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Drivers of conservation crimes in the Rungwa-Kizigo-Muhesi Game Reserves, Central Tanzania

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ABSTRACT

Conservation crimes are posing serious threats to wildlife species and biodiversity of the Rungwa-Kizigo-Muhesi-Game-Reserves. Devising effective strategies to reduce risks to as low as reasonably possible of these crimes, calls for adequate information on factors driving people to commit these crimes. Data for this study were obtained from 315 respondents in 20 villages and 316 people who were arrested for committing different conservation crimes in the Rungwa-Kizigo-Muhesi-Game-Reserves. Our results suggest that arrested respondents were typically young adult males with limited alternative sources of income and owning virtually no livestock or land. There were heterogeneous drivers for each type of conservation crime. To address the challenge of conservation crimes in the Reserve, we recommend, among other strategies, the establishment of effective conservation education programmes, strengthening law enforcements as a deterrence method, and development of entrepreneurship skills to enhance employment. © 2019 Norwegian University of Science & Technology. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

1. Introduction

Conservation crime is a major challenge facing many game reserve managers in Africa and elsewhere (Gibbs et al., 2010; Essen et al., 2014). The crime is often conducted to cater for commercial and/or subsistence needs. There is no universally accepted definition of the term conservation crime. However, a general consensus suggests that conservation crime impacts negatively on people and survival of fauna and flora (Gore, 2011; Ayling, 2013; Essen et al., 2014; Potter et al., 2016; Rizzolo et al., 2017). Conservation crime, therefore, entails illegal activities such as poaching, capture, collection or processing of animals and plants taken in contravention of national, regional or international laws, and any subsequent trade in such animals and plants, including their derivatives or products (Cooper et al., 2009; Kideghesho, 2016; Potter et al., 2016). For this article, activities such as mining, timber extraction and bushmeat hunting were categorized as local/regional markets, while the other sub-category is poaching for the international market with very high market value products such as African elephant (*Loxodonta africana*) ivory.

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There are different types of conservation criminals; firstly, those who perform subsistence conservation crimes to meet food needs and or in exchange of food materials such as maize, sugar, salt etc. Such people mostly use less expensive technology such as traps, wire snares but with severe impact on wildlife populations because snares and traps are non-selective (Essen et al., 2014). Illegal logging, illegal bushmeat hunting and illegal mining are often driven by need for sources of cash income and domestic subsistence uses, whereas illegal livestock grazing is driven by the availability of pasture and water resources in protected areas (PAs) due to lack of or deteriorated grazing land outside the PA (Mgawe et al., 2012; Ceppi and Nielsen, 2014; Kiffner et al., 2015; Knappa et al., 2017; Dudley et al., 2018). Naturally, the dependence on natural resources is higher among relatively poor households than wealthier ones, but it does not necessarily translate greater levels of extraction as they use poor technology (Duffy and St John, 2013). Poverty impedes conservation because poaching and environmental degradation is often pursued by the poor in a short-sighted way. Normally, such people will not think of long term consequences of the unsustainable use of natural resources (Loibooki et al., 2002; Duffy and St John, 2013; Essen et al., 2014; Kideghesho, 2016; Knappa et al., 2017). Poverty normally encourage people to poach, but sometimes people poach as part of social resistance, cultural expression, to get cash money, or as a source of food (Duffy and St John, 2013; Knappa et al., 2017; Kyando et al., 2017). Individuals from poor communities would for instance not engage themselves in poaching of commercially valuable species, unless there has been a demand from wealthier communities (Duffy and St John, 2013). Secondly, are the commercial criminals who target commercially valuable species such as black rhinos (*Diceros bicornis*) and African elephants (Ayling, 2013; Duffy and St John, 2013). Thus, there is a need for different approaches for different types of crimes to control such different crimes (Duffy and St John, 2013; Essen et al., 2014). According to Brennan and Kalsi (2015) many seizures have been associated with China, but multiple transit-hub countries (e.g. Hong Kong, Malaysia, Thailand and Japan) are involved in the movement of illegal ivory originated from East Africa.

Conservation crimes threaten earth's natural ecosystems, wildlife species, and people (Gibbs et al., 2010; Essen et al., 2014; Kideghesho, 2016). Overharvesting of mammals such as elephants and habitat loss due to illegal timber logging, and subsequent decline of most of the species listed by the World Conservation Union (IUCN) as threatened. Hunting and international trade contribute to approximately one-third of the bird and mammal species listed as threatened by the IUCN. Furthermore, the situation is striking in Africa due to an increasing number of consumers (>1 billion in 2010), that is expected to reach 1.6 billion around 2040 (Apaza et al., 2002; Ripple et al., 2016). Overexploitation of wildlife resources have recently increased due to the fact that the human population has increased in Tanzania from 12 million people in 1967 to more than 54 million people in 2017 (URT, 2017), accompanied by other factors such as interconnectivity through development of infrastructures such as telephone and road networks, airports, railways as well as shipping which has become significantly cheaper after the 2008 global financial crisis (Brennan and Kalsi, 2015). In Tanzania, illegal logging for timber is a major problem facing virtually all PAs (Kideghesho et al., 2006; Kideghesho, 2015). Illegal timber logging, threaten many species of extinction due to habitat loss caused by environmental degradation and deforestation (Prendergast and Adams, 2003; Essen et al., 2014; Kideghesho, 2015). For example, the black rhino population in Africa dropped by 97.6% since 1960 (Leader-Williams et al., 1990; Metzger et al., 2007; AWF, 2018). The number of mountain gorillas (*Gorilla beringei beringei*) is around 1000 individuals (Robbins et al., 2018), while only 2680 individual Grevy's zebras (*Equus grevyi*) remained on the African continent in 2016, 90% of which are found in northern Kenya (O'Brien et al., 2018). Land conversion, for agriculture and settlements, has reduced the lion's (*Panthera leo*) historical range by more than 80% and reduced the numbers to an estimated total population of 20,000–30,000 across Africa (Lindsey et al., 2012; Bauer et al., 2015; O'Brien et al., 2018). The population of African elephants has been declining over time due to poaching and other crimes. For example, the numbers declined from 3 to 5 million in the 1930s to 1.3 million in the 1970s to less than 500,000 in 2007 (Blanc et al., 2007). The population has further declined to around 350,000 in 2014 (Chase et al., 2016) whereas the Tanzania population consisted of only 42,272 individuals (Chase et al., 2016). The Ruaha-Rungwa ecosystem held ca. 15,000 elephants in 2015 (TAWIRI, 2015).

