Understanding the drivers of subsistence poaching in the Great Limpopo Transfrontier Conservation Area: What matters for community wildlife conservation?

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Abstract

While subsistence poaching is a large threat to wildlife conservation in Southern Africa, this behaviour is seldom researched. Individual and community level factors that really drive such behaviour are less understood because of both lack of data and literature's predominant focus on commercial poaching. To study the drivers of subsistence poaching, this article uses primary survey data from a large number of respondents and communities in the Great Limpopo, a transfrontier reserve spanning across Mozambique, South Africa and Zimbabwe. We focus on two features, reported poaching incidences in the community and the previous hunting behaviour of individuals, in multivariate regression analysis. There is no evidence of the role of education, employment and livestock ownership on poaching. However, speaking to previous theoretical accounts, our results suggest that factors such as age, gender, trust, group size, local institutions, resource quality and perceptions about park management influence subsistence poaching. The findings indicate that capacity building in local

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institutions, training related to wildlife management and public awareness campaigns could be used by policymakers to affect peoples' perceptions and behaviours in this context.

1 INTRODUCTION

Poaching of plants and wild animals constitute a severe threat to biodiversity and to the livelihoods of poor communities around the world. In fact, illegal harvesting of wildlife resources in violation of laws or rules is viewed by many researchers as the biggest challenge threatening conservation efforts in developing countries (Tranquilli 2014; Gandiwa et al. 2013; Lindsey et al. 2011; Keane et al. 2008; Jachmann 2008). As shown by Kahler and Gore (2012), plants and wildlife subjected to poaching often experience decreases in abundance, range collapse, and extinction, which in turn pose severe challenges to ecosystem functions. The consequent loss of biodiversity may also jeopardize livelihoods by affecting food security and the security of rural economies dependant on wildlife tourism (Kahler and Gore 2013; 2012).

Poaching is, however, a phenomenon with many potential drivers, ranging from the subsistence requirements of individual poachers to availability of opportunities in international markets for commercial poachers and crime syndicates selling illegal wildlife trophies (Hubschle 2016; Bassett 2005; Leader-Williams and Milner-Gulland 1993). It may also stem from human-wildlife conflicts where crop damage or livestock depredation may motivate retaliatory or preventive poaching (Hill 2004; Naughton 1997). In addition, subsistence poaching can also manifest itself as an act of social defiance, symbolic protest of local management practices, or as an act of rebellion toward specific laws or state authority in general. It also happens because of the need for households to cushion themselves against poverty and shocks, income generation, supplementing household nutrition and cultural or traditional beliefs. Muchapondwa (2003) noted that poaching in Zimbabwe initially subsided with the onset of the Communal Areas Management for Indigenous Resources (CAMPFIRE) programme as people started to benefit, but was later on amplified by a combination of socio-economic factors[1]. Theoretically, these diverse motivations may coincide, but this has rarely been evaluated in empirical research. This research gap is especially true with regards to the type of behaviour in focus in this article, subsistence poaching: the illegal taking of wildlife resources primarily for household consumption but also for limited local trading.

Taking the resulting loss of biodiversity – 'eroding our own life support system from under our feet' (Steffen 2012, see Ayling 2013) – as our starting point, this article set out to empirically investigate the drivers of subsistence poaching. While commercial poaching is a serious problem, as reflected in some national and global biodiversity statistics, subsistence poaching may also result

[1] The CAMPFIRE programme is a benefit sharing arrangement where a hunting quota is allocated to local communities through their respective RDCs, who in turn sell hunting licenses to safari operators and share part of the revenue with local communities.

in equally disastrous outcomes for some localised species and socioecological systems in the absence of proper institutions to control illegal behaviour[2] (Ntuli and Muchapondwa 2018; Lindsey et al. 2013). Yet the drivers of subsistence poaching are far less understood, this study addresses this research gap and aims to investigate the individual and community level drivers of subsistence poaching through using survey data collected from the Great Limpopo Transfrontier Conservation Area (GLTCA), including three national parks in Mozambique, South Africa and Zimbabwe. Subsistence poaching is rather common and while park authorities tend to be lenient, or seem to turn a blind eye on such activities, it is banned in the whole study area.

The GLTFCA is an interesting case study since it includes three countries with different experiences in terms of wildlife conservation policy and in different stages of development. Rather than looking at poaching in general terms, we consider a type of environmental crime involving small wild animals that is ordinarily not reported, but contributes significantly to the loss of biodiversity especially at local scales in Africa. Poor people in the study area ordinarily target small wild animals for subsistence consumption. Subsistence poaching is exacerbated by economic hardships (Gandiwa et al. 2013; Balint and Mashinya 2008) and declining institutional capacity in the communities (Ntuli and Muchapondwa 2018; Balint and Mashinya 2008).

This paper contributes to our understanding of wildlife crime and to the common pool resource (CPR) literature through examining the drivers of subsistence poaching. Community, socioeconomic and policy variables could have differential impacts on subsistence poaching, which result in negative or positive effects on the social-ecological system. For the drivers which lead to destruction of the natural capital base, we need to identify, understand and counter those drivers that are too destructive, while at the same time promoting drivers which lead to sustainable utilization and management of wildlife resources in communities adjacent to GLTCA. A deeper understanding would help us reflect on how to manage these drivers so that specific conservation thresholds are not exceeded. Little is known about the weight that should be given to socioeconomic characteristics such as age, gender, employment, education and wealth compared to ecological, community and institutional variables (Ntuli and Muchapondwa 2018). For instance, it is not well understood whether community members take advantage of poor institutions to evade arrest or whether poor people are more inclined towards subsistence poaching compared to relatively wealthier people. This also might have something to do with how local people perceive wildlife conservation in general and how the park is managed. We therefore ask the following questions: i) What are the factors driving subsistence poaching behaviour in local communities around the GLTFCA? ii) What are the characteristics of individuals who are likely to violate hunting rules? iii) What measures can be instituted to counter the drivers of subsistence poaching?

[2] The former is now thought to be part of organized crime orchestrated by international criminal syndicates (Hubschle 2016; Duffy et al. 2016), while the latter - illegal taking of wildlife resources primarily for household consumption, but also for limited local trading - is perpetrated by local people (Ntuli and Muchapondwa 2018; Muchapondwa 2003).

Our findings confirm a general expectation that the number of reported poaching incidences is higher for communities in Mozambique than it is for communities in Zimbabwe and South Africa. In addition to individual characteristics such as age and gender, other variables relevant for policy such as perceptions, group size and institutions also matter in explaining the observed variance in subsistence poaching across country. The implication of our results is that appropriate interventions such as capacity building and training can be used to achieve the desired conservation outcomes by targeting relevant variables, e.g., by rolling out awareness campaign programme in local communities around the GLTFCA and training related to natural resource management (NRM).

This paper proceeds as follows. We first review the literature and present our theoretical framework. The methods section describes the study site, sampling, data and model specifications. We then present the results and discussion. The final section concludes and discusses implications for further research and policy.

2 LITERATURE REVIEW

Managing CPRs such as wildlife is a daunting task, especially when we have many resource users with diverse interests (Ostrom et al. 2007; Agrawal 2001). CPRs have two unique characteristics, i.e., i) difficulty to exclude others, and ii) harvesting the resource reduces the amount available to others. Under joint use arrangements, CPRs suffer from resource overexploitation because they are subtractable. Most wildlife species in developing countries are overexploited by both local people and people from distant communities or countries. Because of this situation, most governments choose to impose a ban on subsistence and commercial exploitation of wildlife in order to conserve it (Johannesen and Skonhoft 2005; Songorwa et al. 2000; Murombedzi 1999). However, with such a policy in place, local communities may feel marginalized from their resources and yet they sometimes suffer from wildlife intrusion. This situation usually provides excuses for illegal harvesting of wildlife. Poaching is still rife in the GLTFCA because the benefit going to the community might not be sufficient to generate the much needed incentives to conserve wildlife. The utility from individualised poaching may be much larger than the utility from individual dividends when legal exploitation of wildlife is in the hands of the whole community. Local people suffer different levels of crop damages and livestock predation without compensation, i.e., community conservation can be viewed as a threat to individual livelihoods. Hence poaching may occur because people seek to reduce the population of wild animals potentially involved in human-wildlife conflict. Furthermore, poaching may be driven by local people's negative perceptions on the whole conservation system, i.e., from the way wildlife is managed to the structure and magnitude of the benefits shared. Sometimes people perceive that there is plenty of wildlife in the area and they are unfairly denied access to the resource (Songorwa et al. 2000).

