



Anthropogenic Threats to Crocodiles, and the Level and Sociodemographic Determinants of their Utilization in Lower River Tana Basin, Kenya

Authors: Mosse, Margaret N., Odadi, Wilfred O., and Kibue, Grace W.

Source: Tropical Conservation Science, 17(1)

Published By: SAGE Publishing

URL: <https://doi.org/10.1177/19400829241241457>

Anthropogenic Threats to Crocodiles, and the Level and Sociodemographic Determinants of their Utilization in Lower River Tana Basin, Kenya

Tropical Conservation Science
Volume 17: 1–15
© The Author(s) 2024
Article reuse guidelines:
sagepub.com/journals-permissions
DOI: 10.1177/19400829241241457
journals.sagepub.com/home/trc



Margaret N. Mosse^{1,2} , Wilfred O. Odadi¹, and Grace W. Kibue¹

Abstract

Background and Research Aims: Globally, crocodile ranching programs are intended to generate livelihood benefits for local communities and incentives for crocodile conservation. However, there is need for their contextual scientific evaluation in many human-dominated tropical landscapes. We investigated the anthropogenic threats to crocodiles, and examined the level and sociodemographic determinants of their utilization in lower River Tana basin, Kenya.

Methods: We conducted seven key informant interviews, four focus group discussions and a quantitative household survey involving 365 respondents randomly selected from local villages. We analyzed anthropogenic threats to crocodiles and other qualitative data thematically. We summarized quantitative data using descriptive statistics and used multinomial logistic regression to analyze the association between selected sociodemographic variables and crocodile utilization.

Results: The main anthropogenic threats to crocodiles were agricultural expansion into their habitat, their retaliatory killing, and consumption of their meat and eggs. Only 5% of the respondents utilized crocodiles legally, whereas 32% utilized them illegally. Increasing age, increasing income, being male and being Christian all increased the likelihood of illegal crocodile utilization. Being male increased the likelihood of legal crocodile utilization, whereas increasing age decreased this likelihood.

Conclusions: Our study demonstrates multiple anthropogenic threats to crocodiles in lower River Tana despite a long-term ranching program. Furthermore, local community participation in this program is marginal and markedly varies among sociodemographic groups. Taken together, our findings suggest that crocodile ranching, as practiced in this landscape, is largely ineffective in achieving its intended socioeconomic and conservation goals.

Conservation Implications: To enhance their effectiveness, crocodile ranching programs in such landscapes should be tailored for local socio-cultural contexts. We recommend capacity building and awareness raising initiatives tailored for specific groups to increase local community participation in sustainable crocodile utilization and minimize their engagement in practices that are detrimental to crocodiles.

¹Department of Natural Resources, Egerton University, Njoro, Kenya

²Kenya Wildlife Service, Nairobi, Kenya

Received: 8 February 2023; accepted: 6 March 2024

Corresponding Author:

Margaret N. Mosse, Department of Natural Resources, Egerton University, P.O. Box 536, Njoro 20115, Kenya.

Email: mossenabwari@gmail.com



Creative Commons Non Commercial CC BY-NC: This article is distributed under the terms of the Creative Commons Attribution-NonCommercial 4.0 License (<https://creativecommons.org/licenses/by-nc/4.0/>) which permits non-commercial use, reproduction and distribution of the work without further permission provided the original work is attributed as specified on the SAGE and

Open Access pages (<https://us.sagepub.com/en-us/nam/open-access-at-sage>).

Data Availability Statement included at the end of the article

Keywords

community-based wildlife conservation, crocodile ranching, human-dominated tropical landscapes, human-wildlife conflict, sustainable use programs

Introduction

Crocodiles support various important ecological and socio-economic values in many tropical landscapes globally. Ecologically, crocodiles function as apex predators, thereby contributing to the maintenance of the structure, functioning and dynamics of many aquatic and riparian ecosystems (Evans et al., 2016; Somaweera et al., 2020; Wallace & Leslie, 2008). With regard to their socioeconomic significance, crocodiles have been historically exploited by humans for food (meat and eggs) and skins (Pooley, 2016). In addition, crocodiles have always formed an integral part of the culture and traditions of different communities worldwide, serving various religious, medical and ornamental purposes (Corey et al., 2017).