Understanding the factors and drivers of conservation crimes are important in devising mitigation measures, which will halt conservation crime in PAs. Loibooki et al. (2002) and Nielsen and Meilby (2013) analysed demographic characteristics and socio-economic activities of illegal harvesters of wildlife resources as an alternative in understanding and tackling the poaching activities. Most societies living in rural villages close to protected areas in Tanzania consist of small scale peasant farmers owning no/or a few livestock as well as only small pieces of arable land (Campbell et al., 2001; Sunderland et al., 2009; URT, 2012; Lindsey et al., 2015; Knappa et al., 2017). They therefore frequently seek alternative income activities, of which logging, mining, and hunting are feasible alternatives (Campbell et al., 2001; Frosta and Ivan, 2008; Ayling, 2013). Communities living adjacent to PA depend on these areas for firewood, poles and timber for construction, and bushmeat as a source of protein or income (Knapp, 2012; Kideghesho, 2016; Dudley et al., 2018). Rural dwellers lacking alternative sources of income resort to bushmeat as an important source of protein as it is relatively cheaper compared to other alternative protein sources (beef, chicken, bacon etc.) (Ndibalema and Songorwa, 2007; Mfunda and Røskaft, 2010). Rentsch and Damon (2013) worked out a comparative analysis between the price of bushmeat and the alternative protein sources in eight communities in the Serengeti Ecosystem to establish its influence on bushmeat consumption. Their paper suggested that economic motivation had the biggest effect, while, culture also influenced bushmeat consumption. Most Tanzanians, including those living close to the national parks and game reserves, live below the US \$1 a day (URT, 2012). Socio-economic conditions of local communities in most conservation areas have been considered in many discussions of conservation criminology (Prendergast and Adams, 2003; Holmern et al., 2007; Essen et al., 2014).

Various studies (e.g., Mgawe et al. (2012); Ceppi and Nielsen (2014)) have documented that participation in conservation crime in game reserves is driven by factors such as income poverty, lack of accessibility to property ownership (livestock and

land), and unemployment. However, in Tanzania, most of these studies have largely been focused on the Serengeti ecosystem (Holmern, 2010), Katavi ecosystem (Mgawe et al., 2012; Martin and Caro, 2013), Tarangire ecosystem (Kiffner et al., 2015) and areas around the Udzungwa mountains (Nielsen, 2006; Nielsen et al., 2013). The conservation crimes are not limited to these ecosystems and are likely common in other areas as well. Rungwa Game Reserve is another part of Tanzania where these crimes are widespread. This has prompted a need for analysis of these crimes by uncovering their drivers. Additionally, this study had an opportunity to use data from arrested alleged criminals which is very rare. The findings of this study provide a more pragmatic way of addressing these crimes in the study area and other PAs of Tanzania.

The main objective of this study was to assess the socio-demographic characteristics of the arrested people in the RKM GRs. Specific objectives were; 1) to assess socio-demographic characteristics of the arrested alleged conservation criminals and 2) to examine drivers behind different categories of conservation crimes in the RKM GRs. First, we hypothesized that different conservation crimes (illegal hunting for bushmeat, illegal timber logging, elephant poaching, illegal mining, and illegal livestock grazing) will decrease with land and livestock ownership (yes/no), as well as availability of employment. Thus, we predicted that people who owned land, livestock and those who were employed would less likely engage themselves in elephant poaching, illegal timber logging and illegal mining. Second, we hypothesized that involvement in illegal hunting for bushmeat, illegal timber logging, elephant poaching, illegal mining, and illegal livestock grazing will increase with decreased distance to the boundary of PA. Third, we hypothesized that young people in the age group 18–36 years and with immigrant tribal background (ethnicity) engaged themselves more in the conservation crimes than the elder or indigenous respondents. Other studies as e.g. Knapp (2012) and Loibooki et al. (2002) indicated that involvement in bushmeat poaching varied with age, sex, ethnic tribe, and property ownership in the western Serengeti National Park, therefore testing the hypotheses will help understanding if the factors also operate in other protected areas such as in our study area.

2. Material and methods

2.1. Study area

The Rungwa-Kizigo-Muhesi Game Reserves (RKM GRs) are mostly located in Manyoni in the Singida Region (98%), Central Tanzania, while 2% of this area is situated in the Chunya District in Mbeya Region (MNRT, 2011). These three reserves are managed as one entity with headquarters based in Rungwa village in the Manyoni district. The reserves also border the Sikonge district (Tabora region), Iringa rural district (Iringa region) and Chamwino district (Dodoma region) (Hariohay et al., 2017). The total area of these three reserves, which is under Tanzania Wildlife Management Authority (TAWA), totals 17,340 km² (MNRT, 2011) (Fig. 1). In Tanzania, according to the Wildlife Conservation Act No. 5 of 2009, entry into protected areas without prior permission from the director of wildlife, is considered an unlawful entry and is therefore punishable according to the court of law (URT, 2009). Furthermore, this law also states that grazing livestock, mining, or hunting of game without a permit in a game reserve is regarded as an illegal activity. The crime also includes activities that affect wildlife more indirectly, such as pollution of waterways that results in damage to fish or other wildlife species, or the destruction of protected wildlife habitats through illegal livestock grazing and mining (Eliason, 2009). Human populations, growth rates, human densities (people/square kilometres) of the adjacent districts to the RKM GRs are indicated in Table 1, with an estimated population of more than 900,000 people, in the year 2017 in the four study districts.