Quite a huge chunk of theoretical, empirical and experimental literature on

poaching behaviour exists from different fields such as social science, criminology and economics (Ntuli and Muchapondwa 2018; Hubschle 2016; Rizzolo et al. 2015; Moreto and Lemieux 2015; Johannesen and Skonhoft 2014; Rustagi et al. 2011). Much of the work from social sciences and criminology is purely qualitative and focuses on understanding the behavioural motives for poaching and crime prevention (Kahler 2018; Hübschle 2016; Gore 2017; Von Essen et al., 2014). Under this literature, the drivers of poaching behaviours are classified under two primary categories, namely, instrumental approaches and normative approaches. Instrumental approaches hold the view that poaching is driven by self-interest and that individuals are affected by immediate incentives or punishments. These approaches are aligned with rational choice theory and the opportunity-focused approaches to crime prevention. Normative approaches focus on the role of morals, beliefs and values in driving poaching behaviour, rather than looking solely at economic benefits (Von Essen et al, 2014). The drivers of poaching considered under the normative approach range from pleasure seeking behaviour to defiance or retaliatory behaviour. Current criminology work in the GLTFCA focuses on wildlife trafficking and poisoning by local communities (Hübschle 2017).

The point of departure in theoretical modelling is the assumption that poachers are rational individuals maximizing their utility by weighing benefits and costs associated with committing an environmental crime (Fischer et al. 2011; Perman et al. 2003; Milner-Gulland and Williams 1992; Clark 1990). If the marginal benefits outweigh the marginal costs, then crime is committed. Poachers do not care about the loss accruing to the society, but rather focus on the individual benefits they derive from the activity. Most studies in this literature assume that the community portrays a myopic behaviour and do not take stock dynamics into consideration when maximizing net benefit (Johannesen and Skonhoft 2014; Johannesen 2007). The cost function of the poacher includes several variables such as poaching effort, whether the poacher feels ashamed when caught, punishment and the probability of being caught (Akpalu et al. 2009). This simple framework does not only allow researchers to understand what goes on in the mind of the person committing an environmental crime, but can also be extended to analyse the utility function of the community as a whole by adding community variables such as institutions (Ntuli and Muchapondwa 2017b). For this reason, resource economists advocate for community engagement in order to deal with illegal harvesting.

The empirical literature is also diverse with some studies focusing on the drivers of poaching (Lindsey et al. 2011; Brooks 2010; Adams and Hutton 2007; Stiles 2004), while others consider collective action as a solution to the loss of biodiversity (Kerr et al. 2014; Saunders 2014; Büscher and Schoon 2009). Poaching in developing countries is often attributed to poverty (Sanderson and Redford 2003) and communities' lack of ability to self-organize in order to protect resources (Ostrom et al. 2007). The empirical studies that try to look directly at poaching activities are limited by the availability of data or the difficulty in collecting poaching data, particularly in developing countries. Furthermore, most of the empirical studies that look into the subject matter actually focus

on valuable or commercial species since the data is readily available. Because of data limitations, researchers either tend to take an indirect approach and consider aspects such as collective action problems (Ntuli and Muchapondwa 2018; Sjöstedt 2013) or use a qualitative approach to understand poaching behaviour (Gandiwa 2011; Kreuter et al. 2010; Jachmann 2008; Holmern et al. 2007; Linell et al. 2017).

The experimental literature does not take a direct focus on poaching *per se*, but rather generates insights into illegal harvesting behaviour by looking at group dynamics in terms of their harvesting behaviour and strategies under an experimental setting. Experiments allow researchers to control for other factors, while focusing on the variable of interest. Like the empirical literature, some experimental studies also consider the problem of collective action (Ntuli et al 2019b; Rustagi et al. 2011; Nikiforakis et al. 2007; Murphy and Cardenas 2004; Ostrom and Walker 1991). Consistent with this line of reasoning, Ntuli and Muchapondwa (2018) define poaching as lack of cooperation since it represents deviation from the norm, protest behaviour or dissent. Experimental economics allows researchers to compare institutional features such as punishment (monetary, non-monetary, social ostracism, e.tc), and information on communication on the harvesting behaviour of the resource users in a group (Casari and Luini 2009; Masclet et al. 2003; Ostrom and Walker 1991). One important result from experimental economics is that punishment might yields optimal results when it emanates endogenously from community rather than being enforced externally due to budgetary constraints faced by the state (Murphy and Cardenas 2004). Ntuli et al. (2019b) found that punishment is superior to information provisioning in terms of influencing resource extraction strategies and collective action behaviour, while the combination of the two interventions is more superior to either punishment or information alone.

3 CONCEPTUAL FRAMEWORK

The conceptual framework used in this paper borrows heavily from the theory for analysing complex social-ecological systems developed by Ostrom (2007). The theory identifies 8 core components that are linked together and arranged into a 3 tier system. The 3^{rd} tier is made up of the external environment such as economic, political and social forces in addition to other linked ecosystems such as rivers and woodlands. The 2^{nd} tier is made of the resource system such as a transfrontier conservation area (TFCA), resource units, i.e., a fugitive resource such as wildlife, resource users such as local communities and tourists, and the governance system which is made up of community institutions and rules governing the park. The 1^{st} tier is called the action domain where the various components interact together to produce outcomes. These outcomes can either be desirable or undesirable depending on whether it is below, above or at the social optimum level. This study focuses on what happens in 1^{st} tier of this framework as poaching occurs in the action domain. However, what happens in the 1^{st} tier is also influenced directly or indirectly by variables in the 2^{nd} and

3^{rd} tier.

Table 1 puts Ostrom's theorem into perspective. We ignore variables in the 3^{rd} tier since these are more difficult to control since they lie outside the influence of local communities. We can think of these variables as being interwoven in a web that links each variable to another. Of course, some of these relationships are unidirectional as we do not expect variables in the 2^{nd} tier to affect variables in the 3^{rd} tier, while other variables are bidirectional, especially variables in the same tier. In our context, we consider wildlife species such as antelopes and kudus that move freely in the TFCA, and interact with local communities when roaming outside protected areas. The interaction between the community and resource units sometimes produces undesirable outcomes, for instance, members of the community overexploit the resource because wildlife pose a threat to their livelihoods through livestock predation, destroying field crops and sometimes cause injuries to human beings or death. Sometimes, members of the community believe they own wildlife and therefore overexploit it once outside protected areas[3].

Being a fugitive and CPR, wildlife is associated with uncertainty. Resource users are not sure if the resource will be there tomorrow, someone else will harvest the resource if they try to conserve it or whether institutions will improve such that it becomes impossible to harvest the resource in future. If the communities in question are without the means of controlling extraction, then the end result is resource overexploitation and eventually total collapse of the social-ecological system. The prediction of resource collapse usually comes true in a very large and highly valuable resource system under open access conditions when users are diverse, do not communicate and have failed to develop institutions for managing resources (Ostrom 2009; Agrawal 2001). We argue that even with less valuable resources, if the community believes that there is plenty in the protected areas they tend to overexploit the resource. Local communities exhibit a myopic behaviour if they do not benefit from the resource (Johannesen and Skonhoft 2014; 2000). Unless they are made to benefit from the resource, local communities can sabotage government initiatives. In this paper, we consider poaching as a collective action problem and as such it can be viewed as lack of cooperation among community members. In this case, the whole community forms a view about whether poaching is tolerable or not, and hence affect the costs that individuals suffer when they make a decision to go poaching (Ostrom 2007). Thus, in addition to user characteristics, we also expect those variables that facilitate collective action to influence the community's poaching behaviour. The variables we use in our models come mainly from the second tier.