Despite their importance, crocodiles continue to be under threat in many human-dominated tropical landscapes primarily due to heightened negative interaction with humans. On the one hand, this interaction is characterized by human-driven overexploitation of crocodiles as well as degradation, destruction or loss of their habitats through land conversion and excessive extraction of riparian and aquatic resources (Andre et al., 2022; Jeremiah & Reniko 2018; Pooley, 2019; Somaweera et al., 2019; Utete, 2021). On the other hand, the interaction manifests in crocodile attacks on and killing humans and livestock, which in turn triggers retaliatory killing of crocodiles and destruction of their nests and habitat by humans (Aust, et al., 2009; Jeremiah & Reniko, 2018; Musambachime, 1987; Pooley, 2019).

Apart from undermining the viability of crocodile populations, heightened human-crocodile conflict results in considerable negative socioeconomic impacts for local communities including increased livestock losses, healthcare costs and impaired access to critical aquatic and riparian resources (Fukuda, et al., 2014; Sikamani, et al., 2023). Consequently, intensified conflict makes local communities less tolerant of crocodiles, especially when they perceive no tangible benefits from conserving these reptiles (Andre, 2022; Madhusudan, 2003; Than et al. 2020). Therefore, there is a great need to develop strategies that promote human-crocodile coexistence in human-dominated landscapes that host crocodiles (Jyrwa et al., 2020; Kyalo, 2008; Than et al., 2020).

Crocodile ranching is considered as one such initiative that can be used to incentivize local communities to sustainably utilize and conserve crocodiles (Aust et al., 2009; Convention on International Trade in Endangered Species of Wild Fauna and Flora [CITES], 2019; Manolis & Webb, 2016; Weber et al., 2015). This approach generally involves harvesting

crocodile eggs from the wild, incubating them and rearing hatchlings to maturity in ranches for production of various products, especially skins and meat (CITES, 2010). To prevent depletion of crocodile populations, ranches -may be required to release a certain percentage of their hatched juvenile crocodiles back into the wild (CITES, 2010; Manolis & Webb, 2016). Local community members are intended to benefit by collecting and selling crocodile eggs to ranches.

The concept of crocodile ranching originated after widespread overexploitation of crocodiles in the 19th and 20th centuries led to their near-extinction (Aust et al., 2009; Weber et al., 2015). This resulted in the listing of crocodylian species in CITES Appendix I in 1975, thereby effectively banning their commercial exploitation (CITES, 2013; Jelden et al., 2014; Thorbjarnarson, 1999). Subsequent recovery of crocodile populations paved way for the dual listing of such specific populations in both Appendix I and II to allow for regulated international trade in ranches specimens (Aust et al., 2009; CITES, 2013; Fergusson, 2010; Jelden et al., 2014; Weber et al., 2015). Besides, all signatory states involved in ranching of crocodiles were required to demonstrate that commercial utilization of crocodiles is not harmful to the viability of their populations (CITES, 2010). Today, crocodile ranching continues to be practiced in many countries around the world (Daltry et al., 2016; Dzoma et al., 2008; Ovando, 2008; Revol, 1995). In Kenya, crocodile ranching has continued to be practiced since 1985 when the country's Nile crocodile (*Crocodylus niloticus*) population was transferred from Appendix I to II (Crocodile Specialist Group, 2004; Kyalo, 2008).

Whereas crocodile ranching continues to be practiced globally, its effectiveness in achieving intended socioeconomic and conservation outcomes can vary markedly across landscapes, countries and regions depending on cultural, demographic, socio-economic and ecological contexts (CSG, 2004; Daltry et al., 2016). For instance, in the Asia-Pacific region, crocodile ranching programs have been reported to be successful in countries such as USA, Australia and Papua New Guinea, whereas they are largely considered to be unsuccessful in countries such as Thailand, Vietnam, Cambodia and Philippines (Daltry et al. 2016; Sine et al., 2008). In Africa, there is a notable paucity of information essential for comprehensive assessment of the effectiveness of crocodile ranching programs in many countries, including Kenya (CSG, 2004). Based on the limited available information, crocodile ranching programs are believed to be successful in Zimbabwe, while deemed unsuccessful in countries such as Uganda, Malawi and Tanzania (CSG, 2004). Given the context-dependent nature of the effectiveness of crocodile

ranching programs, there is need for their context-specific scientific evaluations. Such evaluations are needed to bolster the development of appropriate strategies for sustainable utilization and conservation of crocodiles in diverse human-dominated landscapes, particularly in Africa.

Many governments in Africa and elsewhere have implemented legislations and policies aimed at enhancing wildlife conservation and management (Aust et al., 2009; CITES, 2010; Fergusson, 2010; Weber et al., 2015). For instance, in Kenya, the law prohibits all forms of wildlife hunting, including subsistence hunting, but allows consumptive utilization of selected wildlife species, including crocodiles, only through ranching or farming (Government of Kenya [GoK], 2013). However, it is worth noting that many communities have depended on wildlife harvesting since time immemorial, with hunting and gathering being an integral part of their culture (Corey et al., 2017).