The area is home to approximately 300 species of birds and a wide diversity of large mammals. Common mammals are the greater kudu (*Strepsiceros strepsiceros*), lesser kudu (*Strepsiceros imberbis*), African elephant, eland (*Taurotragus oryx*), Maasai giraffe (*Giraffa camelopardalis*), impala (*Aepyceros melampus*), Coke's hartebeest (*Alcelaphus buselaphus cokii*), southern reedbuck (*Redunca redunca*), roan antelope (*Hippotragus equinus*), sable antelope (*Hippotragus niger*), warthog (*Phacochoerus aethiopicus*), common waterbuck (*Kobus ellipsiprymnus*) and plain zebra (*Equus burchellii*). The elevation ranges from 800 m asl at the Kizigo/Nzombe river and confluence to 1800 m asl at the Ikili hill (MNRT, 2011). The area experiences a long dry season from June to November, and a single rainy season from November to April. The amount of rainfall ranges from 500 mm to 700 mm, and the mean annual temperature is 28 °C (Nahonyo, 2005). The main ethnic groups in the study area include Nyakyusa, Kimbu, Taturu, Nyaturu, Gogo, Safwa, Sangu and Sukuma. Their main social economic activities are crop cultivation (>60%) and livestock ownership (33%), while beekeeping and some formal employment are in the minority (7%).

2.2. Data collection

Data for this study were collected using a semi-structured interview questionnaire survey, which involved a total of 631 respondents. There were two sets of data (alleged conservation criminals n = 316 and control group n = 315) (Table 2). The first set of data was obtained from the arrested alleged conservation criminals (n = 316), from a total of 32 patrols (i.e. 9.9 arrest per patrol) in the Rungwa-Kizigo-Muhesi Game Reserves between January 2014 and April 2015 (1 year and 4 months). Information was obtained using pre-designed semi-structured questionnaires completed by Game Reserve rangers during interviews. The use of game rangers was the only way to access these data as non-rangers or game wardens were not allowed to be partners in the patrol team. However, only one ranger or game warden per group was trained to interview arrested alleged criminals using a pre-designed questionnaire in a face-to-face interview. The patrol team went out for patrol approximately every two weeks. The patrol leaders were given forms to record the details of alleged conservation criminals immediately at the time of arresting, including age, sex, tribe, their residency (born in the area, or immigrated), assets owned