Theoretically, community variables, institutions, ecological conditions and household characteristics such as age, gender, education, income and employment have been observed to influence the destructive or illegal behaviour in natural resource management (Ostrom 2007). Agrawal (2001) documented more

[3]The basic problem with CPRs is that resource users are not sure if the resource will be there tomorrow, someone else will harvest the resource if they try to conserve it or whether institutions will improve such that it becomes impossible to harvest the resource in future.

than 30 variables that had been posited in major theoretical and empirical work to affect incentives, actors and outcomes related to sustainable governance of a resource system. Since the communities in the study area are similar in terms of their socioeconomic attributes, we expect community variables, institutions and ecological conditions to play a more important role in explaining behaviour at both community and individual level than the socio-economic variables. Specifically, we expect the impact of household variables to be less pronounced or the variable to be insignificant if used in a regression model. We expect poaching to increase with group size and resource quality or abundancy. Finally, we expect poaching activities to be low in communities with good institutions.

4 RESEARCH METHODS

4.1 *The study area*

The GLTFCA was officially established in 2000, when a common treaty was signed between the governments of Mozambique, South Africa and Zimbabwe (Spenceley 2006). A new agreement was approved in 2002 recognizing the 'core protected areas' of the region and thereby establishing the Great Limpopo Trans-frontier Park.It stretches over an area of about 35.000 square kilometres and includes three national parks: Gonarezhou National Park (GNP) in Zimbabwe, Kruger National Park (KNP) in South Africa and the Limpopo National Park (LNP) in Mozambique (SANParks 2018). The future plan for the trans-frontier conservation area (TFCA) is to expand into surrounding areas covering approximately 100.000 square kilometres and thereby becoming one of the world's biggest TFCAs. This also implies that local communities are included in the TFCA. The main objective of GLTFCA is to foster transnational collaboration and increase the effectiveness of ecosystem management. Ideally, it was supposed to provide free movement of both tourists and wildlife within the TFCA. Aside from that, another important purpose is for the local communities to receive economic benefits through increased eco-tourism in the region. The GLTFCA is envisioned to generate economies of scale though public-private partnerships and supplying a much larger habitat for fugitive resources.

Figure 2 shows a map of the GLTFCA, where the national parks are shown in dark green and neighbouring communities are situated in the region shown in light green colour. The park is located between $22^0$22'S and $31^0$22'E, with arid conditions and thus less suitable for rain fed agriculture (Gandiwa 2017; Ntuli and Muchapondwa 2018). The production technology is predominantly subsistence in nature combining livestock rearing and crop cultivation. The study area is dominated by Shangani speaking people (over 95%) although other languages such as Shona, Ndau, Ndebele, Venda and Zulu are also spoken.

On the Zimbabwean side, local communities are organized into CAMPFIRE projects, which are dotted around the GNP, while in South Africa the Makuleke community owns land inside the KNP, but hires a safari operator to manage tourism activities on the community's behalf, while they have an arrangement

with SANParks to manage wildlife (Reid 2001). CAMPFIRE communities do not own land inside the protected area but manage wildlife traversing the adjacent buffer zone through their respective Rural District Councils (RDCs). In Zimbabwe, the proceeds from wildlife conservation are in turn shared between the RDC and the CAMPFIRE communities, while in South Africa revenue is shared between Makuleke and the safari operator. In Mozambique, some communities still live inside the LNP and resettlement of people from the park to the adjacent buffer zone is ongoing.

4.2 *Data and sampling*

This paper uses unique survey data collected between May 2017 and June 2018 from local communities residing adjacent the Great Limpopo TP. The data is based on face-to-face interviews and includes 2282 respondents, with 769 respondents from Zimbabwe, 582 respondents from South Africa and 931 respondents from Mozambique. Table 2 shows the sample statistics. The survey consists of questions on the respondents' socio-economic conditions and themes such as willingness to follow formal rules, corruption and law enforcement, the function and management of the park, poaching trends and number of poaching incidences in the community, and the respondent's attitudes towards different strategies and policies to combat poaching. Our survey posed indirect questions about poaching incidences that have happened in the community as well as previous hunting behaviour of the respondents. For instance, we ask about the number of confirmed poaching incidences in the community that respondents have heard about and the last time the respondent was actually engaged in hunting activities. We believe that these questions are able to capture information about poaching behaviour of individuals and the community. There could be incidences described by communities as (de facto) legitimate harvesting when they in fact constitute (de jure) poaching. Realizing this is important if one wants reliable responses about poaching in communities. The strategy that this research took during the interview stage was not to make a judgement on whether communities where poaching or not. Communities themselves had to give the label to the type of harvesting occurring in their area. However, while analysing data, the study would class any harvesting conducted in areas where the law forbids it as poaching.

Simple random sampling was applied to select 11 out of 29 CAMPFIRE communities located near Gonarezhou National Park in Chiredzi district. These were all identified by the Rural District Council (RDC) in Zimbabwe. In South Africa, a full sample of 5 villages closely situated to Kruger National Park was identified by the local chief. On the Mozambican side, we purposefully selected three administrative areas in two districts that are very close to LNP with the help of local authorities and then randomly selected 21 villages.

The chairpersons of each CAMPFIRE project and each chief respectively provided a list of beneficiaries in each project and community. We then performed a simple random sampling procedure starting with a random household on the list. Each respondent was chosen after every $n$households where n is the

sampling interval calculated as the total number of households in the project divided by the required sample size. The selection procedure continued until the required number of respondents in the sample was achieved.[4]

Sampling on the Mozambican side was complicated by the fact that we could not get a reliable list from both the traditional and local authorities, and since people were still being relocated from the park into the buffer zone. However, we used an old household list supplied by local authorities as a starting point to give us a rough idea of the proportions of households in each village and to compute the sampling interval n. Upon entering a village, enumerators randomly selected a starting point and direction by flipping a coin and tossing a dice respectively[5], and then followed the same procedure described above after every n households in that direction.[6]

4.3 *Empirical model specification*

In this study, we model the drivers of subsistence poaching in indigenous communities around the GLTFCA covering Zimbabwe, South Africa and Mozambique. The analysis is accomplished by running two models whose results speak to each other and as such should not be viewed separately, but as part of a structural framework. Our choice of dependent variables used in the two models is based on the sensitive nature of the study and the difficulty in collecting poaching data. Consistent with theory and empirical literature, we assume that poaching is a function of socio-economic, ecological, community and institutional variables in addition to how respondents perceive wildlife and conservation in general.

For model (1), we use the reported number of poaching incidences in each community as the dependent variable to analyse the drivers of subsistence poaching in communities. This measure gauges the individual perception of group behavior (i.e., how much poaching is being done in the group). Thus the question used in the survey allowed respondents to talk about the poaching activities of others in the community, i.e. N-1. This strategy avoids judging the respondent, but gives them a platform to talk about others in strict confidence. In deciding on the number to report, each respondent recalls community-level poaching data based on the poaching they have witnessed as well as the poaching they have been reliably informed about. The only element missing from their reported data is their own poaching, that is if they happen to poach. This strategy gives a more reliable estimate of poaching as the sample size increases than if each respondent was asked to report their own poaching statistics. Since the

[4] If reaching the end of the list before collecting the required number of questionnaires, we restarted the sampling process selecting a different starting point at random on the list. The target sample was exceeded in most of the communities.

