	G,S	44	16	12
10	Tabora B-Mugumu	Nyamerama	1 & 2	3	G,W	87	11	16
11	Mugumu- Isenye	Nyiberekera	1 & 2	3	G,W,S	67	15	18
12	Mugumu-Isenye	Maburi	1 & 2	3	G,W,S	47	2	14
13	Mugumu-Isenye	Mosongo	1 & 2	3	G,W,S	38	7	10
	EAST				**WEST**			
	Average number of species counted				**Average number of species counted**			
	Herb	**Woody**	**Alien**		**Herb**	**Woody**	**Alien**	
	45.7	16.5	4.5		59.5	10.7	13.7	

Alien species were sampled along the Serengeti road and feeder roads in the studied villages.Alien species were recorded along 20 km road in 500 m stretches in 2 m broad bands on both side of the

road. In villages and close to Klein's gate, recording was done at 2 km intervals. Recording was done from a car (Land rover-hardtop), driven at 15-20 km/hr with two observers in each side. *Datura stramonium, Lantana camara, Chromoleana odorata, Parthenium hysterophorus, Argemone mexica* and *Opuntia sp* were focal species but other alien species were recorded as well. For each 500 m stretch, the abundance of each recorded alien species was recorded according to the scale: 1= single individual; 2 = several individuals scattered; 3 = single cluster, 4 = several clusters scattered). Also the GPS-position, altitude, site features (0 = normal, 1 = disturbed; 2 = drainage passing; 3 = 1&2). The road sections were coded as: 1 = Mto wa Mbu - Loliodo; 2 = Loliondo-Kleins gate; 3 = Kleins gate-TaboraB; 4 = Tabora B-Mugumu, and 5= Mugumu-Isenye (Table 1).

3.2.5 Environmental Science

(Gereta, E., Bevanger, K., Kaswamila, A., Haule, K., Mwakipesile, A., Kihwele, E. & Kaitila, R.)

Several methods were used during the data collection. The main ones were discussions with different stakeholders at regional, district, ward and village level, and interviewing 30 local communities, soil survey, flow rate measurements (water discharge) and water quality data collection. The team also visited water basin offices, Tanroads and some police stations to get information related to weather data, traffic densities and road accidents respectively. Interviews with local communities were done in five villages visited namely Mbirikiri in Serengeti District and Ololosokwan, Maaloni, Olsoito, and Digodigo in Ngorongoro District. The interviews were mainly on land uses, deforestation status, encroachments, poaching, agriculture, climate, and accidents. Soil profiles were dug in some selected sites along and/or near the proposed road and soil samples were taken. The profiles were dug in Isenye, Ololosokwan, Mbirikiri and Maaloni villages.

On water quality measurements, water quality checkers were used to read various physico-chemical parameters of water. These included water temperature (using Digital pocket water tester, DO DMT-50), Dissolved Oxygen (using Digital pocket water tester, DO DMT-50), Salinity (Using Salt meter ATC) and Transparency (using a 20 diameter Secchi Disc). PH values were not recorded during first sampling due to the unavailability of pH meter. However, during the second phase of data collection pH readings were recorded in all sampling sites. Physico-chemical water parameters (DO, Salinity, Temperature and pH) were measured in-situ using water quality checkers. Flow rates were determined using general formula Q = V * D * W where; Q is the flow rate in m^3s^{-1}, V is the velocity of water in ms^{-1}; D is the water depth in M and W is the width of the river in meters. Noise pollution was measured using sound recorder (Radio Shack-Sound level meter).

3.3 Data Analyses

The analyses were done using SPSS 16.0. Descriptive statistics were used to analyze the social-demographical data where percentages, mean and standard error were reported as final results. Multinomial logistic regression analysis was applied to predict the independent parameters (covariates) that could explain the variation in perceptions (dependent variable) towards the road construction through the Serengeti ecosystem. For all tests, $p < 0.05$ was considered significant. Also Excel 2007 and Shannon-Wiener diversity Index (Zar 2010) were used for data analysis (Zoology).

