HUMAN-WILDLIFE CONFLICT AND MOBILE PHONE USE AMONG MAASAI PASTORALISTS NEAR TARANGIRE NATIONAL PARK, NORTHERN TANZANIA

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Abstract

Mobile phones are transforming many aspects of rural areas in the developing world. Much of the early research on phones and related information and communication technologies (ICTs) in developing countries has focused on social networking and economic benefits in primarily urban or agricultural settings. Few studies, however, have examined the implications of mobile technologies on pastoralist livelihoods and biodiversity conservation. To build on this opportunity, this study examines the impact of mobile phone technology on four Maasai communities near Tarangire National Park in northern Tanzania. I asked the questions: (1) How do phones affect human-wildlife interactions?; and (2) What are the effects of mobile phone use on measures of human-wildlife conflict (HWC)? This research uses a mixed methods approach to address these two questions and test the hypothesis that mobile phone use reduces HWC. Qualitative group interviews revealed that households use phones to manage wildlife interactions in every aspect of their lives - especially when the interactions relate to pastoralism and crop-based agriculture. Maasai use mobile phones as tools of information distribution to mitigate and reduce the severity of effects of HWC. Multivariate analyses of survey measures of phone use and exposure to conflict (i.e., crop and livestock predation and human attacks) offer mixed evidence that mobile phone use is correlated with a perception of less recent HWC events. These findings provide an indication that the expansion of mobile digital technologies may be able to support livelihoods and biodiversity simultaneously.

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Introduction

Human-wildlife conflict (HWC) is an important threat to biodiversity conservation and economic development around the world, but especially so in rural areas throughout many developing countries (Dickman, 2010; Woodroffe et al., 2005). As modern development and human populations expand into wild areas they can cause biologically diverse areas to become degraded, destroyed, or fragmented (Lamarque et al., 2009). This human expansion can exacerbate competition between humans and wildlife for space and other resources. In addition, wildlife can undermine human livelihoods and pose severe risks for human health. These risks, which are disproportionately borne by those living nearest to wildlife, can contribute to tensions with, and retaliation against, wildlife. Ultimately, these types of tensions can further threaten conservation initiatives (Nyhus et al., 2005).

Alongside these growing trends in human expansion and HWC, developing populations across the world have gained access to mobile phones and other information and communication technologies (ICTs) in the past decade. In 2000 the United Nations established a Millennium Development Goal specifically aimed at increasing ICT access in developing countries. A decade later the UN continues to highlight the importance of ICTs in improving well-being across the world (United Nations, 2013). Now, globally, there are nearly 7 billion mobile phone subscriptions, 5.4 billion of which are in developing countries (ITU, 2014).

This expansion of mobile phone use into developing regions has been socially and economically transformative. Yet, as mobile phone infrastructure moves further into rural spaces questions are raised about the broader implications for increased phone use in these areas. As a type of ICT, mobile phones are a way of transferring information across large distances in a short amount of time – thereby reducing the time and distance barriers to information exchange. In this way they have the potential to broadly affect human livelihoods and well-being and shape human-environment interactions. Although some ICTs have been promoted for conservation initiatives (Banks and Burge, 2004) the implications of ICT use for shaping or influencing human-environment interactions, namely, human-wildlife conflict, is largely under-researched.

Conceptual Framework

In this section I present a conceptual framework that views: (1) barriers to information exchange as potential drivers of HWC; and (2) mobile phones as tools to reduce barriers to information exchange. First, this framework will address rural livelihoods, and then will move on to conceptualizing how barriers of information exchange relate to both HWC and mobile phones.

To organize the thinking about the context in which HWC and mobile phones may be related, I adopt a rural livelihoods perspective. This approach, common for analyzing subsistence livelihoods in the developing world, views livelihoods as household’s access to or possession of capital and activities which are required for a particular means of living (Ellis, 2000). For example, in the context of subsistence pastoralism and agro-pastoralism capital may include: land, livestock, seeds, water, tractors, social networks, and loans. Livelihoods are shaped to manage these capital inputs and activities while promoting human well-being and reducing risk and uncertainty.

A major source of risk and uncertainty for some subsistence livelihoods can be human-wildlife interactions and conflict. Broadly, HWC includes events that promote risk and uncertainty where: (1) wildlife activities result in human losses (to life or property); and (2) human activities result in wildlife losses (to life or habitat). This study focuses on the former situation. While the type of HWC events that lead to wildlife losses may also be affected by the increased access to information that ICTs promote, the framework of this study is built on the ways in which human outcomes associated with HWC are affected by ICT use.

Generally, research on human outcomes has focused on strategies such as erecting fencing, stationing guards, engaging in retaliation (e.g. poisoning, hunting), and other techniques to mitigate or avoid encounters with wildlife (Treves, 2007; Kaswamila et al., 2007). These usually address the typical causes of HWC like the inability to predict when and where wildlife will attack – a problem of information. Fewer studies have focused on the role of information itself in exacerbating or reducing HWC. However, Madden (2004) identified improving communication and information exchange as an important gap when addressing HWC mitigation. Although Madden's suggestions were mostly in reference to improving relationships between local people and conservation interests, they identify the critical role of information barriers in promoting HWC.

In rural areas of the developing world where HWC is prevalent, new mobile technologies are creating novel opportunities to manage livelihoods, spread information, manage risk, and reduce uncertainty. Ellis suggested that infrastructure expansion may support livelihoods by reducing risk and uncertainty (Ellis, 1999). A primary mechanism in this process is reducing barriers to communication. Mobile phones are tools to reduce such barriers to information exchange, particularly in rural areas with poor access to infrastructure. Coupled with the idea that a cause of HWC is poor access to information, mobile phones could be an important tool to mitigating HWC. However, while research on mobile phones in rural areas has focused on economic and social aspects of mobile phone use (Aker and Mbiti, 2010; Myhr and Nordstrøm, 2006; Furuholt and Matotay, 2011) it has left the relationship between mobile phones and HWC largely unaddressed.

To address this gap in knowledge about the effects of mobile phone use on HWC, this study investigated two research questions:

RQ1: How do people use mobile phones to manage human-wildlife interactions?

RQ2: What are the effects of mobile phone use on measures of human-wildlife conflict?

To answer these questions, I used a mixed methods approach. Qualitative interviews (described below) served three functions: (1) provide evidence to address RQ1; (2) inform the design of a household survey instrument; and (3) generate hypotheses for RQ2. Correspondingly, the following hypotheses are justified by qualitative interviews with community members, which revealed that mobile phones were being used in multiple ways to talk about wildlife, and wildlife related problems. I tested three hypotheses:

H1. Phones reduce the incidence of HWC events. By exchanging information about dangerous wildlife (e.g., locations, movements, etc.) households are able to avoid wildlife and reduce conflict.

H2. Phones reduce the consequences of HWC events. By exchanging information about conflict events, households are able to mitigate the effects of conflict.

H3. Phones increase HWC. By supporting economic development and/or making households more aware of existing conflict, phones may increase actual and/or perceived HWC.

Literature Review

In this section I begin with a review of two main fields of scholarship in the developing world: human-wildlife conflict in rural communities and mobile phone use. Then, I discuss the current research on the study population before moving into the methods section.

Human – Wildlife Conflict in Rural Communities

Humans and wildlife coexist and interact in a variety of ways across the world. While conflict is not always a byproduct of human wildlife interaction, HWC can be found in many contexts - it manifests differently across species and regions and varies in frequency and severity (Fascione et al., 2004; Madden, 2004; Verdade et al., 2014). Despite these differences, some general relationships are evident. Perhaps most importantly, when conflict directly affects human livelihoods it can pose important challenges to biodiversity conservation (Verdade et al., 2014; Manfredo and Dayer, 2004; Woodroffe et al., 2005).

Research on HWC has focused mainly on examining causes and effects of conflict events (Woodroffe et al., 2005; Manfredo and Dayer, 2004), estimating direct damage to livelihoods (Mwakatobe et al., 2014; Naughton-Treves, 1998), establishing mitigation strategies (Hazzah, 2006), and judging the efficacy of conservation strategies (Nyhus et al., 2005; Treves et al., 2006). This paper relates most directly to research that examines the causes of and responses to, HWC, which are often complex and interrelated. Furthermore, I focus on research involving HWC and rural livelihoods in the developing world broadly, with the greatest emphasis on East Africa.

HWC can be classified in two main ways: direct damage caused by wildlife and pre-existing human social values (Dickman, 2010). Broadly, direct damage from wildlife can include livestock depredation, crop destruction, disease transmission, vehicle collisions, and human death and injury (Dickman, 2010; Lamarque et al., 2009; Woodroffe et al., 2005). In East Africa, where subsistence pastoralism and agro-pastoralism are common, research on direct damage to human livelihoods focuses on rates of crop-raiding, livestock depredation, and human attacks as main sources of HWC (Lamarque et al., 2009; Treves et al., 2006). Typical East African crop raiding species include zebra (*Equus burchellii*), eland (*Taurotragus oryx*), olive baboons (*Papio cynocephalus*), bush pigs (*Potamochoerus larvatus*), vervet monkeys (various sp.), and elephants (*Loxodonta africana*) (Kaswamila et al., 2007; Naughton-Treves, 1998; Lynn, 2010). Large megafauna like elephant and buffalo (*Syncerus caffer*) are also capable of destroying wells and water sources and attacking humans (Lynn, 2010). Some studies have estimated crop-raiding by wildlife to be as little as 1.3% of household income (Kaswamila et al., 2007) to as much as 16% to 20% of household income (Mwakatobe et al., 2014; Mc Guinness and Taylor, 2014).