[5] The coin was used to choose the starting point if it landed heads, while the numbers 1 – 4 on the dice represented North, East, South and West direction. If the dice landed on 5 and 6 no direction is found then the enumerator would toss the dice again.

[6] The enumerators were trained for two days during which they got the opportunity to go through the survey and get familiar with the questions. In order to test the applicability of the questionnaire, a pilot round was conducted on the third day in one village before the main data collection started. The pilot study was also considered part of the training process.

dependent variable is measured at community level, we make use of community averages in the first model, i.e., average number of poaching incidences, average age, average number of years in school, etc. We acknowledge the limitation of using this indicator to examine the actual group behavior we aim to study. Our assumption is that understanding individual perceptions about group behavior provides some important insights into the actual behavior of the group.

The dependent variable in the first model has both positive values and zeros. It becomes a latent variable since it is combining genuine and zeros where respondents are not saying the truth. For this reason, we fit the craggit model (two-stage tobit model) on the reported number of poaching incidences as a function of socio-economic, ecological, community and institutional variables. It jointly estimates a probit model on whether or not respondents have a positive value and then a linear regression model for those who have positive values. The probit model tells us the likelihood that a respondent will report positive values of poaching incidences.

For the dependent variable in the second model, we solicited information about the last time (year and month) the respondent was actually involved in hunting. The question used in the survey removes the stigma associated with breaking hunting rules by asking the respondent for their hunting data rather than poaching data. To avoid protests from respondents who believe they have a right to hunt for one reason or another despite *de jure* the hunting ban instituted by the government, this question came first in the questionnaire[7]. The unit of analysis in the second model is at the individual level. What differentiates our first and second model is that the dependent variable in the second model actually measures the respondent's own poaching activity, while the latter measures poaching by everyone else in community, except the respondent. Essentially, the logit regression model or model 3 uses a transformed version of the variable measuring the number of years that transpired since the respondent was actually involved in subsistence hunting activities.[8] If we define a natural cut-off point linked to the community-based natural resource management (CBNRM) regime shift as the difference between the survey period and the year of establishment of the community conservation project, the dependent variable for the probit model is re-defined as follows:

$$A_i = \begin{cases} 1 \text{ if years } \leq C \\ 0 \text{ if years } > C \end{cases} \tag{1}$$

where C =year of establishment-survey period (May 2017, Aug 2018) and A_i equals 0 if the number of years the household was involved in poaching is greater than C and 1 otherwise. We chose this natural cut-off point because it is exogenous to the system in the sense that beneficiaries were not able to influence it. Therefore, if CBNRM reduced poaching, then we would want to know whether a respondent ceased poaching after its inception. In other words, those who

[7] If one started with question1, it already introduces illegality and might influence respondents as they move to question 2.

[8] We believe that these are less offensive questions, which respondents are likely to provide answers to comfortably without fear of being victimized.

stopped poaching after the inception of the CBNRM or lie dormant for more than C years are the conservationists, while those who continue poaching or remain active hunters after inception of the programme are against conservation. For the case of Mozambique, we used the year the household was removed from the park and relocated to the village where they are staying now as the year of establishment of the CBNRM. As part of the process of establishing the CBNRM, the government of Mozambique is creating a buffer zone between the relocated communities and the park. Grant (2002) observed that most wildlife species take a very long time to recover after a small perturbation, and this call for local communities to abstain from harvesting wildlife for longer periods of time to allow the resource to recover.[9] From a management point of view, harvesting is sustainable if it does not exceed sustainable take-off. To understand the attributes of individuals who are likely to be involved in subsistence poaching activities, we use a logistic regression model to examine the determinants of the probability that a respondent is an active poacher. Whether a respondent is a conservationist or not is unobservable, but what we observe is the individual's poaching behaviour i.e. $A_i^* = X_i\alpha + \varepsilon$ and so $A_i = 1 \,\text{if}\; A_i^* > 0$, which implies that $\text{number of years} \leq C$ and zero otherwise.

The variables measuring household shocks, expertise, institutions and perceptions are computed indexes. We used the number of times respondent went to bed without eating and whether respondent's family was forced to sell assets as proxy for household shocks, while the variable expertise was captured by respondent's extraction of environmental resources. We use the latter to test whether people poach because they lack "alternative livelihoods" as claimed in the literature (Lindsey et al. 2013). Our argument is that households don't sell assets if there are other alternative ways of generating income. Table A1 in the annexes shows the types of questions that were asked under the various themes. We then used factor analysis to recover the indexes. All categorical variables and variables that require respondents to rate from 1 to 10 (i.e, the use of a Likert scale) were converted into binary variables by splitting them into two and the computed index expressed as a fraction between zero and one for ease of interpretation. For instance, a categorical question was recorded into two values, i.e., zero if the response is negative (or below average on a Likert scale) and 1 if it is positive (or average and above on a Likert scale). Before the indices were computed, negative questions were recorded to match questions that were asked in a positive sense, i.e., zero becomes one and one becomes zero. This was done so that the index lies between 0 and 1 and it is easy to read, where zero signifies a negative outcome or bad situation and one stands for a positive outcome.

Table 3 shows the explanatory variables used in our regression models and their expected signs. Theoretical, empirical and experimental studies suggest that socio-economic, ecological and community variables such as institutions affect community, household and individual poaching behaviour (Carter et al.

[9] Latent shocks can either be exogenous to the system or endogenously driven from within the system. We are interested in man-made shocks because these can be avoided if resource users cooperate or coordinate their efforts (Ostrom et al. 2007).

2017; Kühl et al. 2009; Ostrom et al. 2007; Agrawal 2001). For household level analysis, standard microeconomic literature views a typical agricultural household as a single decision-making unit with the household head dictating or approving the activities of each member in the family, i.e., behaviour is agreed upon by all family members. The critical assumption made is that each household member knows the behaviour that is acceptable in the family (they know the norms the family ascribes to as well as the expectations of others in the family). On that notion, we can therefore view a household as a single poaching unit.

The survey targeted the head of the household as the respondent under the pretext that they he or she will give a representative view of the household. However, the association between individual-level predictors and a measure of household behavior is not immediately intuitive. For simplicity and to avoid confusion, we will maintain our level of analysis and interpretation of the results at individual and infer to households with care where necessary. We will only infer to a household where it is difficult to disentangle individual behaviour from the household behaviour.

From the literature, the effect of some of the socio-economic variables is mixed. For instance, there are scholars who found that the age of an individual is positively related to poaching behaviour (Moreto and Lemieux 2015; Kahler and Gore 2012), while other studies find a negative relationship (Knapp 2012; 2007; Stern 2008). Baruch-Mordo et al. (2011) find a negative relationship between education, livestock ownership, access to electricity or employment and poaching. They argue that better-off individuals are less likely to depend on environmental extraction since they have better livelihoods options. The literature seems to suggest that men are more likely to poach wildlife (Knapp 2007; Holmern et al. 2007), while women are more likely to illegally harvest less valuable environmental resources such as firewood, insects, weaving material and wildlife vegetables on a daily basis (Ntuli and Muchapondwa 2017a; Thondhlana and Muchapondwa 2014; Thondhlana et al. 2012; Shackleton and Shackleton 2006). The argument is that women do not have the time, energy and expertise needed to harvest fugitive resources such as wildlife. Furthermore, women display a higher degree of risk aversion when it comes to poaching resources that attract a fine (Stern 2008). The effects of household size, social grants, household shocks and expertise on poaching could not be determined a priori from the literature.