The data collected by Botany Thematic Area from the designed transects away from the roads were analyzed as gradients within each vegetation type to evaluate the effect of the road on each vegetation type (changes in abundance of functional groups, functional and species diversity, and in the occurrence and abundance of special target species and the environmental conditions. The effects will also be compared for sites with different distances to the main road and for sites situated in villages with different land use systems (farming, pastoralist and no land use). The methods will depend on the distribution of the sampled data (most likely ordination, GLM, and LME will be part of the data processing).

The data on alien species along the road sections will also be analyzed with respect to distance to village and where the centre of introductions occur, for differences in regions with different land use systems and most importantly descriptively for later comparisons of spread of the recorded species and newcomers.

A total of 20 soil samples were collected and have been sent to Selian Agricultural Research Institute (SARI) for analysis. The water-flow/discharge estimates were determined using floater method. The discharge volume was calculated from the water depth, length, width and time taken for the floater to cross the determined length. However, in non-flowing rivers, estimates on water quantity were undertaken by measuring the water depth, width and length of the standing water where by volume was obtained.

4 Preliminary Results

4.1 Socio-ecology

4.1.1 Socio-demographic characteristics

Altogether, 429 respondents were interviewed in Ngorongoro and Serengeti Districts. The majority were males (63.2%) and young people (18 and 40 years). In Ngorongoro District 64.3% were Maasai followed by Sonjo (18.7%). The remaining tribes scored less than 4% each. In Serengeti District, Kurya (65.8%) was the most common followed by Ngoreme (7.5%). The remaining tribes scored 5% or less. Overall, the majority completed only primary education (55.5%). However, a good number did not attend any formal education at all (24.0%). 51.3% from Ngorongoro District received only primary education while 27.3% did not attend any class at all. Compared to Serengeti, 60.3% attended primary education while 19.6% did not attend any class at all. In Serengeti District, 20.1% attended secondary school while only 15.3% attended secondary school in Ngorongoro District.

Results showed that 50% in the two districts were not born in the villages they are currently living. When data is pooled, 46.6% claimed that they were not born in the village where they are currently residing. Several socio-economic factors such as searching for grazing land, farm, marriage, business opportunities, access to natural resources, water for both domestic and livestock, employment etc. were the lead to movement among the villages, regions and/or countries. In Ngorongoro District, almost 40% of the respondents (36.5%) were not born in the villages they are currently living while 58.3% immigrated to the villages sampled in Serengeti District.

Overall mean household size was 8.5 ± 0.3. In Ngorongoro District, the mean household size was 7.7 ± 0.4 compared to 9.4 ± 0.3 in Serengeti District. The overall household income was 138,000 ± 8,914.2. The respondents from Ngorongoro District earned on average more than 13 those from Serengeti District (Mean income for Ngorongoro 181,000 ± 14,980, whereas those from Serengeti had average income of 89,600 ± 6,982.6).

4.1.2 General perceptions of local communities on road construction

One of the questions included in the questionnaire demanded the respondents to produce their opinion about the planned road. The majority claimed that the road will bring positive (81.3%) impact to their livelihood. However, 17.0% had the opinion that the road will bring both positive and negative impacts to their livelihood. In contrast, few respondents claimed that road will bring negative (1.7%) impact to their livelihood. The data treated per districts, ethnicity, and distance from the road and genders are summarized in Table 2.

4.1.3 Multinomial logistic regression

A multinomial logistic regression analysis was applied in an attempt to predict the parameters that can explain the amount of variation in perceptions towards the road construction through the Serengeti ecosystem by the respondents. In this analysis, the dependent variable was the opinion of respondents on the road to be constructed. The covariates included age, sex, household income, level of education the respondent attained, the tribe of the respondent and whether the respondent was born in the village or not. More covariates included village distance from the road, household size, and area for grazing livestock, area for crop production, cattle number, goat number and sheep number. Furthermore, the types of materials used for house wall, roof and floor were also transferred to the covariates window for analysis. In addition, the number of household members employed and the wealth (items the household own) were also included in the analysis. Generally, the model fit to our prediction significantly (Likelihood Ratio Test: $\chi^2 = 58.9$, df = 36, p = 0.009). The variables that explain the fit of the model of which if removed from the model would result in a significantly poorer fit of the model are amount of land available for crop production (Likelihood Ratio Test: $\chi^2 = 14.006$, df = 2, p = 0.001) and number of goats (Likelihood Ratio Test: $\chi^2 = 12.2$, df = 2, p = 0.002). The remaining variables were not significant (p > 0.05).