Similarly, studies of pastoralists in East Africa suggest that carnivores depredate between 1% and 4.5% of livestock annually (Holmern et al., 2007; Kolowski and Holekamp, 2006; Patterson et al., 2004; Kissui, 2008). These losses can equate to financial losses of almost 20% of pastoral household income (Holmern et al., 2007) and are largely attributable to spotted hyena (*Crocuta crocuta*). Lions (*Panthera leo*) and leopards (*Panthera pardus*) are also common predators of livestock. Additionally, venomous snakes, such as the highly poisonous black mamba (*Dendroaspis polylepis*) and various viper species (Genus *Bitis)* are native to the region, with some species capable of maiming or killing even large stock like cattle. Furthermore, many of the same species that attack livestock can also threaten human life and safety.

However, even when direct conflict is minimal or nonexistent social and cultural factors can strongly influence HWC. Some of these factors may include religious affiliation, ethnicity, cultural beliefs, and community interactions with the government, which can all shape how humans value wildlife (Dickman, 2010). These values then can shape how humans or communities interact with wildlife and respond to HWC. For example, a study in Kenya found that pastoralists who had converted to Christianity were more likely to engage in retaliatory killing of lions than those who had traditional beliefs (Hazzah, 2006). Social relationships with other humans also shape HWC. Studies in Tanzania have suggested that there is local resentment toward the government regarding wildlife protection measures, which then manifests as resentment toward the wildlife itself. This resentment is mainly in places where communities have been removed from their land and banned from using resources in national parks (Madden, 2004; Goldman, 2003). Often locally or culturally specific, these types of social factors contribute to influencing the overall context of HWC.

A variety of other contextual factors, particularly those relating to the environment, contribute to the incidence of HWC. Environmental factors of conflict are especially affected by human behavior (Dickman, 2010; Okello, 2005). Some of these factors include geographic phenomena such as human land use changes and edge effects. Research in East Africa shows that changes in land use, particularly from grazing lands to agricultural lands, can increase incidences of HWC (Okello, 2005; Ottichilo et al., 2001). Additional studies both in East Africa and across the developing world found that communities bordering protected areas, forest edges and other wildlife habitat areas are at higher risk in scale and frequency for experiencing direct damage from wildlife (Mwakatobe et al., 2014; Linkie et al., 2007; Soto-Shoender and Giuliano, 2011). Coupled together, these environmental factors and social factors can prompt various human responses.

Responses to HWC

Humans can respond to wildlife conflict in different ways when they feel like their livelihoods are threatened. Two main ways humans may respond to HWC are through retaliation and mitigation. Retaliation often occurs against wildlife that cause direct or perceived damage to human life or property, but can also be influenced by social values (Dickman, 2010). Killing a carnivore that has predated upon livestock is a common example of retaliation due to direct damage. However, killing a carnivore can be motivated both by the direct damage it has caused a livelihood and by other cultural values. This cause and effect relationship can be difficult to deconstruct and is not the focus of this thesis. Another available response to HWC is to try to mitigate conflict. In Africa, where crop-raiding is the most common type of HWC, human guards are often posted in fields to deter attacks from a wide variety of wildlife including antelope, primates, rodents, elephants, and birds (Lamarque et al., 2009; Sitati et al., 2005). Similarly, pastoralists have used strategies such as posting guard dogs, fencing homesteads, and using repellents to deter carnivores from attacking (Goldman et al., 2010; Kissui, 2008; Holmern et al., 2007). These human responses can inform how organizations interested in biodiversity conservation develop local strategies to address HWC.

Some conservation organizations are working toward reducing retaliation and increasing mitigation strategies. Studies researching the efficacy of these strategies, which range from economic compensation for wildlife damage to promotion of better livestock husbandry and farm management (Wunder, 2007; Packer et al., 2013; Treves et al., 2006) have found mixed results. For example, some conservation programs have used sophisticated monitoring and reporting to compensate herders for livestock loss due to predators (Treves, Wallace & Naughton-Treves 2006; Nyhus, Osofsky, Ferraro, Madden and Fischer 2006). Other programs target endemic social and cultural attitudes. In East Africa for example, programs have directly targeted cultural norms to reduce lion killing (Hazzah, 2006). Finding novel approaches to improve HWC mitigation is important considering that schemes to reduce direct wildlife damage alone are rarely successful (Dickman, 2010).

ICTs in the Developing World

One novel approach to mitigating HWC may relate to the rise in access to ICTs, particularly mobile phones, across the world. In Africa mobile phone subscriptions have doubled since 2009 to an estimated 629 million subscriptions in 2014 (ITU, 2014). In the context of East Africa, Mtenzi et al. (2008) attributed this growth to the adaptation of mobile services to meet low-income subscribers' needs. These adaptations include the relative affordability of maintenance of mobile phones as well as the growth in value-added services available to subscribers, such as voicemail, caller number display, short messaging service (SMS) and wireless application protocol services that introduced basic mobile banking and internet usage (Mtenzi et al., 2008).

Research on ICTs in the developing world has focused on exploring the broad economic and social effects of expanding mobile phone use, but less on the effects of mobile phone use on human-environment and human-wildlife interactions. To build towards a greater integration of HWC and ICT research, I discuss the literature on the social and economic effects of phones in the developing world, along with recent efforts to incorporate environmental factors into this field of research.

Martin and Abbott (2011) have argued convincingly that mobile phones contribute to economic and social aspects of livelihoods in three main ways: (1) gathering information, (2) coordinating activities, and (3) networking (Martin and Abbott, 2011). Regarding economics, communications development can support market improvement, information expediency, and resource mobilization (Ellis, 1999). ICT adoption in the developing world has shown broad impacts in lowering user vulnerability to risks in markets (Myhr and Nordstrøm, 2006; Aker and Mbiti, 2010) and increasing overall market efficiency (Aker and Mbiti, 2010; Abraham, 2006). Examples of these types of efficiencies include bypassing brokers by being able to check market prices independently (i.e. gathering information) (Aker and Mbiti, 2010) and buying and selling goods and services directly (i.e. coordinating activities) (Aker and Mbiti, 2010). Mobile phones can also encourage economic equality by providing increased access to financial services, such as banking (i.e. networking) to rural users who previously had no access to banking services such as loans (Aker and Mbiti, 2010).

Research has found that these economic effects and efficiencies are consistent across various types of livelihoods. Fishermen use mobile phones to check markets and to get the best price for their catch (Myhr and Nordstrøm, 2006; Salia et al., 2011). In agricultural livelihoods, rural farmers benefit year-round from mobile phone access (Martin and Abbott, 2011; Furuholt and Matotay, 2011). In addition to using phones to manage labor, coordinate buying and selling of seeds and crops, gather information about new seeds and pesticides, and many other agricultural endeavors, farmers also use phones to maintain their social networks (Furuholt and Matotay, 2011; Souter et al., 2005). Similar results have also been found with herders, who use the phone to share information about livestock health, forage, water location, and nearby predators (Butt, 2014).

Socially, mobile phones have encouraged interactions within and across social networks (Souter et al., 2005; Sife et al., 2010) and increased information exchange during time-sensitive events (Souter et al., 2005; Sife et al., 2010; Hellström and Tröften, 2010). In 2004 a survey among rural Tanzanians indicated that mobile phones were the primary way of accessing information during urgent or emergency situations such as livestock illnesses (Souter et al., 2005).

In light of the rapid expansion of mobile handsets and suspected broad benefits, many studies have focused on the economic effects of mobile phone technology and other ICTs. However, these studies were conducted primarily in urban or agricultural settings (Furuholt and Matotay, 2011; Martin and Abbott, 2011; Jensen, 2007) rather than in pastoral or agro-pastoral contexts, though exceptions exist (Butt, 2014). Mobile phones are known to broadly affect society, the economy and thus, as Feldman and Zerdick (2005) suggest, ecology – however less is known about the ecological implications of mobile technologies on livelihoods as they relate to human-wildlife interactions and biodiversity conservation (Martin and Abbott, 2011).