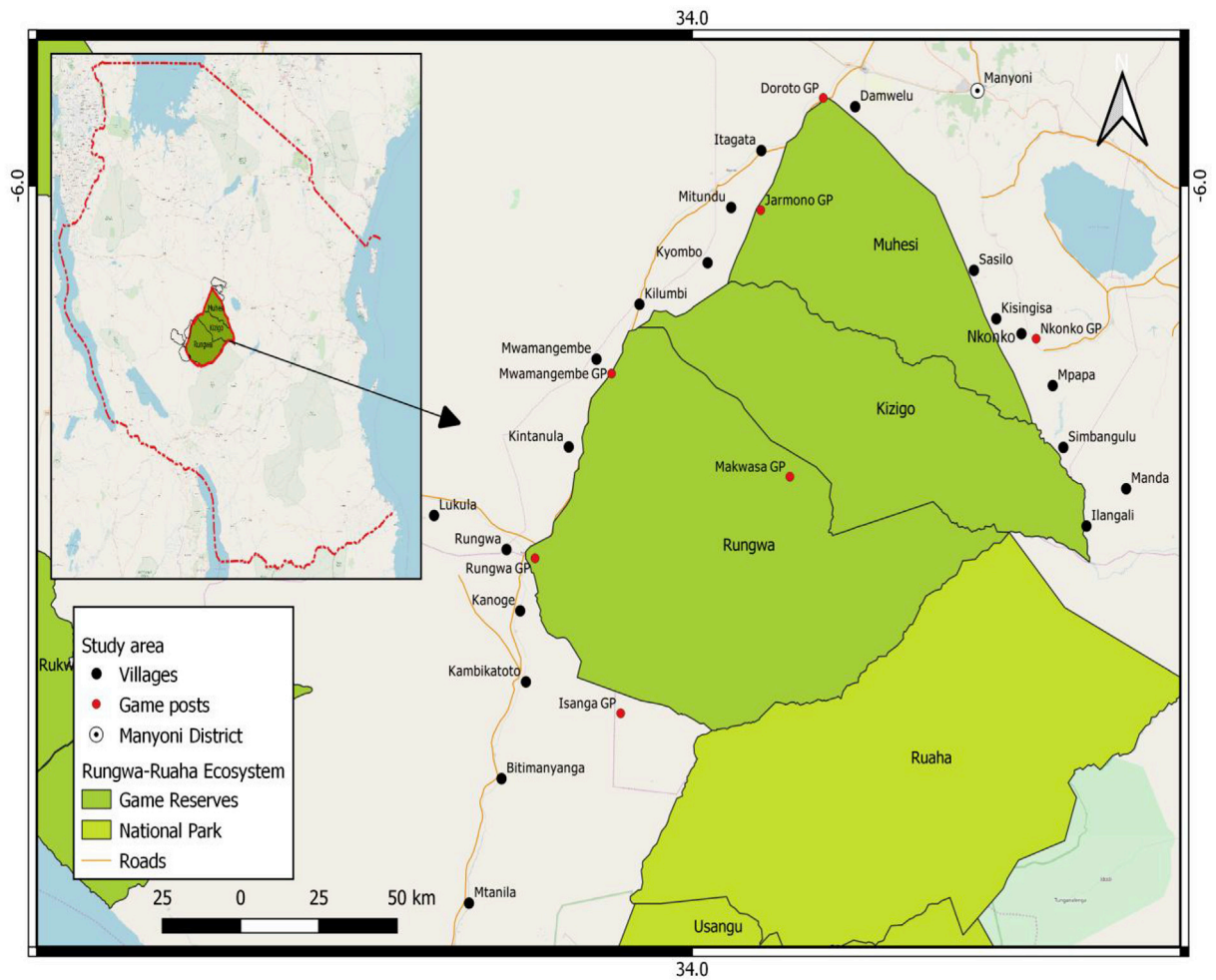


Fig. 1. Map of villages from where the arrested people were living around Rungwa-Kizigo-Muhesi Game Reserves. Villages are indicated by black dots and ranger (or game) posts in red dots. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Table 1

The human population sizes in the five districts bordering RKMGRs in 2012, 2016 and 2017, as well as then human population increase from 2016 to 2017.

District	2012 n	2016 n	2017 n	2017–2016 n (% increase)	Area (km ²)	Density (people/km ²)
Manyoni DC	146,776	161,054	164,835	3781 (2.3%)	28,934	5.69
Chunya DC	156,786	172,797	177,049	4252 (2.4%)	29,219	6.06
Sikonge DC	179,883	202,210	208,211	6001 (2.9%)	27,873	7.47
Chamwino DC	330,543	359,244	366,801	7557 (2.1%)	9204	39.9

Modified from (URT, 2017). "n" represents number of humans in each district in the respective year.

(land and/or livestock) and other activities, such as formal employment or self-employed. The arrested alleged criminals were always requested for their consent before an interview was conducted. Thus, in this article we only recorded information from those who were willing to participate in the interview. After two weeks the patrol team returned to the office where we collected the filled forms with the list of alleged criminals from patrol leaders and compiled the information in an excel computer program. The names of the alleged conservation criminals were kept anonymous, as they were yet to be convicted in the court. Thus, for ethical reasons, we have not disclosed their names. Almost all arrested respondents were males (98.1%). Moreover, there was some variation in the types of conservation crimes as out of 316 alleged criminals; 71.5% were involved in timber logging, 10.8% in bushmeat poaching, 6.3% in illegal livestock grazing, 6.0% in illegal mining, and 5.4% in elephant poaching. The major ethnic tribe of conservation criminals was Gogo (32.3%), Nyaturu (17.1%), Sukuma (15.2%), Kimbu (13.6%), Nyamwezi (13.3%), and other tribes combined (8.5%).

The second data set came from the control group (n = 315), were collected using a semi-structured interview questionnaire survey conducted from June to August 2015 (Table 2). The researcher randomly stopped respondents at the village

Table 2

Number of respondents interviewed in the control group and the arrested alleged conservation criminals from each respective village.

Village names	Mtanila	Bitimanyanga	Rungwa	Kambikatoto	Kilumbi	Kintanula	Kyombo	Lukula	Mwamagembe	Ilangali	Manda	Nkonko	Damwelu	kanoge	Mitundu	Chisingisa	Sasilo	Simbangulu	Mpapa	Itagata	Total
C	10	15	30	15	30	10	15	10	20	10	10	15	30	10	15	15	10	15	10	20	315
AC	4	12	38	12	43	10	16	9	21	8	8	14	36	6	11	15	8	15	10	20	316
HH	1708	1710	1452	572	678	587	1202	1175	588	2014	1052	1384	668	1144	2244	418	1000	785	1172	1400	22,953
AHH	5.1	5.5	4.5	6.2	5.6	5.5	5.6	5.5	5.5	4.3	4.3	5.4	5.7	6.2	5.8	5.7	5.7	5.7	5.7	5.5	5.45

HH – household, **AHH**-average household, **AC**-arrested alleged criminals, **C**- control.

centres and requested them to participate in the interview one at a time. The researcher interviewed people from the 20 villages from where alleged criminals originated (Table 2). In villages where 1–10 alleged criminals were recorded, ten people were interviewed in the control group. In villages where 11–19 alleged criminals were recorded, 15 people were interviewed, while in villages where 20–29 alleged criminals were recorded, 20 people were interviewed. Finally, in villages where more than 30 alleged criminals were recorded, 30 people were interviewed (Table 2). After a respondent was recruited, a researcher continued to ask questions that were pre-designed with face-to-face interview. Before proceeding with the questions, and after the introduction of the researcher to the respondent, researcher ensured that the respondent was a resident of the respective village. Those who were born or lived in the village before 1974 were termed indigenous (non-immigrants), because 1974 is the year in which many villages were formed in Tanzania, whereas those respondents that moved to the respective village after 1974 were termed immigrants in this study. The researcher asked the respondents if she or he would be willing to answer the questions in the questionnaire. The respondents were 18 years of age or above, as arrested alleged criminals were all aged 18 and above years. The researcher chose to do the questionnaire interviews in the village center and moved from one village to another. Within each village, the researcher moved from one sub-village center to another sub-village center. The assumption was that people from the periphery to the center would be coming to the village center or sub-village center to purchase goods for household needs, and therefore, the interviewed people were expected to be representative of the whole village. However, interviewing the respondents in the village or sub-village center might have missed those who were unable to walk and purchase goods in shops located in those centers. In the control group, the major ethnic tribes were Gogo (26.6%), Sukuma (24.7%), Kimbu (24.1%), Nyamwezi (10.1%), Nyaturu (5.4%), Kinga (2.8%), Nyiramba (2.5%), Ngoni (1.6%), Hehe (1.3%), and Safwa (0.9%). Further analysis, involved grouping tribes into two categories: 1) indigenous (Gogo, Nyaturu, Kimbu Nyamwezi, and Nyiramba) and 2) immigrants (Kinga, Hehe, Safwa and Sukuma). Demographic and socioeconomic data of the respondents were recorded. We recorded the respondent's age, sex, tribe, place of birth (village), livestock and land ownership, and types of cash income generating activities conducted (Knappa et al., 2017).