Table 2: *The percentage of respondents about the road to be constructed between Makutano (Mara) and Mto wa mbu (Arusha) based on district location, major ethnic groups, the distance of the village sampled to the road and gender of respondents*

Claims	Overall	Districts		Major ethnic groups			Distance from the road (km)		
	(n = 422)	Ngorongoro (n = 227)	Serengeti (n =195)	Maasai (n = 145)	Sonjo (n = 43)	Kurya (n = 129)	0 (n = 172)	10 (n = 139)	20 (n = 111)
Positive	81.3	75.8	87.7	71.0	86.0	85.3	74.4	82.7	90.1
Positive & negative	17.0	22.0	11.3	25.5	14.0	14.0	23.3	16.5	8.1
Negative	1.7	2.2	1.0	3.5	0	0.7	2.3	0.8	1.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Overall, the number of goats owned by household (Wald Statistic: χ^2, = 5.48, p = 0.019), was the only parameters in the final analysis that influenced the perception in a positive way. When the data was treated per district, again, the number of goats was the significant parameter that would change the model to fit poorer if removed (Likelihood Ratio Test: χ^2 = 14.7, df = 36, p = 0.004) in Ngorongoro District. In the final analysis only type of material used to make house floor that influenced positive opinion on the planned road in Ngorongoro District. In contrast with Serengeti District, village distance from the road (Likelihood Ratio Test: χ^2 = 6.37, df = 2, p = 0.041) and household roofing materials (Likelihood Ratio Test: χ^2 = 5.91, df = 2, p = 0.05) where the most significant variables in the model of which if removed, the model would fit poorer. In the final analysis, there was no any parameter that was able to explain significantly the amount of variation in perception observed.

4.2 Human and Animal Health

4.2.1 Respondents' knowledge on human and domestic animal diseases

The results obtained showed that responses from agro-pastoralists and pastoralists are more knowledgeable on common diseases affecting humans and livestock. Majority of respondents explained that malaria was the most common disease (49.4%) followed by pneumonia (13.3%), diarrhoea/ dysentery (9.8%) and typhoid (6.2%). Other important human diseases mentioned by respondents were Tuberculosis (4.9%), helminthosis (4.7%), anthrax (4%), fever (3.8%), sexually transmitted infections (3.2%), bed bugs (2.5%), HIV/AIDS (2.3%), brucellosis (1.8%) and measles (1.3%). The Maasai pastoralists who are semi-nomadic had more knowledge on livestock diseases than the more sedentary agro-pastoral communities. The respondents from agro-pastoral communities were more knowledgeable on common diseases affecting humans. The common livestock diseases mentioned by respondents were East Coast Fever (44.7%), helminthosis (29.4%), trypanosomosis (15.8%), anthrax (11%), brucellosis (7.9%), Malignant Catarrh Fever (8.8%), coenurosis (6.1%), Foot and Mouth Disease (5.7%), rabies (5.7%), Rift Valley Fever (5.3%), diarrhoea (4.8%), Tuberculosis (4.4%) and Contagious Bovine Pleuro-Pneumonia (1.8%). This survey showed preference of some pastoral people to eat raw meat and milk and that most households in Maasai and Sonjo communities lacked latrines. The results also showed that pneumonia was a common disease in Maasai communities (see also Table 3).