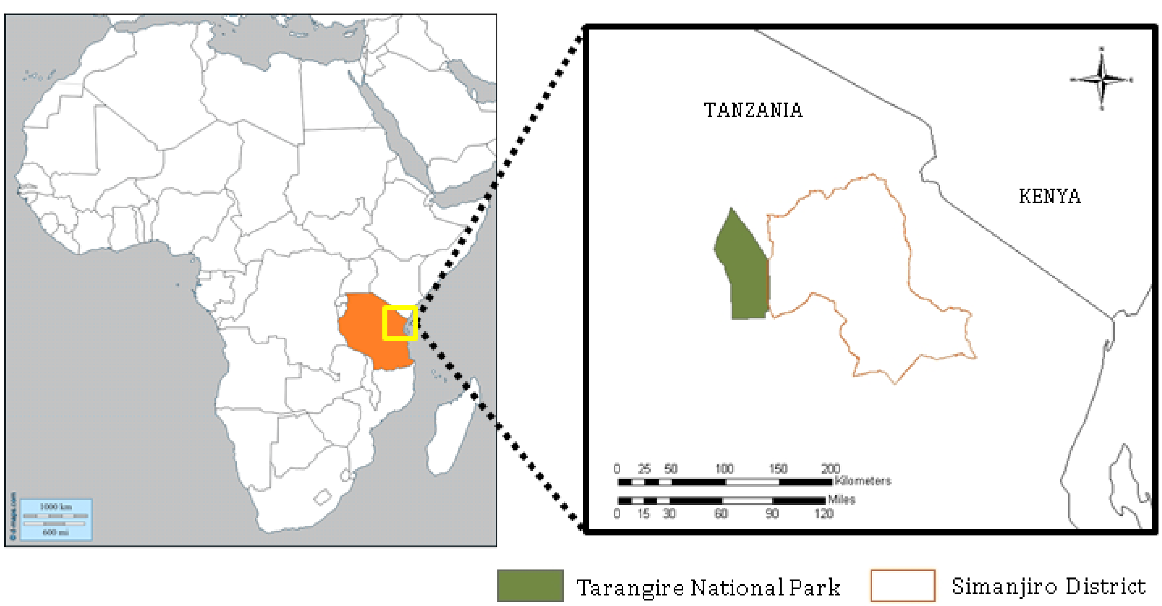
One study in particular examined the effect of mobile phones on HWC. Graham et al. (2012) suggested that mobile phones may reduce human-elephant conflict in East Africa. The mechanism to reduce conflict was through improved communication, which allowed community members to engage in preventative measures through early warnings, and also for coordination of response to specific incidences of HWC (2012). However, their study focused on communication of community members with local authorities, rather than *in situ* communication between communities and across social networks. Thus, one goal of my research was to take advantage of the opportunity to investigate the ways in which communities use mobile phones to discuss HWC among themselves.

Study Area

Tanzania's Simanjiro District is well-suited to study the effects of mobile phone use on HWC. Simanjiro District is representative of East Africa's Maasailand, where Maasai communities have documented examples of HWC (Kissui, 2008; Lynn, 2010) as well as a high level of mobile phone adoption (Baird, 2012).

Simanjiro District is located within the Tarangire-Manyara ecosystem in northern Tanzania (Figure 1). Geographically, this region connects a wider network of protected areas that extends from Serengeti National Park in the west to Kilimanjaro and Mkomazi National Parks in the east. A central component in this region is Tarangire National Park (TNP) which adjoins the western boundary of Simanjiro District. However, TNP protects only 15% of the larger Tarangire ecosystem, which stretches into human communities in Simanjiro District.

Figure 1. Map of study area - northern Tanzania

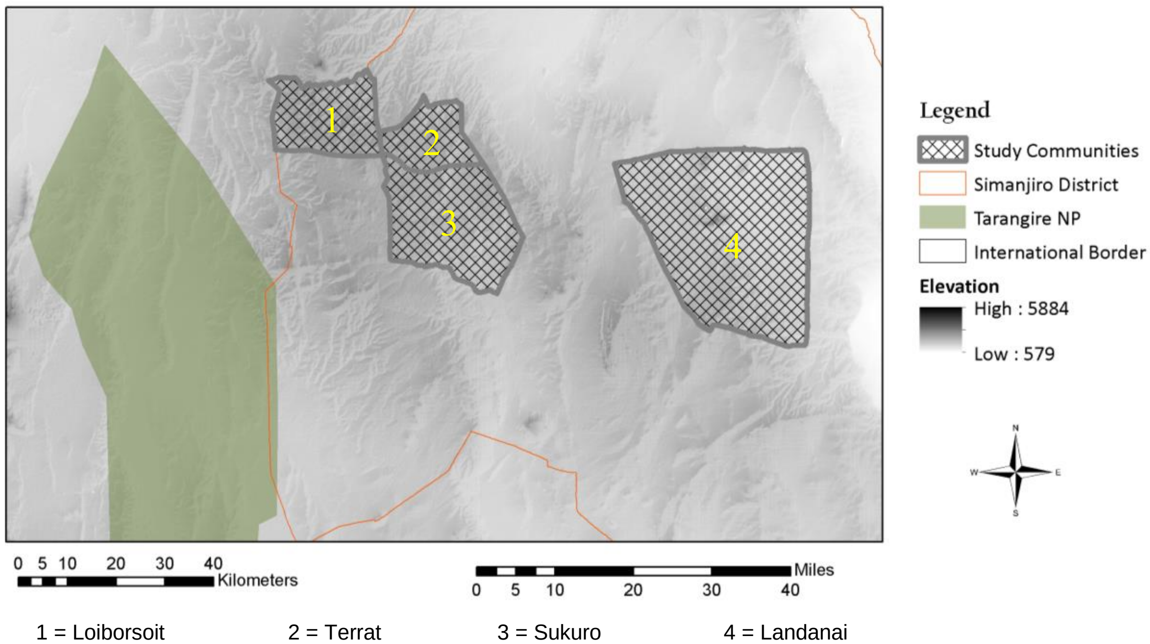


Ecologically, this region includes one of the most diverse grasslands on the planet (Olson and Dinerstein, 1998). The Tarangire-Manyara ecosystem supports large populations of herbivores, including the second largest migration of blue wildebeest (*Connochaetes taurinus*) in East Africa, many of which calve in the Simanjiro Plains to the east of TNP (Msoffe et al., 2010). This ecosystem also supports the largest population of African elephants in northern Tanzania. Carnivores in the region include African lions, leopards, spotted hyena and African wild dogs (*Lycaon pictus*). Wildlife congregate within TNP during the dry seasons and disperse widely outside of park boundaries during the wet season months, November through May (Kahurananga and Silkiluwasha, 1997; Msoffe et al., 2010). However, there are also resident populations of carnivores and herbivores across the entire ecosystem which makes HWC a year-round issue for local communities.

Communities within Simanjiro are overwhelmingly Maasai; an ethnic group which inhabits southern Kenya and northern Tanzania. Four Maasai communities in Simanjiro are included in the study (see Figure 2). These villages were stratified by proximity to TNP – three villages (Loiborsoit, Sukuro and Terrat) were near (10-50km) but not next to TNP, and one village (Landanai) was relatively far (>70km) from TNP. Simanjiro itself includes many Maasai villages, which are further divided into sub-villages, then *bomas*, and then individual households. A *boma* in this region usually consists of a fenced area that includes several households and may also have an inner fencing to contain livestock at night.

Socially, these Maasai households consist of an adult male, his wife or wives, and any of their children. Maasai communities are organized strictly by sex determined cohorts, known as age-sets. These age-sets dictate when in life males are expected to go through major ceremonies, including becoming warriors, marrying, and becoming elders.

Figure 2. Study communities in Simanjiro District



Traditionally pastoralists, Maasai keep domesticated stock including cattle, sheep, goats, and donkeys. Wealth and status within the community are still commonly measured by how many cattle the household head owns (Homewood et al., 2009; Grandin, 1988). Within the past 50 years, however, Maasai have been adopting additional land-use strategies, notably small and large-scale cultivation (Homewood et al., 2009; McCabe et al., 2010; Baird and Leslie, 2013). Although this expansion into agriculture was largely in response to new social and cultural expectations, as well as for mitigating economic risks at a household level, (McCabe et al., 2010; Homewood et al., 2009; Baird et al., 2009) it also created opportunities for new tensions with wildlife to develop (Okello, 2005).

The combination of farming and pastoral livelihoods in the study site introduces opportunities for a variety of HWC and Maasai use various mitigation strategies to counter

HWC. Maasai *bomas* are traditionally built with acacia fences to keep predators away from livestock. In Simanjiro, *bomas* are still constructed mostly with acacia, however in nearby regions conservation organizations are integrating modern chain-link fencing and lighting schemes that reduce or prevent predator attacks (Holmern et al., 2007). Maasai send herders with grazing livestock and may keep guard dogs with them and at the *boma* (Kissui, 2008). Maasai who engage in agriculture will also set guards to watch over their crop fields to make noise, start fires, and drive away wildlife (Sitati et al., 2005).

Like much of the rest of sub-Saharan Africa, Tanzanian infrastructure lacks in reliability and accessibility (Souter et al., 2005). Communities in Simanjiro do not have access to the national power grid or to the national fixed line telephone system. Prior to the increase in development aid through churches and government agencies, water access, health clinics and schools in the communities near TNP were also nonexistent or unreliable (Baird, 2014). However, since 2005 communities in Simanjiro have had access to mobile phone networks (Sachedina and Trench, 2009) at a time when mobile phone ownership was expanding rapidly (Souter et al., 2005). Between 2003 and 2013 Tanzanian mobile phone subscriptions grew from just over 1 million to almost 28 million (ITU, 2014). By 2010 more than 40% of households across the four communities in this study had mobile phones (unpublished data).

Multiple companies that offer mobile phone service exist, but the most widespread companies in northern Tanzania are Vodacom and Airtel/Zantel. SIM cards are free to acquire but must be registered to a user. Mobile phone users can charge the SIM card money through purchasing vouchers, which can be loaded onto the SIM card to use toward paying to make calls and send text messages.