2.3. Statistical analysis

To identify characteristics of alleged criminals among types of conservation crimes (timber logging, elephant and bushmeat poaching, illegal mining and illegal livestock grazing) and a control, we performed Chi-square (χ^2) tests for the following variables: age (with two levels: young 18–36 years and old > 36 years), immigration status (with two levels: indigenous, immigrant), and village (with two levels: close; less than 10 km to the PA and far > 10 km to the PA). Other factors include; employment status (with two levels: unemployed, employed), land (with two levels: yes/no), and livestock ownership (with two levels: yes/no) (Presnell, 2000). To examine the importance of factors within each conservation crime, we used generalized linear models (GLMs) with binomial error distribution, to ascertain the most important drivers of conservation crime compared to a control. Separate models were made for each type of conservation crime, using a binary response variable (crime or control) in each respective model. Age, immigration status, village, employment status, land and livestock ownership status were added as explanatory factors. The significance level was set at $P < 0.05$. All statistical analyses were performed using the software R (R Core Team, 2016).

3. Results

3.1. Differences in socio-demographic characteristics of arrested alleged conservation criminals across crime groups

More than 80% of all kinds of the alleged conservation criminals were in the young age category with no statistically significant differences across illegal conservation crimes (Table 3). Immigration status of the arrested alleged conservation criminals statistically significantly varied with less than 60% of the alleged timber loggers and elephant poachers belonged to the indigenous tribes while more than 70% of the bushmeat poachers, illegal livestock grazers, and illegal miners belonged to

Table 3
Distribution of socio-demographic characteristics across crime groups. Differences within crime groups were tested with χ^2 -tests.

Crime group	Livestock		Land		Age class		Immigration		Employment		Distance		Respondents (n)
	Yes (%)	No (%)	Yes (%)	No (%)	Young (%)	Older (%)	Indigenous (%)	Immigrant (%)	Unemployed (%)	Employed (%)	Close (%)	Far (%)	
Bushmeat	38.2	61.8	32.4	67.6	82.4	17.6	26.5	73.5	67.6	32.4	64.7	35.3	34
Elephant	29.4	70.6	17.6	82.4	82.4	17.6	58.8	41.2	82.4	17.6	58.8	41.2	17
Timber	5.8	94.2	11.5	88.5	80.1	19.9	50.9	49.1	79.2	20.8	90.7	9.3	226
Grazing	85.0	15.0	45.0	55.0	80.0	20.0	15.0	85.0	5.0	95.0	75.0	25.0	20
Miners	5.3	94.7	15.8	84.2	84.2	15.8	10.5	89.5	78.9	21.1	84.2	15.8	19
χ^2	107.57		22.16		0.3		25.57		53.42		27.18		
df	4		4		4		4		4		4		
P	<0.001		<0.001		0.991		<0.001		<0.001		<0.001		

NB: arrested alleged conservation criminals were grouped into bushmeat, elephant poachers, illegal timber loggers, illegal livestock grazing and illegal mining in the Game Reserves.

immigrant tribes (Table 3). The majority of the arrested alleged bushmeat hunters, elephant criminals, timber loggers and illegal miners were unemployed while most illegal livestock grazers were employed with a statistically significant difference (Table 3). Generally, less than 50% owned land for all arrested alleged conservation criminals (Table 3). There was significant differences between different kinds of conservation criminals as 45.0% of illegal livestock grazers and 32.4% of alleged bushmeat criminals owned land while less than 25% of other kinds of alleged conservation criminals owned land (Table 3). Livestock ownership differed significantly between different kinds of conservation crimes (Table 3). Most arrested alleged criminals for bushmeat, elephant poaching, illegal timber loggers and illegal miners did not own livestock while more than 80% illegal livestock grazers owned livestock (Table 3). The frequencies of conservation crimes from different village distances categories from the boundary of RKM GRs differed significantly (Table 3). Generally, more than 50% of arrested alleged criminals were form closest villages with most of them being timber loggers followed by miners, grazers, bushmeat, and elephant criminals (Table 3).

3.2. Predictors of conservation crimes

In this set of analyses, we examine the importance of drivers within each conservation crime category.

3.2.1. Bushmeat poachers

We used a generalized linear model to examine the importance of factors driving participation in bushmeat poaching, testing with six independent variables; land ownership, livestock ownership, distance from villages to boundary of game reserve, age and employment status (Table 4). Employment status, immigration status, age and land ownership were the significant factors explaining variation in illegal bushmeat poaching. Those who were employed were less likely to be engaged in bushmeat poaching (Table 4). Age of the respondents was an important driver for participating in bushmeat poaching as respondents above 36 years old were less likely to be engaged in bushmeat poaching. On the other hand, immigrants were more likely engaged in bushmeat poaching than indigenous (Table 4). Respondents who did not own land were more likely to be engaged in bushmeat poaching (Table 4). Other factors such as distance to the PA and livestock ownership were not significant (Table 4).