4.2.2 Knowledge on zoonotic diseases transmission

Among Maasai pastoralists, 30.1% of the respondents admitted to drink raw milk for the reason that it is more tasty (45.9%) or increases energy (9.8%). The survey showed that 25.2% of respondents prefer use of raw blood, the reason being that it increases energy (12.2%) and that it is a tradition (7.12%). On the use of raw, meat 13.3% of respondents admitted to take raw meat on the reason that it is their tradition (63.5%) while others mentioned that they eat raw meat because they don't have time to cook.

Table 3: *Common diseases affecting human and livestock in agro-pastoral and pastoral communities in Ngorongoro and Serengeti districts*

Districts	Community	Human diseases	Livestock diseases
Ngorongoro	Maasai pastoralits	Malaria, diarrhoea/dysentery, brucellosis, tuberculosis, typhoid, pneumonia, measles, worm infestation and beg bugs	Tick-borne diseases (East Coast fever (ECF) and anaplasmosis), trypanosomosis, malignant catarrhal fever (MCF), helminthosis and coenurosis (by *Taenia multiceps*),tuberculosis and CBPP
	Sonjo agro-pastoralists	Malaria, diarrhoea/dysentery, typhoid and tuberculosis	ECF, anaplasmosis, coenurosis and helminthosis
Serengeti	Multi-ethnic agro-pastoralists	Malaria, typhoid, tuberculosis, HIV, diarrhoea, pneumonia and helminthosis.	ECF, anaplasmosis, trypanosomosis, babesiosis, helminthosis, foot and mouth disease (FMD), Newcastle disease and rabies.

4.3 Zoology

4.3.1 Species richness and diversity

Table 4: *Species richness and diversity of birds along the highway*

Segment	Place	Species richness	Species Diversity
Segment 1	Maalon/Losoito	61	1.57
segment 2	Ololosokwan/Endulele	41	1.52
segment 3	Tabora B/Kleins	69	1.68
segment 4	Koreri/Mbirikiri	48	1.45
segment 5	Nyiberekera/Wageti	38	1.32

Table 5: *Species richness and diversity of small mammals along the highway*

Segment	Place	Species richness	Species Diversity
Segment 1	Maalon/Losoito	5	0.41
segment 2	Ololosokwan/Endulele	1	0.00
segment 3	Tabora B/Kleins	5	0.56
segment 4	Koreri/Mbirikiri	6	0.73
segment 5	Nyiberekera/Wageti	6	0.62

A total of 133 bird species and 11 small mammal species were obtained in the study area. The highest bird species richness was observed in the national park whereas the highest species richness for the small mammals was obtained in the western side of the study area i.e. segment 4 and 5 (Tables 4 & 5). Small mammals were dominated by the rodents and some few shrews. There was no correlation of diversities between small mammals and birds. The short rain season data was too few to perform a comparative analysis. Repetitive sampling will yield more data for more analyses.

4.4 Botany

The number of herb, shrub and trees species found in four out of the five road sections is summarized in Table 2. The result further shows that not all the three vegetation types intended for sampling were available in each sampled village. There are more alien plant species and herbs in the west of SNP than in the east whereas the woodlands and scrublands investigated in the East was on average richer in woody species.

4.5 Environmental science

Physico-chemical parameters slightly varied from village to village and slightly fluctuated from first sampling to second sampling. The pH values ranged from a minimum value of 7 recorded at Engaserosambu Village (River King'arama) to a maximum value of 8.16 recorded at Maaloni Village (Maaloni River). The smallest value of salinity was 0.00 ppt observed at Digodigo, Maaloni and Ololosokwan Villages at Maaloni, Mbilikiri and Giheri Rivers, while the highest value of 0.433 ppt was observed at Maaloni site during second sampling. The dissolved oxygen concentration (DO) ranged from the lowest value of 0.53 mg/l recorded at Tobora River in Mbilikiri Village and the highest value of 11.35 mg/l was observed at Tobora River in Koreli Village.