The effects of community and institutional variables such as rules governing the resource and management on poaching behaviour are mixed since the impact of these variables also depend on the context under consideration (Ostrom 2007; Agrawal 2001; Baland and Platteau 1996). Theory predicts that wildlife benefits are likely to create incentives for people to refrain from poaching (Ostrom et al. 2007). Good institutions[10] positively affect community's ability to self-

[10] In this paper we distinguish between good and bad institutions. Ostrom (2007) proposed eight design principles upon which sound institutions are based. Good institutions are able to serve the intended purpose of constraining human behaviour so that the community's objective is achieved.

organize, which in turn affects biodiversity outcomes (Ntuli and Muchapondwa 2018). Both theoretical predictions and empirical evidence illustrate that there is a positive relationship between human-wildlife conflicts and poaching, i.e., poaching is a retaliatory behaviour by local communities towards wildlife intrusion (Lindsey et al. 2013; Stern 2008; Songorwa et al. 2000; Johannessen and Skonhoft 2000). Community and individual perceptions about wildlife and conservation in general have a significant effect on poaching behaviour depending on whether they perceive wildlife as an asset or a threat to their livelihoods (Ebua et al. 2011). Evidence reveals that most communities in Africa view wildlife as a threat to their livelihoods (Ntuli et al. 2019a; Lindsey et al. 2013).

5 RESULTS AND DISCUSSION

5.1 *Descriptive statistics*

The average age in the total sample was 42 years. The respondents from Zimbabwe are on average slightly older than respondents from South Africa and Mozambique. Overall, there were more female respondents in the sample (65.5%) in the study area. This was expected since most males from the area are often employed elsewhere (Ntuli and Muchapondwa 2018). The Zimbabwean side had a significantly higher proportion of male respondents (39.0%), while South Africa had the least (28.2%). The respondents from South Africa are on average more educated (spent approx. 8.6 years in school), while their Mozambican counterparts had on average the least education (spent about 3 years in school). This was expected because the rural communities of South Africa are relatively well developed compared to those in Zimbabwe and Mozambique. Furthermore, most people in the latter countries do not normally finish primary education as they prefer to cross the border into South Africa in search of jobs at a tender age in order to fend for their families (Ntuli and Muchapondwa 2018; Spenceley, 2006). The average household size is slightly higher in Mozambique (7 members per family) and slightly lower in South Africa (5 members per family) compared to Zimbabwe (6 members per family). The group sizes for communities in South Africa are much higher on average (937 members per group), while those in Zimbabwe are much lower (60 members per group) compared to Mozambique (610 members per group). This difference emanates from the fact that the lowest administrative unit in the three countries is different.

Approximately 91% of the respondents on the South African side have electricity, while less than 1% of respondents on the Zimbabwean and Mozambican side have access to electricity. This huge difference shows that communities around KNP are better off than those around GNP and LNP. Likewise, the proportion of respondents who are employed is also higher for South African communities (27.8%) than it is for communities in Zimbabwe (12.7%) and Mozambique (19.5%). Respondents around GNP reported more household shocks (55%) compared to respondents from the neighbouring countries (48% and 12% around LNP and KNP respectively), while respondents around the

LNP appear to have more expertise (39%) and hence depend more on environmental resource extraction than respondents around GNP (26%) and KNP (6%). Additional information gathered during interviews revealed that CAMPFIRE communities are experienced to severe hardships because of the economic crisis in Zimbabwe. About 76.1% of the respondents around KNP indicated that they received social grants, followed by 30.3% of respondents around LNP and lastly 10.2% of the respondents around GNP. About 94.1% of the respondents on the Zimbabwean side indicated that they benefitted from wildlife income, while 46.7% and less than 1% of the respondents on the South African and Mozambican side indicated that they benefitted from wildlife conservation respectively.

Surprisingly, our results show that there is slightly more human-wildlife conflict in Zimbabwe than in Mozambique. We expected communities in Mozambique to experience more conflict since some of them are still located inside the park. This could be evidence of dwindling wildlife population inside the LNP, while Zimbabwe still has plenty of wildlife roaming inside and outside GNP. A t-test reveals that the difference in the reported numbers of human-wildlife conflict between the two countries is not significantly different from zero. However, local communities on the South Africa side are experiencing less conflict possibly due to the effect of the fence around the KNP and effective management or quick response by the responsible authorities to wildlife intrusion in the community.

The average number of reported poaching incidences is significantly higher for communities in Mozambique (1.4) than it is for communities in Zimbabwe (0.97) and South Africa (0.95). This was expected since poaching in Mozambique may be exacerbated by poor CPR institutions, communities living inside the park (which makes it difficult to monitor what they are doing) and limited budget to fund anti-poaching activities by the park agency. These communities are also used as entry points by poachers from other areas or countries. In another study in Zimbabwe, Ntuli et al. (2019a) observed that communities located very close to the game park sometimes act as if they own wildlife and treat it just like livestock roaming in the backyard. Given variability in individual, community and institutional characteristics across countries, it is of great interest to examine if these differences also explain the variation in poaching behaviour in the study area.

5.2 *Regression Analysis*

Table 5 shows that there are 561 observation with zeros reported for the number of poaching incidences. The full sample has 2282 observations, which reduce to 1721 after removing the zeros. As expected, the mean in the truncated sample is much higher than the mean in the full sample because of the effect of the zeros, while the reverse is true for the standard deviation or variance.

Table 6 shows the results of both the craggit and logistic regression models. Model 1 show the results of the craggit model when the dependent variables is the number of poaching incidences as reported by the respondents. The first

stage of the craggit model estimates a probit model where the dependent variable is one if the number of poaching incidences is positive and zero if there were no poaching incidences. The second stage of the craggit model estimates a linear regression on the positive values of the reported poaching incidences only or restricted sample. The third column of the craggit model shows the marginal effects, i.e., the effect of the explanatory variable on our right hand side variable when it is changed by a margin. In model 2, we transformed information about the past hunting behaviour of the household into a binary variable represented by zero if a household did not hunt since the onset of CBNRM in their community and one otherwise. All models are highly significant at the 1% level of significance. We observe that variability in the dependent variables is explained by both ecological and community variables in addition to socioeconomic variables such as gender and age. The sign on the explanatory variables in both models agree most of the time and for this reason, we prefer to interpret the results of the two models together where appropriate to show the big picture.

The result of the first stage of the craggit model suggest that the likelihood to report positive poaching incidences was much higher for communities with a higher proportion of men, plenty of wildlife and experiencing conflict, while the likelihood of reporting zero poaching incidences was higher in communities with good institutions, who benefited from wildlife conservation, perceived that the management of the park is good, where the level of trust is high and in communities around the KNP and GNP. This was expected and consistent with other studies (e.g., Ntuli et al. 2019a; Lindsey et al. 2013; Gandiwa 2011). The marginal effects in column 3 of the craggit model show that the number of poaching incidences either increases or decrease by at least unit as we marginally alter variables such as wildlife abundance, institutions, trust, conflict and perceptions. The coefficient for institutions has the highest magnitude, while the magnitude of the coefficients for wildlife abundance and conflict are almost similar. This result highlights the importance of CPR institutions in constraining poaching behaviour and thus improving biodiversity outcomes. Our results demonstrate a cyclical effect and negative reinforcement between wildlife abundance and conflict on the animal population through poaching. For instance, while there is more wildlife in communities that are less poached, there is more human-wildlife conflict which in turn generates more incentives for poaching.

Considering the truncated sample, our results suggest that a community with a higher proportion of men is more likely to engage in poaching activities and vice versa. The logit model suggests that the likelihood to engage in poaching after the establishment of the CBNRM decreased as age increased. Combining these two results we conclude that young men are more likely to poach than older men, while women and particularly older women exhibit pro-conservation behaviour. A possible explanation is that poaching is a very risky activity, with a very high opportunity cost in terms of time spend in prison if caught and effort. The opportunity cost of forgone agricultural activities could be very high for older men with families to feed and it is even higher for women because of their responsibilities at home (Ntuli et al. 2019b; Kahler and Gore 2012). Furthermore, their reputation might be affected if they are caught. On the other

hand, young men are risk loving and they can afford to invest plenty of time and effort in poaching if it is relatively profitable to do so, i.e., they do not have a reputation to protect and can sacrifice to spend some time in prison (Ntuli 2015; Schneider 2008). Hubschle (2016) observed that men are also more likely to engage in wildlife trafficking than women since it is a risky activity. Policy interventions should therefore target young men through creation of alternative livelihood activities to divert their effort from poaching.