3.2.2. Illegal timber loggers

We used a generalized linear model to examine the factors driving participation in illegal timber logging, testing with six independent variables; land ownership, livestock ownership, distance from villages to boundary of game reserve, age and employment status (Table 5). Employment status, immigration status, age, livestock ownership and land ownership were the significant factors in explaining the variation of participation in illegal timer logging. Those who were employed were less likely to be engaged in illegal timber logging (Table 5). Age of the respondents was an important driver for participating in the bushmeat poaching as those respondents above 36 years old were less likely to be engaged in illegal timber logging. Immigrants were more likely to be engaged in illegal timber logging (Table 5). Respondents who did not own land or livestock were more likely to be engaged in illegal timber logging (Table 5). Distance to PA was the only non-significant variable (Table 5).

3.2.3. Elephant poachers

We used a generalized linear model analysis to determine the factors driving participation in elephant poaching, with six independent variables (Table 6). The most important drivers were the employment status and land ownership (Table 6). Respondents who were employed were less likely engaged in elephant poaching while those who did not own land were more likely to be involved in elephant poaching (Table 6).

3.2.4. Illegal livestock grazing

A generalized linear model was used to examine the factors explaining participation in illegal livestock grazing in the game reserve, with six independent variables (Table 7). Three independent variables were found to be important drivers (Table 7).

Table 4

Arrested alleged bushmeat criminal vs. control and six factors that might predict attendance in illegal activities related to bushmeat. In the table we present parameter estimates from a generalized linear model with alleged bushmeat poachers and control group as a binary response variable (binomial error distribution and logit-link function) and six explanatory factors: employment status, distance, age, land ownership, immigration status, and livestock ownership. OR: odd ratio, Estimate: Z: z-score, SE: standard error and P: p-value.

Variables	Intercept	OR	Estimate	SE	Z	P
		0.49	-0.71	1.17	-0.60	0.548
Do you own land (Yes/No)	No	7.76	2.05	0.74	2.78	0.005
Do you own livestock (Yes/No)	No	1.12	0.11	0.67	0.17	0.865
Age (Young/Older)	Older	0.57	-0.56	0.75	-2.09	0.036
Distance to PA (Close/Far)	Far	2.88	1.06	0.72	1.47	0.142
Immigration status (Immigrant/Indigenous)	Immigrant	10.07	2.31	0.75	3.09	0.002
Employment status (Employed/Un-employed)	Employed	0.01	-4.51	0.79	-5.72	< 0.001

Table 5

Timber loggers vs. control and six factors that might predict attendance in illegal activities related to timber logging. In the table we present parameter estimates from a generalized linear model with alleged illegal timber loggers and control as a binary response variable (binomial error distribution and logit-link function) and six independent explanatory variables; employment status, distance, age, land ownership, immigration status, and livestock ownership. OR: odd ratio, Estimate: Z: z-score, SE: standard error and P: p-value.

Variables	Intercept	OR	Estimate	SE	Z	P
		1.568	0.45	0.77	0.58	0.562
Do you own land (Yes/No)	No	4.137	1.42	0.37	3.84	< 0.001
Do you own livestock (Yes/No)	No	5.641	1.73	0.41	4.18	< 0.001
Age (Young/Older)	Older	0.458	-0.78	0.37	-2.10	0.035
Distance to PA (Close/Far)	Far	0.472	-0.75	0.51	-1.48	0.138
Immigration status (Immigrant/Indigenous)	Immigrant	7.099	1.96	0.39	4.97	< 0.001
Employment status (Employed/Un-employed)	Employed	0.013	-4.35	0.58	-7.40	< 0.001

Table 6

Elephant poachers vs. control and six factors that might predict attendance in illegal activities related to elephant poaching. In the table we present parameter estimates from a generalized linear model with alleged elephant poachers and control as a binary response variable (binomial error distribution and logit-link function) and six explanatory variables: employment status, distance, age, land ownership, immigration status, and livestock ownership. OR: odd ratio, Estimate: Z: z-score, SE: standard error and P: p-value.

Variables	Intercept	OR	Estimate	SE	Z	P
		0.135	-2.00	1.93	-1.04	0.300
Do you own land (Yes/No)	No	15.800	2.76	1.27	2.18	0.029
Do you own livestock (Yes/No)	No	4.393	1.48	1.09	1.35	0.176
Age (Young/Older)	Older	0.185	-1.69	1.18	-1.43	0.151
Distance to PA (Close/Far)	Far	3.781	1.33	1.17	1.13	0.258
Immigration status (Immigrant/Indigenous)	Immigrant	2.915	1.07	1.17	0.92	0.358
Employment status (Employed/Un-employed)	Employed	0.006	-5.06	0.97	0.96	< 0.001

Table 7

Livestock grazers vs. control and six factors that might predict attendance in illegal activities related to livestock grazing. In the table we present parameter estimates from a generalized linear model with alleged illegal livestock grazers and control as a binary response variable (binomial error distribution and logit-link function) and six explanatory variables: employment status, immigration status, distances of villages, age, land ownership, and livestock ownership. OR: odd ratio, Estimate: Z: z-score, SE: standard error and P: p-value.