PH readings ranged from 7.0 to the highest value of 8.16 suggesting that the soils in these areas are more basic than acidic. The salinity differences could have been contributed by soil types or geological formation of the areas where water passes. The flow rate ranged from lowest value of 0.00058 m3s-1 noted at Nyamisano River in Isenye Village to highest value of 23.856 m3s-1 recorded at Tirina River in Isenye Village. Most of the streams and rivers are seasonal with a few perennial rivers such as Digidigo, Tobora, Giheri and Mbilikiri villages.

Noise pollution: the sound level ranged from below 60dB to 98 dB at Mugumu Town. However, this noise level is still below 140dB which is acceptable limit by Tanzania Bureau of Standards (TBS). On traffic density: We were unable to get figures from the road engineers. Police was willing to get us some figures but time was not enough to carry out the exercise because the work had to be done manually.

5 Discussion

5.1 Socio-ecology

General perception of local communities about the planned road through Serengeti is positive (81.3%, n = 429). Majority of our respondents were adult men of different ethnic groups born in different

villages. Local communities believe that the construction of the road will improve their livelihoods through sale of agricultural produce including both crops and livestock, especially goats. They will be able to access good market in large cities directly as opposed to the current use of middle men. In Maasai communities the constructions of house (Manyata) do not require iron sheet or bricks made of cement. Thus, the positive relationship between the perception of the road construction and the house floor materials might have occurred by chance. In Serengeti Districts, inspection of houses reveals that most of them were roofed with iron sheet and wall were constructed using baked bricks and mud. Thus, the roofing materials would be the most expensive material for constructing house to local communities in the district. Iron sheets are transported all the way from Dar es Salaam through Arusha or Mwanza. That distance plus poor road would automatically elevate the price. This is more evident when comparing the price of iron sheets between two town where in Arusha 30 gauge, 3 metre iron sheet in January 2012 was TAS 17,000 while the similar item cost TAS 21,000 in Mugumu (Serengeti) (Shayo G. and Peter O., personal Communication).

5.2 Human and Animal Health

This survey has shown a high reported prevalence of both human and livestock diseases in the two districts, as well as high community knowledge on human and livestock diseases including zoonoses. The survey has also shown a similarity in disease problems in human and livestock in pastoral and agro-pastoral communities with few exceptions on diseases which are related to poor hygiene. Furthermore, the survey has shown that malaria, pneumonia, diarrhoea and dysentery are the major diseases affecting humans in agro-pastoral and pastoral communities. In livestock, the survey indicated that the diseases of concern are East Coast Fever, helminthosis, trypanosomosis, anthrax, MCF, brucellosis, diarrhoea and FMD which affect animals in both communities. The results relates to the findings of other similar study in Serengeti Ecosystem as described by Fyumagwa (2010). A feature worthy to note in this study is the fact that the majority of Maasai respondents admitted to eat raw meat, drink raw blood and raw milk. Few Sonjo respondents admitted to drink raw blood. The practices are caused by traditional beliefs that raw animal products have some healing effect, more tasty and increases energy compared to boiled ones. Respondents in the study area also reported a number of neglected zoonotic diseases (disease that are transmitted from animals to man) including brucellosis, TB, helminthosis, trypanosomosis and rabies. The prevalence of zoonotic diseases coupled with the socio-cultural habit of eating or drinking raw animal products makes communities to be at a very high risk for infection with zoonotic diseases, especially TB, brucellosis and taeniosis which all are transmitted through consumption of raw meat, blood and milk.

This survey also indicated that very few Maasai and Sonjo households have toilets suggesting that the level of pasture contamination with human faeces is very high, therefore increasing transmission of zoonoses. Lack of pit latrines and failure of routine deworming of domestic dogs and humans in the Maasai and Sonjo communities causes contamination of pasture with tapeworm eggs. Coenurosis (a disease of small ruminants caused by *Taenia multiceps* cysts from carnivores) was reported to be a serious problem in Maasai and Sonjo communities in Loliondo division (6.1%). The presence of Pneumonia in Maasai communities was probably due to the type of traditional shelter that are characterised by poor ventilation, which is exacerbated by the traditional habit of sharing shelter between humans and small stocks and calves. Diarrhoea and dysentery were also very common in the study areas probably due to lack of clean and potable water, which lead to poor sanitation.