Despite widespread local use and use throughout Maasailand, specific details about how mobile phones are used in this region are sparse. In similar ecosystems in Southern Kenya, Maasai use mobile phones in many information-sharing aspects of herding, including location of predators, forage, water, and lost livestock (Butt, 2014). Previous research in northern Tanzania anecdotally indicates that Maasai have used SMS to communicate with researchers about wildlife movement (Goldman, 2007). Furthermore, rural farmers on the west side of TNP use mobile phones in all stages of farming to create opportunity and decrease risk by communicating about labor and equipment, checking prices, transferring money, and coordinating other daily and yearly activities (Furuholt and Matotay, 2011). The effect of ICT and mobile phone use on biodiversity and human-wildlife interactions specifically is under-examined.

Methods

Multiple methods of data collection and analysis were used to address each research question. The main methodological approaches used here were semi-structured group interviews and a structured survey of households. Data were collected in 2014 by a team of researchers led by Dr. Timothy Baird, and research protocols were approved by Virginia Tech's IRB (#13-524) prior to collecting data. In this section, I will first explain our use of qualitative methods and then follow with a description of the structured household survey.

Qualitative Data Collection

To identify how Maasai use mobile phones to manage human-wildlife interactions (RQ1), we conducted qualitative, semi-structured group interviews (n=12) with community leaders and community members in three of the four study communities spanning nine different sub-villages in Simanjiro District. These sub-villages were chosen based on their participation in an ongoing study in the study area (see Quantitative Data Collection) as well as the availability of households for interviews. These group interviews, conducted between June and August 2014, also informed the creation of a structured survey.

This interview method allowed for open discussion about individual mobile phone use as well as participants' perceptions of broader household and community mobile phone use. Male community members and leaders were selected to participate based on their knowledge and willingness to discuss mobile phones. Generally, interviews allowed for open discussion about how people use mobile phones and what types of problems wildlife pose to Maasai livelihoods (RQ1). More specifically we asked about wildlife problems in each community, such as recent attacks and responses to those attacks. We also asked about communication of sightings or evidence of dangerous wildlife nearby, and spatial variation in mobile phone coverage between the communities. All group interviews were conducted in Maa, the language of the Maasai, and Swahili, the national language of Tanzania, with the help of 1 or 2 Maasai assistants/translators.

Quantitative Data Collection

To measure the effect of mobile phone use on human-wildlife conflict we conducted a structured survey of household heads (n=153) in four ethnically Maasai communities. Data were collected on issues including: metrics of mobile phone use; incidence of HWC events; mobile phone use regarding HWC; and basic household (HH) demographic and economic variables (RQ2). Specific metrics of mobile phone use were limited to the household head (HHH) and included the perception of mobile phone signal and the amount of money spent on vouchers. Trained Maasai enumerators conducted this survey with household heads between August and December 2014. Households were already part of an ongoing land-use study in the region and were originally selected in a best effort to draw on a representative sample (Baird and Gray, 2014). Quota sampling (Bernard, 2011) was employed to draw on households from a variety of geographic and demographic categories including sub-villages, age-sets and wealth statuses in the study area.

Data Analyses

My analysis of the relationships between mobile phone use and HWC proceeded in two stages. In the first stage I used content analysis to describe how respondents are using mobile phones to communicate about wildlife (RQ1). In the second set of analyses I use regression models to estimate how measures of mobile phone use are associated with measures of HWC (RQ2). Specific measures are described below.

Qualitative: Descriptions of Phone Use

To examine how humans are using mobile phones in the study area I analyzed all 12 group interviews using qualitative analytical software (Dedoose). Codes were developed through content analysis, which allowed me to examine and sort the content of the interviews using common themes in the existing literature on HWC (Bernard, 2011). I identified three categories of wildlife conflict within the interviews: attacks on humans, attacks on livestock, and attacks on farms. These three categories are some of the most emphasized and previously studied examples of HWC (Dickman, 2010; Lamarque et al., 2009; Woodroffe et al., 2005; Lynn, 2010). Additionally, taking into consideration the increase of cultivation in Maasai communities, these categories are all relevant to Maasai livelihoods. Beyond these three themes, coding focused on identifying conditions under which mobile phones are used to communicate about conflict events and the details of the information being conveyed (RQ1).

Quantitative: Statistical Modeling

To examine the association between mobile phone use and HWC (RQ2) I constructed four regression models. Each separate model was framed to test the three hypotheses provided earlier. The descriptions of variables used in the regression analysis are summarized in Table 1 along with some basic descriptive statistics.

To construct the dependent variable for the model, each survey respondent was asked to list the three most dangerous wildlife species for humans, livestock and farms and then to list the most recent time the respondent's *boma* had experienced an attack from each species in each category (Appendix C). The identified animals represent the respondent's perceptions and, as would be expected, varied across respondents. Similarly, the time identified since the most recent attack represents the respondent's recollection of the most recent attack, and may not necessarily be an accurate representation of reality. The dependent variable in each model, the reported recency[1] of HWC, was determined using these responses. For Model 1, I calculated the mean recency of the respondent's reports across all attack categories (human, livestock and farm attacks). For the remaining models I used the mean of recent attack values reported for human attacks (Model 2), livestock attacks (Model 3), and farm attacks (Model 4) separately.

Based on the distribution of the responses and the possibility of recall bias I categorized the means in order to make a categorical dependent variable. For Models 1 and 3, the dependent variable was separated into three categories and an ordinal logit was used to test the relationship between mobile phone use and perceived recency of HWC. However, for Models 2 and 4, only two categories were created and thus a logistic regression was used. The description of these categories is provided in the footnotes to Table 1. This binary categorization is due to human

[1] Throughout this thesis I use "recency" when referring to reported time since the most recent attack.

attacks being relatively uncommon and farm attacks being relatively common, which caused variance issues when trying to use three categories in the models.

In each model, measures of mobile phone use represent the key explanatory variables. Several measures were investigated, including number of SMS sent and received in the 24 hours prior to the survey, number of phone calls made and received in the 24 hours prior to the survey, mobile phone network signal quality, whether or not a respondent used a mobile phone to communicate about an attack, and money spent on phone vouchers in the 7 days prior to the survey. Ultimately, only mobile signal quality, whether or not a respondent used a mobile phone to communicate about an attack, the percentage of times a respondent used the phone to communicate evidence or sightings of wildlife, and money spent on phone vouchers were included in the final models. These variables were chosen based on group-interview responses and existing literature on measuring mobile phone use.

To isolate the effect of phone use on HWC from the effects of other factors that may contribute to HWC, each model included several independent variables, which included measures of proximity to wildlife and household demographics. Since proximity to wildlife habitat and protected areas is a predictor of risk of exposure to human-wildlife conflict (Mwakatobe et al., 2014; Nyhus et al., 2005) I used proximity to TNP as a proxy for proximity to wildlife. The regression models also used key demographic data collected during the survey, such as household size, wealth, income generation, and household head age and education.

Table 1. Description of variables used in regression analyses

Variable	Description	Sample Mean (n=147)	Money spent on vouchers in the 7 days prior to survey (USD): Low (0-$1.51)	Money spent on vouchers in the 7 days prior to survey (USD): High ($1.51+)	Low vs. High Phone Use
HWC measures					
All attacks	Categorical measure of the mean recency of all reported attacks on the HHH's boma[2]	24.8	22.1	28	**
Attacks on humans	Categorical measure of the mean recency of attacks on human residents belonging to the HHH's boma[3]	69.5	71.1	75.8	
Attacks on livestock	Categorical measure of the mean recency of attacks on livestock of the HHH's boma[4]	21.2	19.4	23.3	
Attacks on farm	Categorical measure of the mean recency of attacks on farms belonging to the HHH's boma[5]	9.1	6.6	12	
Mobile phone use measures					
Signal Quality (0/1)	Dichotomous measure of the respondent's perception of mobile phone signal quality in his subvillage[6]	0.69	0.66	0.73	
HWC reported by phone (0/1)	Dichotomous measure of whether a respondent reported using a phone to communicate about a wildlife attack	0.44	0.43	0.45	
Wildlife reported by phone (%)	Percentage of wildlife evidence or sightings that the respondent communicated using the phone	0.15	0.2	0.13	
Household head (HHH) controls					
Age	Categorical measure of age-set, which is a proxy for age. [7]	2.3	2.58	1.97	

[2] Categories (Model 1, Overall Attacks): 1= 0-12 months, 2= 12-24 months and 3=24+ months
[3] Categories (Model 2, Human Attacks): 0= 0-24 months, 1=24+ months
[4] Categories (Model 3, Livestock Attacks): 1= 0-12 months, 2= 12-24 months and 3=24+ months
[5] Categories (Model 4, Farm Attacks): 0 = 0-6 months, 1= 6+months
[6] Signal Quality Categories: 0=Very Bad, Bad or Average: 1=Good or Very Good
[7] Age-sets are: Korianga (24-38 yrs); Landis (39-53 yrs); Makaa (54-68 yrs); Seuri and older age-sets (over 68 yrs).