Variable	Intercept	OR	Estimate	SE	Z	P
		0.228	-1.48	1.7	-2.04	0.041
Do you own land (Yes/No)	No	7.316	1.99	0.55	3.57	< 0.001
Do you own livestock (Yes/No)	No	0.411	-0.89	0.71	-1.26	0.021
Age (Young/Older)	Older	0.419	-0.87	0.63	-1.39	0.164
Distance to PA (Close/Far)	Far	1.568	0.45	0.65	0.70	0.484
Immigration status (Immigrant/Indigenous)	Immigrant	11.246	2.42	0.71	3.42	< 0.001
Employment status (Employed/Un-employed)	Employed	0.357	-1.03	1.52	-0.68	0.497

Respondents who owned livestock, those from immigrant tribes and those who did not own land were more likely to be involved in illegally grazing of their livestock in the game reserve (Table 7). Distances to boundary, age and employment status of the respondents were not significant (Table 7).

3.2.5. Illegal mining

We used a generalized linear model to examine the factors driving participation in illegal mining in the game reserve, with six independent variables (Table 8). Three independent variables were found to be important drivers (Table 8). Those who were employed were less likely involved in illegal mining than un-employed people (Table 8). Finally, respondents with no livestock and immigrants were more likely to be involved in illegal mining in the game reserve (Table 8).

4. Discussion

Our results indicated that the illegal harvest of wildlife and forest resources from Rungwa-Kizigo-Muhesi Game Reserves is linked with unemployment and lack of asset ownership (livestock and land). Conservation and poverty are separate policy realms in a way that if the conservation policies do not take poverty into consideration, poverty will hamper the success of conservation (Duffy and St John, 2013). Poverty can impede conservation because the poor often pursue poaching and environmental degradation in a short-sighted way. It therefore creates no acceptance of conservation policies by people before poverty reduction is on the political agenda (Duffy and St John, 2013; Kyando et al., 2017). Addressing poverty is

Table 8

Miners vs. control and six factors that might predict attendance in illegal activities related to mining. In the table we present parameter estimates from a generalized linear model with alleged illegal miners and control as a binary response variable (binomial error distribution and logit-link function) and six explanatory variables: employment status, distance of villages, age, immigration status, land ownership, and livestock ownership. OR: odd ratio, Estimate: Z: z-score, SE: standard error and P: p-value.

Variables	Intercept	OR	Estimate	SE	Z	P
		0.006	-5.07	2.28	-2.22	0.026
Do you own land (Yes/No)	No	10.074	2.31	1.25	1.84	0.065
Do you own livestock (Yes/No)	No	16.119	2.78	1.33	2.09	0.036
Age (Young/Older)	Older	0.225	-1.49	1.14	-1.31	0.188
Distance to PA (Close/Far)	Far	0.923	-0.08	1.36	-0.06	0.949
Immigration status (Immigrant/Indigenous)	Immigrant	71.522	4.27	1.32	3.24	0.001
Employment status (Employed/Un-employed)	Employed	0.019	-3.97	1.31	-3.03	0.002

therefore a means of directly and indirectly promoting conservation through sustainable use of resources. Where livelihoods depend on living resources their sustainable use will promote both the resource and the livelihood associated with it (Knappa et al., 2017). In fact commercial poaching, such as elephant poaching, is normally conducted by a chain of syndicate criminals with several levels (porters, shooters, middlemen (transporters), as well as affluent businessmen (in the country of origin or in another country of destination) (Wittemyer et al., 2014; Brennan and Kalsi, 2015). Thus, our data only reported the porters and shooters as this group is most likely the ones prone to be arrested, partly due to imperfect detection, non-linear relation between the effort devoted to searching and the number of encounters (Keane et al., 2011).

4.1. Asset ownership (land and livestock)

In most African societies, land and livestock are considered an investment (Meltzer and Values, 1995). Like businessmen keeping money in the bank, the livestock owners regard their livestock as a bank on hooves. Participation in wildlife crime was influenced by the lack of ownership of livestock and land, as most illegal mining, timber logging, elephant poaching and bushmeat poaching were practiced by those who do not own land or livestock. A similar trend was found in villages surrounding the Serengeti National Park, where those who participated in bushmeat poaching were not livestock owners (Loibooki et al., 2002). Those who went to the PA to cut trees were selling wood or timber to obtain cash to purchase meet for household demands, while some of them pursued the activity as a commercial purpose by doing business as an extra source of income. However, these reasons might not be the same for those who were involved in elephant poaching; they poach for commercial purposes as a significant number of elephant poachers did not own land. Access to land and livestock ownership might not be a good strategy of mitigating conservation crimes as argued by Ceppi and Nielsen (2014) and Lindsey et al. (2015). Access to domestic animal protein did not reduce the bushmeat consumption whilst anti-poaching law enforcement was an effective deterrent of illegal bushmeat consumption. Our results support the first hypothesis that involvement in different conservation crimes decreased with access to land or livestock ownership. However, illegal grazing in the RKM GRs was influenced by ownership of livestock as those who owned livestock were more likely involved in grazing of their livestock in the reserve.