We observe that the coefficients on GNP and KNP are negative and highly significant under all the models. Hence, taking LNP as the baseline category, our results suggest that poaching in local communities around the other two national parks is less relative to the LNP. Furthermore, respondents from communities around KNP and GNP were less likely to be active poachers after the establishment of the CBNRM relative to respondents from communities living adjacent to LNP. This is not surprising for South Africa since the park is fenced and as a result there is less interaction between local communities and wildlife inside the KNP.[11] Balint and Mashinya (2006) observed that economic hardships in Zimbabwe force households to divert their effort from subsistence farming and other income generating activities towards poaching. Ntuli et al. (2019b) reported that the level of poaching in local communities around GNP could be comparable to that of communities around LNP in reality because of economic hardships and opportunities presented by abundant wildlife on the Zimbabwean side.

Our results also illustrate that there is less poaching in communities where local people trust each other, respect institutions, perceive that the management of the park is good and view wildlife as an asset. Furthermore, we are also less likely to find active poachers in such communities after the establishment of the CBNRM. In a study around the GNP, Ntuli and Muchapondwa (2018) found that CAMPFIRE communities are more likely to cooperate when good institutions are in place. Focus group discussions (FGDs) and key informant interviews revealed less evidence of self-organization and the role of community institutions in wildlife conservation on the Mozambican side. This situation poses a serious threat to wildlife conservation not only in Mozambique, but in the GLTFCA at large. Although in South Africa there is a community board responsible for managing wildlife income, it is not representative of the communities in the study area. Ntuli and Muchapondwa (2018) found that there are about five communities around KNP claiming ownership of the conservation land inside the park, but only one of these five communities actually benefits more from the contractual park arrangement.

According to Ostrom et al. (2007), self-organization is a precondition for good environmental citizenry in poor communities. It is argued that local communities that are able to develop robust CPR institutions are also able to manage their resources sustainably. The CPR literature suggests that trust is an important ingredient that forms the social fabric for collective action (Hodge

[11] However, expert interviews revealed that commercial poaching is high in South Africa because there are more rhinos inside the KNP than anywhere else in the TFCA.

and McNally 2000; Ostrom 2000; 1990). The role of trust in NRM via its influence on collective action is well documented mostly in Asian and Latin American studies on forestry and fisheries (Ostrom et al. 2007; Agrawal 2001). In the case of the GLTFCA, we expect those communities with high levels of trust to quickly self-organize in order to protect wildlife as the resource becomes depleted. On the other hand, lack of trust among resource users can result in overexploitation because of competition even if the resource is facing extinction (Ostrom 2010). This is a classic textbook example of an open access regime where resource users will continue to mine a resource until the marginal costs exceed the marginal benefits of doing mining in the absence of restrictions.

Respondents that have expertise to extract environmental resources and that have experienced shocks such as chronic food shortages are more likely to be active hunters because of the need to either increase the intake of calories or supplement their diet. The two variables are not significant in the first model suggesting that expertise and shocks are only experienced by respondents at household level rather than affecting the whole community. Communities around the GNP and LNP are made up of relatively poor people, whose livelihood strategies are heavily dependent on the environment (Muboko 2017; Spenceley 2006). FGDs revealed that people around both national parks harvest environmental resources such as bushmeat, firewood, thatch grass, weaving and craft material, poles, wildlife vegetables, mopani worms, mushroom, fruits, ancient Shangani wine called njemai or uchema harvested from palm trees, etc. Most of these environmental resources are sold on both local and distant markets as raw or value-added products (Ntuli and Muchapondwa 2017a). It is undisputable that a policy instrument which seeks to increase devolution of NRM and consumption of environmental resources will enhance the welfare of local communities, but the real challenge is how to strike a balance between welfare and conservation objectives.

The results show a very strong link between resource quality and environmental extraction. While there are fewer poaching incidences in a community where wildlife is plenty, the community members were also less likely to be active poachers after the establishment of the CBNRM in such communities. This is consistent with theory and expectations since reduced poaching is likely to translate into a healthy population of wildlife in communities that have good institutions (Ostrom et al. 2007). Kideghesho (2016) argues that plenty of wildlife in an area is a good indicator of a sound social-ecological system where users can manage their resources sustainably and efficiently. Carter et al. (2017) argue that abundant wildlife in an area can induce poaching because of the opportunities created to people that would otherwise not commit a crime if the chance was not there. This calls for tailor-made policy interventions in order to strengthen local CPR institutions and prioritization of resources towards anti-poaching enforcement in communities showing poor environmental husbandry in order to protect wildlife resource. Furthermore, there is also need for a better reward system for those communities that demonstrate good environmental stewardship to reduce incentives for poaching (Songorwa et al. 2000).

Another important driver of poaching in the literature that has received huge

attention from many scholars is human-wildlife conflict (Hubschle 2016). Our results demonstrate that there is more poaching in communities with conflict and that community members were more active poachers after the onset of the CBNRM in these areas. Conflict is exacerbated by wildlife abundance and human encroachment into wildlife habitat in addition to poaching itself (Knell and Martínez-Ruiz 2017; Lendsey et al. 2013). Knell and Martínez-Ruiz (2017) observed that the social structure of most species living in groups is affected by killing the either dominant male or female (matriarch), which in turn might exacerbate conflict as the leader or matriarch responsible for establishing order in the family or storing the memory about where to find food and water is lost. As a result of conflict, it is believed that communities sometimes poach as a way of protesting or revenge for the damages suffered (Carter et al. 2017). Scholars argue for alternative livelihoods through economic development as a solution to address human-wildlife conflict in rural areas that are dependent on crop cultivation and livestock production.

In line with theoretical expectations, our results show that communities that have very large groups experience more subsistence poaching incidences and vice versa. This result is also consistent with empirical studies done in the region and elsewhere (Cooney et al 2017; Gandiwa et al. 2013; Jachmann 2008). The explanation is that poaching might be rife in a larger group size due to the difficulty in monitoring the resource and in exercising effective external anti-poaching enforcement (Ostrom et al. 2007). We are also likely to find active hunters in communities with very large groups after the establishment of the CBNRM due to difficulty for similar reasons. Under such circumstances, scholars argue that it is more efficient for members of the communities to monitor each other since most governments in developing countries are not equipped to deal with communities due to a tight budget constraint which makes it difficult to conduct effective monitoring and enforcement (Cooney et al. 2017; Murphy and Cardenas 2004). However, other studies found that extensive resources such as game parks and forests actually require a larger group size in order to efficiently monitor the resource (Ostrom et al. 2007; Agrawal 2001). A larger group size could have a negative effect on wildlife in the presence of poor institutions (Ntuli and Muchapondwa 2018).

6 CONCLUSION AND POLICY RECOMMENDATIONS

Fighting illegal hunting of wildlife is still the main task in wildlife conservation in Southern Africa. Poaching activities are perpetrated by both local people and sophisticated commercial poachers from distant communities and other countries. Unlike commercial poaching, this paper focuses on subsistence poaching, which is mainly perpetrated by local communities. Subsistence poaching is not generally viewed as an offense by indigenous communities since it involves less valuable species such as impalas, kudus, water bucks, inyalas, rabbits, birds, etc.

Even park authorities and police condone such activities as evidence by either insignificant penalty or lack of punishment for subsistence poaching or repeat offenders. Furthermore, illegal hunting has been part of the culture in local communities around protected areas and is hence very difficult to eradicate.