Household (HH) controls					
Total income (USD)	Total HH income (harvest, livestock, leasing, remittances, other work)	2953	2749	3196	
Herfindahl index	Measure of income concentration, or the inverse of diversification[8]	0.68	0.66	0.71	*
TLU	Tropical Livestock Units: a measure of livestock holdings that accounts for differences across species	59.7	53.3	67.3	*
Percent TLU Cattle	The percentage of TLU that are cattle (versus sheep, goats, etc.)[9]	0.61	0.59	0.64	
Household size	Total number of individuals residing in the household	11.3	11.6	11	
Proximity to TNP	The distance of the HH's sub-village from TNP (in km), which is a proxy for proximity to wildlife	43.0	43.6	42.3	

†p <0.10, *p <0.05, **p <0.01, ***p<0.001

[8] The Herfindahl index is calculated as the sum of the squared percentage of income per source of total household income. Sources of income include: livestock, agriculture, wage labor, business activities, and proceeds from leased land

[9] Tropical Livestock Units (TLUs) are defined here as: 1 adult zebu cow = 0.71; adult sheep/goat = 0.17 (Homewood et al., 2009)

To build income and wealth variables, prices of livestock and commodities for 2014 were inflated from prices obtained from previous in-depth surveys of study site respondents in 2010. I obtained inflation values from the Tanzania National Bureau of Statistics/World Bank average yearly non-food item inflation estimates. When appropriate, a conversion rate of $1 (USD) per 1660 TZS[10] was used to compare these results with other findings in the literature. I corroborated these inflated price estimates with 2014 price estimates from an informant in the study site.

Strengths and weaknesses of the approach

The methodological approach described above has several strengths. First, mixed methods data collection and analysis allowed me to combine detailed qualitative information about mobile phone use with quantitative data on the perceived recency of HWC and phone use. There is a conspicuous shortage of literature on ICT use that combines qualitative descriptions of causal mechanisms of mobile phone use with statistical modeling of incidence of HWC. Second, this study incorporated respondent perceptions of multiple wildlife species across several types of HWC to consider a broader range of HWC events. Many studies focus only on species that attack farms, or on species that threaten humans and depredate livestock – fewer studies examine HWC in a broader sense. Third, this study used several measures of mobile phone use and human wildlife conflict. By incorporating instances of phone use after attacks and for evidence or sightings of wildlife I was able to more broadly examine the type of information being exchanged about wildlife.

The central weaknesses of this approach are that the sample size was small, the sampling strategy was not random, and the cross-sectional design limited us to collecting data only during the dry season.

[10] This conversion rate was estimated based on the 2014 average USFOREX exchange rate - http://www.usforex.com/forex-tools/historical-rate-tools/yearly-average-rates

Though 153 respondents answered the surveys, only 114 could be fully included in all four models due to missing data for some of the variables. A larger sample size could provide more robust models. Also, although the sampling strategy was not random, mean measures of household wealth obtained in this sample during a 2010 study, (Baird, 2012) however, are similar to measures from large randomized studies of Maasai households in Tanzania (Homewood et al., 2009), suggesting that this sample may not necessarily be skewed with regard to wealth. Furthermore, we could only collect data during the dry season. Some wildlife have seasonal migrations that may affect some of the sub-villages more than others. A better approach may be to use a panel design to visit sub-villages at the end of the long rains and at the end of the dry season.

Findings

Descriptions of mobile phone use

Analysis of qualitative interviews (n = 12) on mobile phone use and human-wildlife interactions revealed several general themes (RQ1). The primary ways in which phones affect human-wildlife interactions fall into three categories that relate to information distribution. Mobile phones assist in distributing information that reduces: the incidence of wildlife conflict events (H1) and the consequences or severity of wildlife conflict events (H2). This distribution of information pertains to broad aspects of human safety, pastoral livelihoods and agricultural livelihoods.

(1) Reducing the incidence of wildlife conflict events

The primary ways in which mobile phones reduce the incidence of wildlife conflict events is through communicating sightings of wildlife or evidence of wildlife presence or passage on the landscape. Wildlife sightings involve a variety of species in the area including lion, leopard, elephant, baboon, and zebra. Although different wildlife species leave different types of evidence (i.e. “sign”, or “spoor”), respondents indicated they are aware of certain specific evidence of wildlife presence such as dung and tracks.

Both herders and household heads reported communicating with others about wildlife presence and movement. Though it is more typical that herders communicate amongst each other, household heads reported communicating with the herders of their livestock about sightings and tracks, as well as with other household heads.

The decision to communicate evidence or a sighting of wildlife by mobile phone varied based on multiple factors. Communication of sightings and sign varied based on wildlife species, familiarity of the herder with the local area, relative recency of sightings, relative freshness of sign, and the location of wildlife or direction of wildlife movement relative to people, livestock, or farms. For example if herders were less familiar with the area, they said they were more likely to communicate about potentially dangerous animals. The presence of individual wildlife that are local and known to herders (e.g. a local leopard that lived nearby) was not likely to be communicated. Also, sightings of predators or their sign were more likely to be communicated if there was a herder going in the same direction as the predator. The herder was made aware so they could either decide to go a different way and avoid the predator, or be more prepared and alert. Furthermore, the relative freshness of certain tracks or sign also determined the need to communicate about them. Older tracks or sign were less important to communicate whereas fresher tracks or sign were more important to communicate.

The species that are typically communicated about relate most directly to protecting human safety and agro-pastoral livelihoods. For example, species that were typically communicated about to preserve human safety include lions, buffalo, and elephants. Though attacks by these species are infrequent, they can be fatal. Species that were typically communicated to prevent livestock attacks include jackals, leopard, hyena, lion and snakes, whereas elephant, zebra, and baboon sightings are communicated to prevent farm attacks. Specific instances of conflict reported during the group interviews included jackals and leopard preying upon smaller stock including sheep and goats, and snakes and lions attacking cattle.

However, agreement on which species would typically be communicated about varied between interview groups. While most groups agreed that lion and leopard tracks or sightings would definitely be communicated, reports of jackal and hyena were not unanimously important to every interviewed group. One notable difference in the decision about whether to communicate sign was the commonality of the species. For example, if there was a leopard in the area that people were familiar with, they were less likely to report tracks or sign of leopards. Furthermore, there were many species that attack farms including baboons, vervet monkeys, eland, warthog, porcupine, zebra and even hyena. In this area these species are common and widespread, so it takes a sighting of the wildlife in the act of crop-raiding to communicate about the event rather than just a sighting of the animal anywhere. Respondents however, do communicate when they see elephant tracks. They said this is because elephants are uncommon, and they have destroyed fields in the study area, though this is an infrequent occurrence. In general, when mobile phones were used to communicate about farm attacks in real-time, household heads reported being able to drive away the wildlife to reduce the severity of a particular event.

(2) Reducing the consequences of wildlife conflict events

The primary ways in which mobile phones reduce the consequences of wildlife conflict events are through communicating real-time events efficiently and coordinating a response to these events.

Responses to events varied from driving away wildlife to delivering medicine and aid to livestock and herders.

With phones, herders are able to communicate directly with household heads and others after livestock are attacked. One specific example of this group interview respondents provided was a case where, following an attack in which lions killed several cattle, herders organized a response to scare away the lions and collect the meat and bring it back to the *boma*. While this had the direct effect of trying to get the lions out of the area, it also meant that the family that owned the cattle could eat the meat of the slaughtered cattle rather than the lions. Prior to having mobile phones to communicate, lions would have been more likely to eat the meat before herders could organize a response.

Herders also use the mobile phone to communicate the need for medical aid in the event of human or livestock injury or illness. Respondents communicated major concerns about venomous snakes in the region which are capable of killing or maiming humans as well as cattle and other livestock. Mobile phones have been used to communicate the need for care for people who have received life-threatening snake bites or other injuries. One village adjacent to TNP reported being able to access emergency care by calling an ambulance for any type of ill or injured person, and emergency care was cited in multiple interviews as a major positive benefit of mobile phones. The mobile phone is also a tool that has led to “big changes in saving livestock”. Phones allow for faster conveyance of information which can more quickly facilitate of veterinary care and medicine in the event of an illness or wildlife attack compared to the previous practice of using messengers.

Additionally, household heads communicate with laborers and other community members about the security of their farms. They use the phones to coordinate general activities with laborers such as setting guard rotations and checking on the health and status of their crops. Household heads also communicate with each other about crop-raiding animals. Interview participants indicated that if they see wildlife eating crops at someone's farm, they would call the farm owner to tell them. Farm owners could then alert the laborers or take action to organize a time to drive away the wildlife. Additionally, household heads could then organize community events to drive away particular crop-raiding species. For example one community used mobile phones to coordinate events to drive away baboons, which reduced the number of crop-raiding events until the baboons return. Mobile phones allow for details such as timing and meeting place to be communicated over lengthy distances without sending a messenger to each potential participant. The mobile phones contribute to increased awareness, communication and capacity to organize a response, which serve to reduce losses from crop predation.

Predictors of wildlife conflict incidence

The results of the regression analyses of the association between mobile phone use and wildlife conflict events (RQ2) are presented in four tables. Basic descriptive statistics of key variables are reported separately in Table 1.

In this sample 74% of household heads owned phones. Of those who owned phones 67% owned more than one SIM card. Of 98 household heads that reported which SIM card they used the most, 97 of them used either Airtel or Voda most frequently. An average phone owner spent about 3900 TZS ($2.35 USD) per week on vouchers and had owned his phone for between 6 and 7 years. More detailed descriptive statistics are provided in Table 1.

Survey respondents reported data on 976 HWC incidents. Respondents reported 24 unique wildlife species[11] that they believed to be most dangerous to humans, livestock, and farms. As reported in Table 2, the most commonly reported species responsible for both human attacks and livestock

[11] This number also includes several responses such as "antelope" and "snake" that would encompass multiple species.

attacks was lion, followed by the general category of "snake." The two most commonly cited species for farm attacks were zebra and bush pigs.