4.2. Lack of employment (neither formal nor self-employed)

Most of the alleged conservation criminals were unemployed. This result support the first hypothesis that involvement in different conservation crimes decreased with employment as people who were employed less likely participated in conservation criminalities. Employment status was also the main driver for people involved in illegal bushmeat hunting, timber logging, elephant poaching, and illegal mining in the RKM GRs. Similar findings, have been reported by other researchers such as Knappa et al. (2017) and Rogana et al. (2017) that lack of income was one of the main driving motives behind poaching. Therefore, the finding that most of those arrested alleged criminals were unemployed might indicate that people in the study area practiced illegal harvesting of natural resources as a coping strategy against unemployment. The link between conservation crimes and the lack employment has also been reported in other parts of Tanzania (Loibooki et al., 2002; Holmern, 2010; Kideghesho, 2010, 2015). The lack employment can drive people to become conservation criminals (Mulder et al., 2007; Kideghesho, 2016). Knappa et al. (2017), reported that employment is related to education level in areas around southern Ruaha National Park which is supporting our findings. The reason for high poaching rates of elephants and rhinos in the 1980s was the price increase for ivory and rhino horns in the international markets. The same driver still exists today (Kyando et al., 2017). The price tag of elephant ivory in the black market drove the poaching of elephants in the Selous Game Reserve and resulted in a 60% population decline from 2009 to 2013 (Kyando et al., 2017) and corruption (Polinsky and Shavell, 2001). Local people, in particular those sharing borders with the wildlife areas, are unemployed or lacked other alternative livelihood options to guarantee food security (Nielsen et al., 2013). Most community conservation services (CCS) programmes by Tanzania National Park have been implemented since the 1990's but little success have been reported in reducing level of poaching (Kaaya and Chapman, 2017). Some of the reasons for the little impact of CCS in reducing poaching levels are

probably that these projects focus at the community level such as classrooms, dispensaries e.t.c while at the individual level people are less likely to receive any benefit. [Kaaya and Chapman \(2017\)](#), showed that establishing micro-credit loans and education of entrepreneurship will help individual to reach the necessary benefits as reported in areas around Serengeti National Park. Deterrence methods through law enforcement helps in reducing the poaching level especially when behaviours of both the poacher and the ranger are taken into consideration ([Keane et al., 2008](#); [Dobson et al., 2018](#)). Presence of frequent patrols combined with conservation information will help controlling conservation crimes in an area.

4.3. Age and immigration status as drivers of different conservation crimes

Most people committing conservation crimes were aged between 18 and 36 years old. This can be attributed to the fact that activities associated with these crimes demand energy and readiness to take risk. People in this age group are more likely to take such risks as being captured by the anti-poaching team. [Loibooki et al. \(2002\)](#), also reported that males aged 15–35 years were more likely involved in hunting for bushmeat in western Serengeti. Age was an important driver for bushmeat and timber whereby those people in the higher age category were less likely involved in these illegal conservation crimes. This might be because such an activity is demanding energy and thus riskier for the older people, therefore young people are more likely involved in conservation criminality as also found in Nigeria ([Friant et al., 2015](#)).

Among the participants in this study the immigration status of the conservation criminals varied regarding their participation in type of crime whereby most of the timber loggers were immigrants. This group dominated the illegal timber logging, bushmeat poaching, illegal grazing and illegal mining in the RKM GRs. Differences between ethnic groups in illegal bushmeat hunting have been reported in other parts of Tanzania ([Mgawe et al., 2012](#); [Ceppi and Nielsen, 2014](#)). The ethnic tribes from category of immigrants in the study area might have immigrated into to the vicinity of the RKM GRs pulled by the access to resources such as pasture for their cattle, timber and mining to generate cash income. Illegal livestock grazers were, however, from immigrant tribes. Frequently immigrants are the major livestock owners in our study area ([Hariohay et al., 2017](#)). The Sukuma tribe keep big herds of cattle. The concurrent shortage of pasture or land for grazing and water outside RKM GRs, might have forced them to graze their livestock inside the Game Reserve ([Hariohay et al., 2017](#)). The growing human population in Tanzania (over 54 million people) ([URT, 2017](#)) as well as in the study area might have resulted into less availability of land and pasture. Therefore, land conversion to agriculture and settlement is pushing people to take their livestock to the PA. The increasing human population will continue to put pressure on protected areas and will increase impacts on wildlife conservation as protected areas are becoming more isolated due to habitat fragmentation and more overutilization. The growing per capita demand on resources such as bushmeat, timber, and land for cultivation and pasture for livestock will be the main causes. Our results support the third hypothesis that participation in different conservation crimes will be higher among young aged people (18–36 years) as well as immigrants in the study area. However, village distance from the game reserve boundary was not a significant driver in all categories of conservation crimes.

5. Conclusions and recommendations

The key findings on drivers of conservation crimes are that there were multiple drivers for each kind of conservation crime. Firstly, bushmeat poaching was mostly done by people who did not own land, aged 18–36 years, were immigrants and unemployed. Secondly, the arrested timber loggers were unemployed, did not own land and/or livestock, and were young immigrants. Thirdly, elephant poachers did not own land, and were unemployed. Fourthly, livestock grazing in the RKM GRs was mostly done by immigrants, who owned livestock but did not own land. Finally, illegal mining was mainly done by unemployed immigrants who did not own livestock. These characteristics generate poverty and hunger, factors forcing people to adopt conservation crimes as an alternative livelihood and survival strategy. Anti-poaching activities will be more successful if the communities around the protected areas receive tangible benefits and have alternative ways of generating income.

We recommend the following actions as part of the mitigation to reduce conservation crimes risks in most PA in Tanzania. Increasing law enforcements, for instance by ranger patrols in the Game Reserve will deter people from committing crime. Motivating the youth to form groups and offering micro-credit loans to establish businesses, especially to the people who are committing conservation crimes, for subsistence needs is also important. However, we need to be careful doing thorough analyses as people might use extra money to purchase sophisticated weapons and even start hunting valuable species such as elephants. It is important to provide them with education in entrepreneurship so that they can see the tangible benefits of wildlife conservation and PA. Conservation education programmes should be provided in villages around PA and included in the primary school education curriculum. Conservation literacy will spread to the society because the children will learn in schools and teach their parents at home.

Author contributions

KMH and ER designed the study. KMH collected and analysed the data, and wrote the article with support from ER, JRK, RDF and PSR.

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Appendix A. Supplementary data

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