There is therefore a need to understand what motivates people to engage in illegal activities by focusing on the drivers of subsistence poaching such as socioeconomic factors, community, institutional and ecological variables as some of these factors can be influenced by policy. The influence of these variables differs according to context. This study contributes to a less understood topic on wildlife crime in CPR literature in poor African by examining the drivers of poaching and empirically confirming various hypotheses in the literature. This study uses purposefully collected primary data from 2282 respondents and 81 communities to examine the drivers of subsistence poaching in the Great Limpopo Trans-frontier Conservation Area. Because of the sensitive nature of the study and the difficulties involved in collecting data on illegal harvesting of wildlife, both reported poaching incidences in the community and previous hunting behaviour of individuals as stated by the respondents are used as dependent variables in this analysis. We use both ordinary least squares estimation and logistic regression analysis to achieve this objective.

Our results demonstrate that both community and policy variables such as community level trust, group size, the quality of local institutions and people's perceptions of park management and wildlife are important variables which counter the real motivation for poaching. From the literature, the motivations for poaching are self-interest, human-wildlife conflict, retaliatory and protest behaviour. There is also evidence of the role of socioeconomic variables such as age and gender on subsistence poaching. As a matter of policy, we suggest capacity building in local CPR institutions in order to deal effectively with illegal harvesting of wildlife, particularly in Mozambique where the hunting behaviour is still present. Training related to wildlife management and awareness campaigns could be used by policy makers to influence peoples' perceptions, which in turn affect behaviour and large-scale cooperation in the TFCA.

If local communities are able to eradicate subsistence poaching, then the actual problem of the state is fighting commercial poaching. Fighting commercial poaching requires joint efforts from the state, safari operators and local communities, provided that the latter also benefit from wildlife conservation. This also requires that all important stakeholders work together to achieve the common goal.

Our results have implication for large-scale collective action. There is a need to invest in local CPR institutions in order to stabilize large-scale cooperation so that local communities are able to protect wildlife resources. On the same token, people's perception about wildlife and park management is also important for collective action. Policy interventions such as training and awareness campaigns in the study area might help to change community perception and behaviour in the long-run.

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Table 1: Second tier variables used in this paper

Resource System	**Governance System**
RS1: Sector – wildlife sector RS2: Resource size – finite RS3: Renewable resource RS4: Resource type – small wild animals	GS1: Wildlife Management Committee - *Expected to continue with conservation outside park* GS2: State - *Enact bylaws and sometimes monitoring & enforcement* - *Has the rights to wildlife (who benefits?)* - *Collect and distribute revenues (is system fair?)* GS3: National Parks - *Custodian of wildlife* - *Set hunting quotas or impose total hunting ban* - *Monitoring & enforcement inside protected area*
Resource Units	Users
RU1: Fugitive resource - *Wildlife destroy crops and livestock* RU2: Legal harvesting and tourism - *Generate income to the community* RU3: Illegal harvesting by poachers	U1: Large number of users + user attributes U2: Conflict of interest - *Maximize community welfare (altruistic motive)* - *Maximize short-term gain (self-interest)* - *Nuisance motive for harvesting wildlife*
Interaction	Outcome
I1: Maximum harvesting levels by poachers I2: Crop damage and livestock predation	O1: Poaching leads to resource overexploitation O2: Destruction of the ecological system

Source: adapted from Ostrom (2007)

Table 2: Sample size

Country	**Freq.**	**Percent**
Zimbabwe	769	33.70
South Africa	582	25.50
Mozambique	931	40.80
Total	**2,282**	**100**

Source: survey data May 2017 - June 2018

Table 3: Explanatory variables and their definition

Variable	Explanation	Expected sign
Gender	0 = Female, 1 = Male	-
Education	Number of years in School	+
Age	In years	+
Household size	Number of household members	Undetermined
Employment	Is respondent employed?	±
Electricity	Access to electricity? 0 = No, 1 = Yes	+
Group size	How big is your community?	-
Livestock	Does respondent own livestock? 0 = No, 1 = Yes	-
Social grant	Does respondent receive a social grant?	Undetermined
Shock index	Went to bed without food/forced to sell assets	Undetermined
Plenty of wildlife	Is wildlife plenty in your community? [0, 1]	±
Conflict	Number of times household suffered wildlife intrusion	+
Perception	Perception about wildlife and good park management	±
Institutions	Community institutions	
Expetise index	Expertise in resource extraction	Undetermined
Benefit	Respondent benefit from wildlife conservation?	+

Source: Empirical literature and theory

Table 4: Descriptive statistics

Variable	**Obs**	**Zimbabwe**		**South Africa**		**Mozambique**		**Total**	
		Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
Age	2,282	43.04	15.11	42.19	15.01	42.05	16.47	42.42	15.65
Gender	2,282	0.390	0.488	0.282	0.450	0.322	0.467	0.335	0.472
Hhld size	2,282	6.209	2.532	4.627	2.115	7.073	3.765	6.157	3.165
Education	2,282	5.816	3.834	8.589	4.430	2.995	3.078	5.387	4.342
Group size	2,282	60.20	53.22	937.2	208.3	610.2	477.3	509.4	473.1
Electricity	2,282	0.01	0.133	0.91	0.292	0.02	0.121	0.243	0.429
Livestock	2,282	0.897	0.303	0.237	0.426	0.70	0.457	0.650	0.477
Employment	2,282	0.127	0.334	0.278	0.449	0.195	0.397	0.194	0.395
Grant	2,282	0.102	0.302	0.761	0.426	0.303	0.460	0.352	0.478
Shock index	2,282	0.550	0.498	0.142	0.350	0.374	0.484	2.438	6.501
Expertise	2,282	0.258	0.573	0.056	0.207	0.392	0.245	0.243	0.183
Plentywildlife	2,282	0.653	0.325	0.891	0.542	0.215	0.451	0.756	0.328
Benefits	2,282	0.941	0.481	0.467	0.493	0.012	0.458	0.253	0.435
Conflict	2,382	2.341	0.241	0.037	0.013	2.052	0.347	0.129	0.435
Incidences	2,282	0.97	0.783	0.95	0.569	1.37	0.992	1.096	2.094
Lastpoach	2.282	0.493	0.325	0.197	0.135	0.690	0.436	0.382	0.218

Source: survey data May 2017 – June 2018

Table 5: Statistics for the full sample and truncated sample

	Full sample	**Truncated sample**
Observations	2,282	1721
Mean	1.096	1.745
Standard deviation	2.094	2.428