Reported recency of HWC incidents ranged from the day of the survey to 23 years prior to the survey. Reported sightings or evidence of reported species ranged from 10 minutes to 10 years prior to the survey. As shown in Table 1 and in Table 2 the mean times since the human attacks were greater than the mean times since both livestock and farm attacks across the entire sample. This indicates that attacks on humans are relatively less common than attacks on both livestock and on farms.

Table 2. Most reported wildlife species, by conflict type and mean attack recency

Human			**Livestock**			**Farms**		
Species	*n*	*recency (months)*	*species*	*N*	*recency (months)*	*species*	*n*	*recency (months)*
Lion	123	52	Lion	122	39	Zebra	79	6
Snake	119	96	Snake	111	21	Bush pig	76	6
Buffalo	90	54	Hyena	74	13	Warthog	68	7
Elephant	22	19	Leopard	26	18	Baboon	50	6
Hyena	21	13	Baboon	11	3	Porcupine	28	5

Recency is the average time since the last attack by that species across all respondents that reported an attack from that species.

The results of the regression models are displayed in four tables. Table 3 shows that for Model 1 (Overall Attacks) the pseudo $R^2 = 0.3029$ indicated a good fit, and the overall likelihood ratio ($\chi^2 = 55.52$, $p < 0.0001$) indicated that the overall model was significant. Table 4 shows that for Model 2 (Human Attacks) the pseudo $R^2 = 0.4673$ indicated a very good fit, and the overall likelihood ratio ($\chi^2 = 128.78$, $p < 0.0001$) indicated that the overall model was significant. Table 5 shows that for Model 3 (Livestock Attacks), the pseudo $R^2 = 0.0918$ indicated a weak fit, though the overall likelihood ratio ($\chi^2 = 72.13$, $p < 0.0001$) still indicated that the model was significant. Table 6 shows that for Model 4

(Farm Attacks) the pseudo R^2 = 0.1636 indicated a weak fit but the overall likelihood ratio (χ^2= 27.81, $p < 0.0035$) indicated that the overall model was significant.

To check that the assumptions statistical models were being met, I conducted several additional tests. First, to check the proportional odds assumption of the ordinal logit models (Models 1 and 3) I conducted Brant tests[12]. The Brant test results for Model 1 (χ^2 = 2.97, df = 11, p = 0.991) and Model 3 (χ^2 = 7.75, df = 11, p = 0.735) were insignificant, indicating in each case that the proportional odds assumption was met. Then, to check for errors related to multicollinearity in all models, I conducted collinearity diagnostic tests and compared the reported standard errors and odds ratios within each model in Stata 13. All tolerance levels were above 0.30, thus multicollinearity issues were not suspected.

Table 3. Model 1 – Ordinal Logit Model Fit Statistics, All Attacks

Variable	Coefficient	Odds Ratio	SE	Z
HWC reported by phone (0/1)	0.97	2.64	0.62	1.56
Voucher Money (USD)	0.01	1.01	0.00	1.84†
Signal Quality (0/1)	0.92	2.51	0.59	1.55
Wildlife reported by phone (%)	-3.39	0.03	1.13	-2.99*
Proximity to TNP	-1.80	0.94	0.02	-3.88***
Age 24-38	-1.80	0.17	0.67	-2.70**
HH Income (USD)	0.00	1.00	0.00	1.99*
HH Size	-0.02	0.98	0.02	-0.91
Herfindahl Indez	0.95	2.59	1.20	0.79
Percentage TLU Cattle	2.26	9.67	1.02	2.23*
TLU	-0.01	1.00	0.00	-3.54***

N = 114; Log Likelihood = − 83.076; Likelihood Ratio $\chi2$ = 55.52, $p < 0.0001$;
McFadden R^2 = 0.3029 †p <0.10, *p <0.05, **p <0.01, ***p<0.001

[12] A Brant test could not be run for Models 2 and 4 since Brant tests only apply to ordinal logit models.

Table 4. Model 2 – Logistic Regression Model Fit Statistics, Human Attacks

Variable	Coefficient	Odds Ratio	SE	Z
HWC reported by phone (0/1)		Not used in this model		
Voucher Money (USD)	-0.04	0.96	0.02	-2.49*
Signal Quality (0/1)	1.36	3.90	0.80	1.69†
Wildlife reported by phone (%)	-5.11	0.006	1.44	-3.53***
Proximity to TNP	-0.05	0.95	0.02	-3.07**
Age 24-38	-1.02	0.36	0.81	-1.27
HH Income (USD)	-0.00	1.00	0.00	-0.81
Herfindahl Indez	1.94	6.97	1.29	1.51
HH Size	-0.08	0.92	0.06	-1.39
Percentage TLU Cattle	-1.54	0.21	1.37	-1.12
TLU	0.02	1.02	0.01	1.89†

N = 114; Log Likelihood = − 33.242; Likelihood Ratio $\chi 2$ = 128.78, p < 0.0001; pseudo R^2 = 0.4673 †p <0.10, *p <0.05, **p <0.01, ***p<0.001

Table 5. Model 3 – Ordinal Logit Fit Statistics, Livestock Attacks

Variable	Coefficient	Odds Ratio	SE	Z
HWC reported by phone (0/1)	1.24	3.47	0.595	2.09*
Voucher Money (USD)	0.000	1.00	0.005	-0.18
Signal Quality (0/1)	0.434	1.54	0.588	0.74
Wildlife reported by phone (%)	-3.26	0.04	1.11	-2.94**
Proximity to TNP	-0.014	0.99	0.012	-1.28
Age 24-38	-0.60	0.55	0.424	-1.42
HH Income (USD)	0.000	1.00	0.000	-0.46
Herfindahl Indez	1.76	5.81	1.30	1.35
HH Size	-0.035	0.97	0.046	-0.76
Percentage TLU Cattle	0.765	2.15	0.985	0.78
TLU	-0.002	1.00	0.002	-0.97

N = 114; Log Likelihood = − 112.721; Likelihood Ratio $\chi 2$ = 72.13, p < 0.0001; McFadden R^2 = 0.0918 †p <0.10, *p <0.05, **p <0.01, ***p<0.001

Table 6. Model 4 – Logistic Regression Model Fit Statistics, Farm Attacks

Variable	Coefficient	Odds Ratio	SE	Z
HWC reported by phone (0/1)	-0.35	0.71	0.487	-0.71
Voucher Money (USD)	0.03	1.02	0.013	2.21*
Signal Quality (0/1)	-0.43	0.65	0.620	-0.69
Wildlife reported by phone (%)	1.38	3.99	0.746	1.85†
Proximity to TNP	0.02	1.02	0.012	1.56
Age 24-38	0.45	1.57	0.574	0.79
HH Income (USD)	0.000	1.00	0.000	-0.31
Herfindahl Indez	-1.26	0.28	1.023	-1.23
HH Size	0.05	1.05	0.036	1.34
Percentage TLU Cattle	0.30	1.31	1.148	0.24
TLU	-0.01	0.99	0.006	-1.58*

N = 114; Log Likelihood = − 61.254; Likelihood Ratio $\chi 2$ = 27.81, $p < 0.0035$; pseudo R^2 = 0.1636 †p <0.10, *p <0.05, **p <0.01, ***p<0.001

As hypothesized, some measures of mobile phone use had significant effects on HHH reported recency of HWC events when controlling for other factors. Given that the categories for the dependent variable were organized from most recent events to least recent events, positive coefficients indicated that a variable was associated with less recent HWC events, whereas negative coefficients indicated association with more recent HWC events. Similarly, odds ratios greater than 1 indicate greater odds of being in a higher category of dependent variable – in this case indicating less recent reported attacks. Odds ratios less than 1 indicate lower odds of being in a higher category of dependent variable, indicating more recent reported attacks

In Model 1 (Table 3), the percentage of wildlife evidence or sightings reported by phone was significantly correlated with more recent categories of perceived HWC events. Money spent on vouchers was marginally significant and associated with less recent categories of perceived HWC. Multiple control variables were also significantly associated with HHH perceived recency of HWC.

In Model 2 (Table 4), the percentage of wildlife evidence or sightings reported by phone was highly significantly correlated with more recent categories of perceived HWC events. Money spent on vouchers was significant and also associated with more recent categories of perceived HWC. Quality of mobile phone signal was marginally significant and correlated with less recent perceived HWC. Only two control variables were significantly associated with HHH perceived recency of HWC.

In Model 3 (Table 5), the percentage of wildlife evidence or sightings reported by phone was significantly correlated with more recent categories of perceived HWC events. Whether or not the respondent had discussed one of their recent reported attacks by mobile phone was significantly associated with less recent categories of perceived HWC. No control variables were significantly associated with HHH perceived recency of HWC.

In Model 4 (Table 6), the percentage of wildlife evidence or sightings reported by phone was marginally correlated with less recent categories of perceived HWC events. Money spent on vouchers was significant and associated with less recent categories of perceived HWC. Only one control variable (TLU) was significantly associated with HHH perceived recency of HWC.