In stark contrast to the Maasai pastoralists, the survey showed that the multi-ethnic agro-pastoral communities in Serengeti district have permanent settlements and the majority of the households have pit latrines. As a result, the coenurosis problem experienced in Loliondo was not a problem in western Serengeti. The survey also showed a low reported prevalence of brucellosis in agro-pastoral communities compared to Maasai pastoralists. Brucellosis has been reported to be about 14% in livestock in Serengeti (Bugwesa et al. 2009), however, proper boiling of milk and cooking of meat have made the communities to be at low risk compared to the pastoral communities in Ngorongoro who drink raw milk, blood and sometimes eat raw meat. This study has also showed that the agro-pastoral communities in Serengeti district were more aware of HIV as one of important pandemic diseases in the community. On the contrary, few respondents from pastoral communities in Ngorongoro district mentioned that HIV was an important disease in the community, suggesting that probably the awareness is low in pastoral communities compared to agro-pastoral communities.

The human and animal health study has shown a high reported prevalence of human and animal diseases including zoonoses. Therefore, there is a need to conduct comprehensive and longitudinal studies on diseases of people and livestock in the two districts in order to have reliable laboratory based findings. With the construction of the new road, which will result into increased influx of people, increased influx of livestock and increased human-livestock interaction; the overall effect will be increased disease prevalence and burden in both people and livestock. This will be exacerbated by poor community knowledge or awareness of important diseases including their transmission pathways and some socio-cultural food habits especially for the Maasai pastoralists. There is also a great need for community awareness creation on human and livestock diseases including zoonoses before, during and after construction phases in order to safeguard human and animal health in communities along the proposed road. On the other hand, the proposed new road is expected to improve road transport system and networking, and therefore will result into easy access to health facilities, more private health and veterinary facilities and reduce cost of transport to health facilities in the area; therefore enhancing prevention and treatment of human and animal diseases.

5.3 Zoology

The reduction in bird richness and diversity could be attributed by agricultural activities that have degraded the habitats for the birds. Most of the birds were confined in the national park. Similar finding have been obtained in Northern Serengeti (Sinclair et al. 2002). With regard to small mammals high diversity and richness were obtained in the western side of the study site. In that area, cereal crops are frequently cultivated and this attract majority of seed eating rodents that have the same basic needs as humans and conflict arises when these creatures are trying to meet their basic needs. They move from their natural habitat onto agricultural land and feed on the produce that humans grow for their own consumption (Magige unpublished data). The situation in the eastern side is different as majority of the villagers are livestock keepers and agriculture is practiced in small scales. The absence of diversity for small mammals in segment 2 (Endulele and Ololosokwan) might be because of the very small sample size.

5.4 Botany

The main impression from this year's fieldwork showed high impact of the road on the nearby vegetation that seemed closely related to land use systems. The sites in regions with farming appeared most affected. The Eastern region had on average higher numbers of tree and scrub species than the Western region, whereas the number of herb species and alien species encountered was much higher in the Western region. It still remains to be evaluated whether this relates to 1) natural factors such as weather (particularly distribution and intensity of rainfall and temperature) and edaphic factors, and 2) land use differences i.e. whether agriculture, cattle herding or both impacted the sites. The villages in the Eastern side of the Serengeti National part between Mto wa Mbu and Wasso road section are dominated by the Maasai ethnic group who are merely pastoralists while the villages in the western part between Mugumu and Isenye road section are dominated by the agro-pastoralists Kurya, Natta and Isenye ethnic groups.