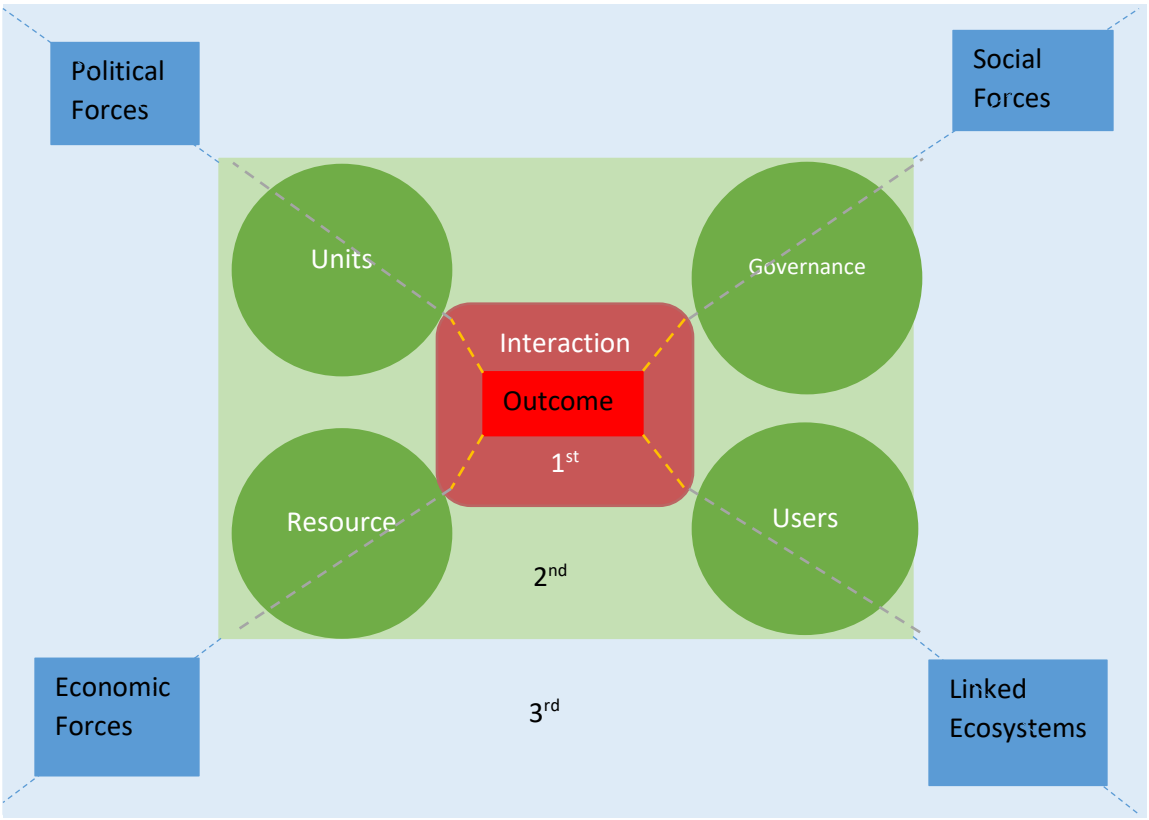
Source: survey data May 2017 – June 2018

Table 6: Regression Analysis

Variables	Tobit model *1st Stage Probit Model*	*2nd Stage Trancated Model*	*Dy/Dx*	Logit Model (0=C , 1=P)
Education	0.0371	0.475	0.003	0.054
	(0.014)	(0.102)	(0.002)	(0.085)
Gender [0=female, 1=male]	0.273*	0.366**	0.321**	0.977
	(0.094)	(2.532)	(0.060)	(0.639)
Age	-0.003	-0.171	-0.012	-0.011*
	(0.004)	(0.318)	(0.007)	(0.057)
Employment [0=no, 1=yes]	0.117	-0.123	-0.836	0.236
	(0.114)	(3.397)	(0.070)	(0.177)
Livestock	0.046	1.955	0.067	0.236
	(0.024)	(1.425)	(0.029)	(0.684)
Kruger national park	-0.385**	-0.351***	-1.193**	-0.490***
	(0.128)	(2.293)	(0.250)	(0. 292)
Gonarezhou National Park	-0.253*	-0.753***	-0.448***	-0.129**
	(0.102)	(1.438)	(0.538)	(0.001)
Shocks	0.017	-1.156	-1.516	0.053**
	(0.008)	(0.251)	(0.126)	(0.170)
Expertise	0.140	-1.798	-0.741	0.186***
	(0.023)	(0.570)	(1.413)	(0.574)
Plenty of wildlife [0=no, 1=yes]	-0.363**	-1.120***	-1.461**	-0.719***
	(0.102)	(0.489)	(0.249)	(0.142)
Group size	0.021*	0.417**	0.154**	0.059
	(0.018)	(0.174)	(0.046)	(0.276)
Institutions	-0.773***	-1.255***	-1.782**	-0.874***
	(0.366)	(2.242)	(5.044)	(0.348)
Trust	-1.694***	-0.392***	-0.992***	-0.879**
	(0.420)	(0.050)	(2.471)	(0.500)
Benefits [0=no, 1=yes]	-0.684*	-0.328***	-0.160**	-0.528***
	(0.230)	(0.176)	(0.137)	(0.376)
Conflict	0.575**	0.439***	1.431***	0.437***
	(0.341)	(0.287)	(1.528)	(0.487)
Perception	-1.409**	-1.731***	-0.974**	-0.531***
	(0.406)	(0.528)	(0.370)	(0.528)
Cons	0.878*	-5.308***	-1,212	0.042**
	(0.232)	(1.168)	1.53	(0.697)
Sigma		1.368***		
		(0.927)		
Obs	2282	1721	1721	2282
LR Chi2 / Wald Chi2	166.37	191.53		181.42
Prob > Chi2	0.000	0.000		0.000
Pseudo R2	0.167	0.1853		0.096

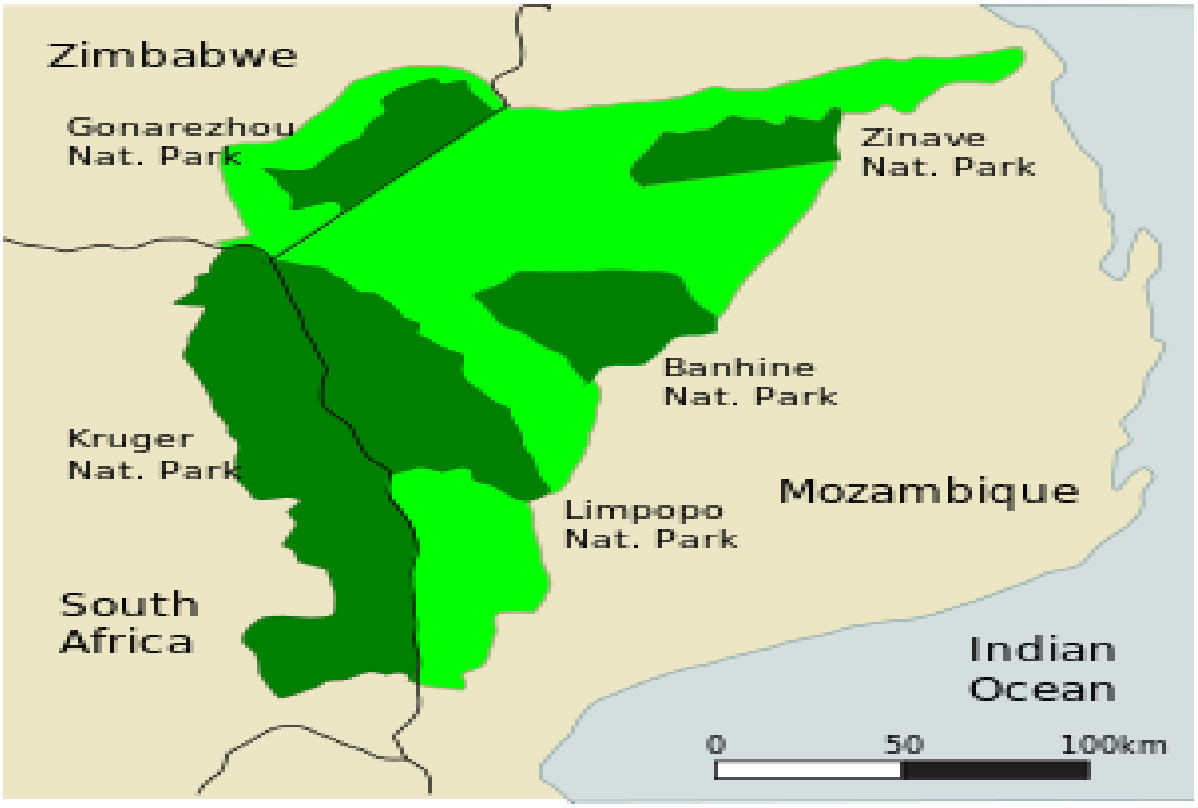
Source: survey data May 2017 – June 2018
*Significant at 10%, **significant at 5%, ***significant at 1%.
NB: The standard errors are shown in bracket

Figure 1: Framework for analysing social-ecological systems



Source: Adapted from Ostrom (2007)

Figure 2: Map of the Great Limpopo Trans-frontier Conservation Area



Source: Wikipedia, 21 January 2018