Two measures of mobile phone use performed similarly across models: percentage of evidence or sightings discussed by mobile phone and voucher money. In all models except for Model 4 the effect of a respondent reporting using the phone to communicate sightings or evidence of wildlife was significantly correlated with more recent HWC events. However in Model 4 (Farm Attacks), where this evidence variable was only marginally significant, it was associated with less recent HWC. In two models the amount of money spent on vouchers was also significantly correlated with less recent HWC, but in one model (Model 2- Human Attacks) this same voucher variable was associated with more recent HWC.

The other two mobile phone use measures considered in the modeling, signal quality and whether or not the respondent reported using the phone to communicate any HWC attack ("HWC reported by phone") were less significant in the models. Signal quality was not highly significant in any of the models, however, it was marginally significant in the human attack model (Model 2). Whether or not the respondent reported using the phone to communicate any HWC attack was only significant in the livestock model (Model 3).

Covariates were not uniform in significance across models. In the overall model the youngest age-set was significantly associated on average with more recent attacks when compared to all other age-sets (the referent categories were the three age-sets older than the 24-38 year old Korianga males). TLU was significantly correlated with more recent perceived HWC in two out of four models, and marginally associated with less recent HWC in one model (Model 2). Also, proximity to wildlife was highly significant in two out of four models, including in the overall model (Model 1).

Discussion

The qualitative results of this study provide evidence that Maasai use mobile phones to aid in reducing both the incidence and the severity of HWC (H1, H2). These findings elucidate broad mechanisms whereby humans use mobile phones to manage interactions with wildlife (RQ1) – a theme which has been under-examined in both natural and social science studies.

In the qualitative findings of this study, communication about wildlife spans all three of Martin and Abott's (2011) contributions of mobile phones to livelihoods: (1) gathering information, (2) coordinating activities, and (3) networking. Mobile phones are used in gathering and distributing information about (1) wildlife footprints, dung, and other evidence or sightings and (2) wildlife damage, which may include attacks on humans, livestock and farms. The communication of evidence, presence and movement of wildlife points to mechanisms through which HWC events could be reduced. Furthermore, where events occur, phones are helpful tools in reducing the severity of these events by assisting quicker mobilization of responses. Maasai use the mobile phones to coordinate activities to drive away wildlife, which also includes forms of networking. Through breaking down barriers to information distribution, coordination of activities, and networking, phones are both a tool for possible HWC reduction and for coping with problems.

However, the quantitative results of this study show a slightly different pattern. The percentage of a respondent's wildlife sightings or evidence that they reported communicating by mobile phone ("Wildlife reported by phone") was significantly associated with more recent perceptions of HWC events (RQ2) in three out of four models. This finding suggests instead that H3 might be supported by the quantitative findings. This correlation may have several causes. For one, communicating more about wildlife may make HHHs more aware of existing conflict, which may then increase their perception of conflict. Furthermore, those HHHs who perceived that they experienced HWC most recently may be more disposed to communicate about wildlife sightings or evidence in the immediate time period following an attack. As noted previously, other predictors, specifically several related to measures of mobile phone use, varied in significance across models and point to other factors that shape a HHH's perception of recent wildlife attacks.

Along these lines, future studies of HWC and ICTs among the Maasai and other societies could be improved in multiple ways. First, sampling more communities could aid in building better predictive models and examination of contextual effects. Second, comparing HHH perceptions with verified incidences of HWC could allow for inferences to be made about HWC events more generally, rather than only respondent-reported data This could be combined with a panel survey design to sample communities after both the long rains and the dry season in order to take into account seasonal wildlife migrations. Lastly, modeling mobile phone coverage based on GIS and tower location data could provide a more robust estimate of network coverage by sub-village than the respondent perceptions this study uses. Despite the limitations referenced above, several conclusions can be drawn from the combination of the qualitative and quantitative methods used in this study.

Taken together, the findings offer mixed support for the idea that mobile phones serve as an important tool for managing HWC by reducing barriers to information exchange. Although statistical analysis does not offer strong evidence for mobile phones reducing the perception of HWC, throughout the group interviews many examples were provided of the phone being "a better way to reach people rather than sending a messenger." This process speaks to a more general transformation in information exchange, of which the possibility of mitigating HWC more effectively is only a small piece.

More broadly, the descriptions of mobile phones in assisting Maasai pastoral and agro-pastoral activities are aligned with the growing body of literature showing the importance of ICTs for rural livelihoods in both societal and economic contexts (Aker and Mbiti, 2010; Furuholt and Matotay, 2011; Sife et al., 2010). Corroborating the findings of Butt (2014), this thesis supports the broad importance of mobile phones as important tools for managing livestock. Phone use is becoming an important herding skill – so much so that young boys in this study area who are better with using a phone are sometimes chosen to guard the livestock over other boys who may be more skilled in the actual mechanisms of herding. In fact, phones are perceived as such a key resource in general that poor access to a mobile phone or to network signal was a problem mentioned alongside water access and education during a group interview on July 8th, 2014. This reliance on mobile phones could hold broad implications for organizations and businesses involved in development and conservation in East Africa and across the developing world.

Importantly, the research presented here reflects research that views mobile phones as supporting efficient communication of information (Martin and Abbott, 2011). More specifically, my findings also offer some support for previous research on mobile phone use and its role in mitigating HWC in Kenya (Graham et al., 2012). Similar to that study, this thesis presents evidence that mobile phones assist in reducing the severity of HWC events or preventing events altogether through better communication of information about wildlife locations and movement as well as more efficient response to HWC events. By allowing for better avoidance, these mitigation strategies could contribute to outcomes which support biodiversity conservation.

However, a final consideration that I will address briefly is the possible negative role that mobile phones may have on managing human –wildlife interactions. Though mobile phones appear to assist the human livelihoods half of HWC, the role that they play for wildlife, and therefore for conservation organizations is less clear. Despite the benefits to human livelihoods the mechanism of the phone could be controversial to conservation and development aid organizations for several reasons, namely in aiding illegal human activities. Increased access to certain sensitive information about human or wildlife movements is not without downsides. For example, in this study site group interview respondents described tactics that thieves use in conjunction with mobile phones to lure people into remote locations, or away from their homes, in order to rob them.

Relatedly, conservationists are concerned about how ICTs such as mobile phones are making it easier to poach wildlife (Banks and Burge, 2004), though another study has examined how local people may be able to prevent or report poaching more effectively using mobile phones (Stevens et al., 2013). Researchers have hypothesized that mobile phones can assist in evading authorities and coordinating activities such as illegal grazing and wildlife poaching (Banks and Burge, 2004), which may harm biodiversity. Research documents that some Maasai in Kenya use their mobile phones to engage in illegal grazing in protected areas by alerting each other of the presence of Kenyan wildlife patrols (Butt, 2014). Furthermore, other literature indicates that poachers can effectively use mobile phones to evade anti-poaching authorities (Martin, 2010) and some conservation professionals have indicated that phones aid poachers (unpublished data). However, the interaction between poaching and mobile phone use was beyond the scope of this study. To understand the broader mechanisms of ICTs and HWC, further studies of the effects of mobile phone use on HWC should explore the role of mobile phones in coordinating poaching and aiding other illegal activities.

The general importance of mobile phones to support livelihoods has been demonstrated in prior literature. This thesis adds to the growing body of literature that shows how Maasai livelihoods can be supported through mobile phone use. However, more broadly this study offers some support for *in situ* community mobile phone use as a tool for reducing HWC incidence and severity in certain contexts. Though human-wildlife conflict is likely to endure, mobile technologies are new and may offer novel solutions to many problems, including HWC. This study has sought out mechanisms through which phones can be used to mitigate human-wildlife conflict in rural communities in the developing world. While there is mixed evidence that mobile phone use is correlated with a perception of less recent HWC events, more work will need to be done to determine the depth of this correlation and whether or not it is a reproducible phenomenon outside of rural pastoralists in Tanzania.

Appendix A: Group Interview Template – Mobile Phones

Initial Phone Interview Village:____________________ Date: _______________________________

SV:_______________ # Attending:________________ Group Comp. ________________________

1. How do you use your mobile phone? Call? Text? Which do you do more? Why? How long have you been using phones? Have you used it more as time as gone by? How much do you spend each week?_____________________

____

____

____

____

2. How many people did you talk to in the last 2 hours? 24 hours? Text? ___________________________________

____

____

____

3. In the past 2 hours, did you talk about agriculture? Livestock? Health issues? Education? Ceremonies? Something else? ____

____

____

____

____

4. Do you use your phone for anything else? News? Weather? Email? Internet? Games? Calculator, Calendar? Twitter? Facebook? ____

____

____

5. Does your phone help you with herding or agriculture? If so, how? ______________________________________

____

____

____

____

6. Have there been any dangerous wildlife sightings recently? Livestock killed? Farms Raided? How long ago? How many? How did people deal with it? ____

____

____

____

____

7. What about situations where livestock or farms were protected when dangerous animals were nearby? ________

____

____

____

____

8. Does having a phone cause any problems for you? If so, what problems?_________________________________

____

____

____

9. How is mobile phone signal in this area? Airtel? Voda? Are there areas with no signal? ______________________

____

____

10. Are any people not using phones? Why not? Are people sharing phones? Using multiple sim cards? __________

____

____

____

Appendix B: Household Survey 2014 – Demographic and Livelihoods Sections

Household survey 2014

Please fill in answers for all questions

1. Date ____________________________ 2. Interview conducted by _____________________________

3. Name of Household head ____

4. Village _________________________ 5. Sub-village _______________________________

6. Household head's **level of education**: _______________________________ 7. **Age-set**: __________________

8. Household head's **religious affiliation** (Circle one)

Roman Catholic	FPCT	TAG	KKKT	Other	None

AGRICULTURE

9. At this time what is the size of your land allocation in acres? _______________________

10. Number of **acres** rented/leased to others ________________________________

11. Relation to owner _______________________ 12. Ethnic group of renter ____________________________

13. When was your field plowed (be specific): ____

14. When did you plant your crops (be specific below):

Maize_______________________________________; **Beans**____

15. Provide the number of **acres planted** and **100kg bags harvested** by the owner for each type of **maize** and **beans** below:

	MAIZE		BEANS		
	Local	Hybrid	Soya	Red	Other

Acres planted					
100 kg bags harvested					

16. Are maize and beans planted separately or together? (Circle one) **Separately** **Together**

17. What were the **major problems with cultivation**? (use the back if more space is needed)

<u>LIVESTOCK</u>

18. At this time how many of each animal type do you have (complete the table below):

	Bulls	Castrated Males	Adult Females	Heifers	Immature Males	Calves	TOTAL
Zebu							
Improved Breeds (e.g., Boran, Saiwhal)							

19. How many **Sheep** do you have? ________________________ 20. **Goats**? _____________________________

21. In the past 12 months, or since we talked to you last year, how many of each animal has been **<u>born, bought, or sold</u>**:

Cattle Born: __________ Bought: _________ Sold: _________

Sheep Born: __________ Bought: _________ Sold: _________

Goats Born: __________ Bought: _________ Sold: _________

22. In the past 12 months, or since we talked to you last year, how many of each animal has **<u>died</u>** and for what reasons:

Cattle Number: ________ Reason: ____

Sheep Number: ________ Reason: ____

Goats Number: ________ Reason: ____

<u>HOUSEHOLD</u>

23. For each wife list the following for people living at home now:

	Adult male (over 15)	Adult female (over 15)	Boys 11-15	Girls 11-15	Boys 6-10	Girls 6-10	Boys 0-5	Girls 0-5
Wife 1								
Wife 2								

Wife 3								
Wife 4								

(for others list on the back of the page)

24. Others living in the olmari? (Circle one) **YES** **NO** (if yes, write the number of each type below)

	Adult Male	**Adult Female**	**Boys**	**Girls**
Number				

25. Are any family members working away from home? (Circle one) **YES** **NO**

If yes, please complete the table below:

Who? (List relation)	**Where are they**	**What are they doing?**	**If they send money, about how**
1.			
2.			
3.			

(for others list on the back of the page)

26. Besides livestock and agriculture, do you do any other work to get more money? (Circle one) **YES** **NO**

27. If yes, what do you do? ____

28. How much money do you get from this work each year (approx.)? ________________________________

29. Anything else that you think are important changes from last year?

Appendix C: Household Survey – Mobile Phone Section

PHONE USE

1. Do you own a phone? (circle one) **YES** **NO**

2. What year did you get your first phone? (write year) ________________________

3. Is your phone charged at this time? (circle one) **YES** **NO**

4. How much have you spent on vouchers for yourself in the past 7 days? ____________________ Tsh

5. How many SIM cards do you have? ______________________

5a. If more than one, which SIM card do you use the most? (Circle one) **Voda** **Airtel** **Tigo**

8a. How is signal quality for **Voda** around your boma (within 1 min walk)? (circle one) **Very Bad** **Bad** **Average** **Good** **Very Good**

8b. How is signal quality for **Airtel** around your boma (within 1 min walk)? (circle one) **Very Bad** **Bad** **Average** **Good** **Very Good**

8c. How is signal quality for **Voda** in your subvillage? (circle one) **Very Bad** **Bad** **Average** **Good** **Very Good**

8d. How is signal quality for **Airtel** in your subvillage? (circle one) **Very Bad** **Bad** **Average** **Good** **Very Good**

9a. According to your phone's SMS log, how many SMS did you send in the **last 24 hours**? ________________ sent SMS

9b. According to your phone's SMS log, how many SMS did you receive in the **last 24 hours**? ________________ received SMS

10a. According to your phone's call log, how many phone calls did you make in the **last 24 hours**? ________________ made phone calls

10b. According to your phone's call log, how many phone calls did you receive in the **last 24 hours**? ________________ received phone calls

11. For each of the animals identified as the most harmful for humans, livestock and farms, please provide the following information on attacks, and evidence you saw or heard of:

		ATTACKS			YOU SAW EVIDENCE			YOU HEARD OF EVIDENCE	
What are the 3 most harmful wildlife species for each group (i.e., humans, livestock, farms)? (List animals)		**When was the last time this species attacked: (List time)**	**Did you use phone to deal with this problem? (Circle one)**		**When was the last time you saw evidence of this species? (e.g., sighting, tracks, scat, etc.) Not necessarily an attack. (List time)**	**Did you tell someone using your phone? (Circle one)**		**When was the last time heard that someone else saw evidence of this species? (e.g., sighting, tracks, scat, etc.) Not necessarily an attack. (List time)**	**Did that person tell you using your phone? (Circle One)**
for Humans		a person in your boma							
1 ____	→	____	YES NO N/A	→	____	YES NO	→	____	YES NO
2 ____	→	____	YES NO N/A	→	____	YES NO	→	____	YES NO
3 ____	→	____	YES NO N/A	→	____	YES NO	→	____	YES NO
for Livestock		livestock from your boma							
1 ____	→	____	YES NO N/A	→	____	YES NO	→	____	YES NO
2 ____	→	____	YES NO N/A	→	____	YES NO	→	____	YES NO
3 ____	→	____	YES NO N/A	→	____	YES NO	→	____	YES NO
for Farms		a farm from your boma							
1 ____	→	____	YES NO N/A	→	____	YES NO	→	____	YES NO
2 ____	→	____	YES NO N/A	→	____	YES NO	→	____	YES NO
3 ____	→	____	YES NO N/A	→	____	YES NO	→	____	YES NO

Question 6. For each type of person listed below, check the box that corresponds with the most recent time you've communicated that type of person **about their work** using the phone (e.g..call, SMS, email, etc).

	Person Types	Most recent use of phone (check one): Within 24 hours	24 hours to 7 days	7 days to 4 weeks	More than 4 weeks	Never	Most recent face to face conversation (check one): Within 24 hours	24 hours to 7 days	7 days to 4 weeks	More than 4 weeks	Never
TRIBE	Maasai										
	Arusha										
	Chagga										
	Other Tribe										
AGE-SET	Nyangulo										
	Korianga										
	Landis										
	Makaa										
	Seuri or Older										
WOMEN	Your Mother										
	Your Wife										
WORKERS (about the work)	Herder										
	Livestock Broker										
	Agricultural Expert										
	Veterinarian										
	Doctor or Nurse										
	Government Official										
	Laigwanani										
	Mwenyekiti										
	Religious Official										
	Laibon										
	Phone expert (kama Laibon)										

Question 7. For each type of information or phone function listed below, check the box that corresponds with the most recent use the phone (e.g., call, SMS, email, etc).to receive or distribute information.

	Information or Function Types	Most recent use of phone (check one): Within 24 hours	24 hours to 7 days	7 days to 4 weeks	More than 4 weeks	Never	Most recent face to face conversation (check one): Within 24 hours	24 hours to 7 days	7 days to 4 weeks	More than 4 weeks	Never
LIVESTOCK	Location of forage										
	Location of water										
	Market (e.g., prices)										
	Problem with herder										
	Problem with livestock										
AGRICULTURE	Markets (e.g., prices)										
	Non-Maasai laborers										
	Female laborers										
	Tractor hire										
	Hybrid Seeds										
OTHER WORK	Work in Arusha										
	Work in Mererani										
	Leasing Land										
COMMUNITY	Help for sick person										
	Arrange Gift, Loan, Restocking										
	Arrange community meeting										
PHONE FUNCTIONS	Sending Money										
	Receiving Money										
	Radio										
	Camera										
	Calculator										
	What's Up										
	Email										
	Facebook										
	Weather Information										
	Other Internet										

Appendix D: Price estimates (2014 TZS) for commodities (Table)

Commodity	2014 price estimate
Goats/Sheep	TZS 71,000
Bull (Zebu)	TZS 650,000
Bull (Imp. Breed)	TZS 1,712,000
Castrated Male (Zebu)	TZS 781,000
Castrated Male (Imp. Breed)	TZS 2,054,000
Adult Female (Zebu)	TZS 342,000
Adult Female (Imp. Breed)	TZS 753,000
Heifer (Zebu)	TZS 298,000
Heifer (Imp. Breed)	TZS 650,000
Immature Male (Zebu)	TZS 260,000
Immature Male (Imp. Breed)	TZS 520,000
Calf (Zebu)	TZS 96,000
Calf (Imp. Breed)	TZS 192,000
Sold Zebu Cattle	TZS 1,096,000
Sold Imp. Breed Cattle	TZS 479,000
Sold Goats/Sheep	TZS 71,000
Milk value	TZS 1,000
Leased Land	TZS 14,000
Maize (per 100kg bag)	TZS 32,000
Red Beans (per 100kg bag)	TZS 110,000
Soya Beans (per 100kg bag)	TZS 113,000
Other Beans (per 100kg bag)	TZS 110,000

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