The differences in number of alien species may not really imply the extent of threat. The threat is mainly a function of the type and invasiveness of the alien plant. For example small areas invaded by *Chromolaena oderata, Parthenium hysterophorus, Datura stramonium* may face more challenge as opposed to the areas highly infected by *Amaranthus hybridus* and *Agave sisalana* Thus priority setting based on species potential threat is important in the control. Furthermore, the data presented in *appendix1* only focus on species numbers and whereas final data will include abundance/density, cover and height and relate the pattern in distribution to both the natural and land use differences. With a complete package of information following full analysis of the data set, we will be able to track down the more detailed patterns in the effects of the road on vegetation. Most importantly, this study will be the baseline for future studies, and we will with the set up be able to follow the spread of different alien species along the road in the years to come and changes in road impact after road improvement.

5.5 Environmental science

The water flow (volume) shows that during the wet seasons there is large volume of water passing through the road waterways. This implies that when designing bridges consideration should be given in providing large enough waterway to avoid damages. This should go hand in hand with the understanding of the rainfall pattern of the area especially during El Nino rains will be expected.

6 Conclusions and Recommendations

The conclusion this study arrives at this preliminary stage, is that, the road construction, if properly done by adhering to environmental safety will improve people livelihoods in the west and east of Serengeti National Park. The thorough analysis of the Biodiversity Thematic Areas, Human and Animal Health, and Environment Science will balance the findings of the Socio-ecology Thematic Area on the local people's positive perceptions on the road construction vis-à-vis the negative effects it will cause to the Biodiversity and the Serengeti Ecosystem.

The phase II of the study will help to reach a definitive diagnosis to establish the most common diseases of people and livestock in communities in Ngorongoro and Serengeti districts. This will help in awareness creation to reduce the risk of contracting the infection in risk communities. Increase in human population from immigration following construction of the road will have a negative effect on vector-borne diseases due to poor waste management. Sexually transmitted diseases like HIV/AIDS

and gonorrhoea/ syphilis are likely to increase due to in-migrants if awareness creation is not conducted to local people along the proposed road (Mmbaga et al. 2008). However, it is anticipated that, some traditional practices among pastoral communities are likely to decrease because of external influence from immigrants to the villages close to the proposed Serengeti road. The improved road infrastructure, however, is expected to improve road transport system and networking, and therefore will result into more private medical and veterinary facilities to distant villages.

Further, the results indicate that there are differences in species diversity and richness among the segments which are probably caused by different land-use practices. Biological monitoring can be used as a tool to monitor the changes due to anthropogenic activities in a long run. Biomonitoring uses biological responses to assess changes in the environment. It is therefore recommended that baseline data collection should continue so as to monitor the trend of the biodiversity in the area where the highway will pass.

The current study will elucidate the effect of the existing roads in the Serengeti area on the surrounding vegetation. We found high impact correlated with land use and land use changes will hence be important to study in a future project. The study results will then be useful for scaling down the effects on vegetation level of importance to the environment. We also found high number and abundance of alien species along the roads – especially in regions dominated by agriculture.

7 The way forward

The project activities for year 2012 will consider continuation of the current research activities by taking into account the following:-

i. Radio coloring resident animals and transects of large mammals and birds to study the movement in relation to the road, and the risks involved.
ii. Develop one year circle of baseline data for the Biodiversity Thematic Areas (Botany and Zoology), and the mapping of distribution, abundance, and seasonality of invasive species along the study areas.
iii. To collect data on human subjects in relation to communicable, non-communicable and zoonotic diseases to understand the health status of community members. Other samples will be obtained from animals for laboratory analysis to confirm and establish the main diseases affecting livestock in the communities along the northern Serengeti road. The intervention measure in livestock will be to initiate disease control and prevention strategies using a protocol with minimum cost that has been piloted in six villages in western Serengeti. Some laboratory consumables for samples collection and field diagnostic kits have already been procured from Norway.
iv. Data collection on facts for human and animal health mapping houses along Serengeti road to test the extent people have been affected by the development.
v. To assess the trend of land use change, continue data collection on traffic density versus road accidents, water flows and water impounded in relation to climate (rainfall), establish water requirements for plant, humans and animals. Continue data collection on water quality to assess levels of pollution. The amount of dust trapped and their effects on plants and distribution of animals.

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