The success of crocodile ranching programs greatly depends on the extent to which local community members adopt legally acceptable practices of crocodile utilization while refraining from engaging in practices considered illegal (Lindsey et al., 2013; Solomon et al., 2015). Notably, whereas legal resource utilization practices are usually considered to be sustainable, and vice versa, this assumption may not always necessarily hold (Hughes et al., 2023; Meeks et al., 2024). Various sociodemographic factors can influence the nature of crocodile utilization practices adopted by local community members (Conover, 2001; Kyalo, 2008; Salem, 2013; Somaweera et al., 2019; Utete, 2021). Such factors include age, gender, level of formal education, level of income, source of livelihood, religion and ethnicity among others (Akinsorotan et al., 2020; Nguyen et al., 2018; Ntuli et al., 2019; Reuter et al., 2018). Whereas these factors can either increase or decrease people's likelihood of engaging in different crocodile utilization practices, their effects may vary across regions, depending on sociocultural, economic and political contexts (Mogomotsi et al., 2020; Mustapha et al., 2012; Ntuli & Muchapondwa, 2018; Yang et al., 2010). Therefore, to better guide crocodile utilization and conservation efforts in any given socio-ecological system, it is important to understand the role of these sociodemographic factors in shaping crocodile utilization practices adopted by local community members.

Kenya's lower River Tana basin hosts one of the largest populations of Nile crocodiles and has continued to be an important landscape for crocodile ranching since 1990s (CSG, 2018; Kyalo, 2008). However, due to intensifying anthropogenic pressures, the number of crocodiles in this landscape has been declining rapidly as evidenced by a recent report indicating a 40% decrease in part of this population, from 18,000 to 10,800 individuals, over a 5-year period (Gari, 2015). The existence of a long-term crocodile ranching program in this landscape presents a potential opportunity for the local community members to improve their livelihoods through engagement in ranching-based crocodile utilization

practices. Deriving livelihood benefits from this program would be particularly important given that approximately three-quarters of the local inhabitants live below the poverty line (Kenya National Bureau of Statistics [KNBS], 2015). However, there has been limited empirical evaluation of this ranching program, especially with regard to its role in addressing negative human-crocodile interactions and generating livelihood benefits for the local communities. Such an evaluation is needed to better inform the development of policies and strategies aimed at enhancing sustainable crocodile utilization and conservation in the lower River Tana basin and similar landscapes. In this study, we aimed to investigate the major anthropogenic threats to crocodiles and examine the level and sociodemographic determinants of crocodile utilization by local community members in the lower River Tana basin.

Materials and Methods

Study Area

The study was conducted in the lower River Tana basin in Tana River County, Kenya (latitudes 0°0'53"30" and 2°0'41" South, longitudes 38°30' and 40°15' East; Figure 1). The basin hosts crocodile egg harvesting zones belonging to three privately-owned crocodile ranches: Galaxy Croc Farm, Kazuri London Limited and Nile Crocodiles Limited (Galaxy, Kazuri and Nile, respectively, hereafter; Figure 1). While the primary facilities of these ranches are located outside Tana River County, they operate seasonal crocodile egg harvesting and incubation field units adjacent to the river.

The annual rainfall in the study area ranges between 400mm and 750mm, and generally occurs in March–May ("long rains") and October–December ("short rains"). However, rainfall exhibits high spatial and temporal variability and the region is prone to frequent droughts and flooding (Odhengo et al., 2014; Mohamed, 2015). The mean annual temperature ranges from 23° to 33° Celsius (Odhengo et al., 2014). Notably, the region is home to many endemic and range-restricted species including the Tana River red colobus monkey (*Piliocolobus rufomitatus*) and the Tana River crested mangabey (*Cercocebus galeritus*) (Odhengo et al., 2014). Additionally, the region hosts the Tana River Primate National Reserve (TRPNR), a government-protected conservation area that serves as an important refuge for many animal and plant species.

Tana River County has a human population of 314,710 (KNBS, 2019). Due to generally dry weather conditions across the county, human settlements are mainly concentrated in areas adjacent to the river (Mohamed, 2015). The county is mainly inhabited by the Pokomo, Orma, Wardei, Watta and Ilwana (also known as Malakote) ethnic groups. The Orma, Wardei, Watta, Ilwana, and Pokomo occupy the upper part of the river and are largely Muslims, whereas the Pokomo

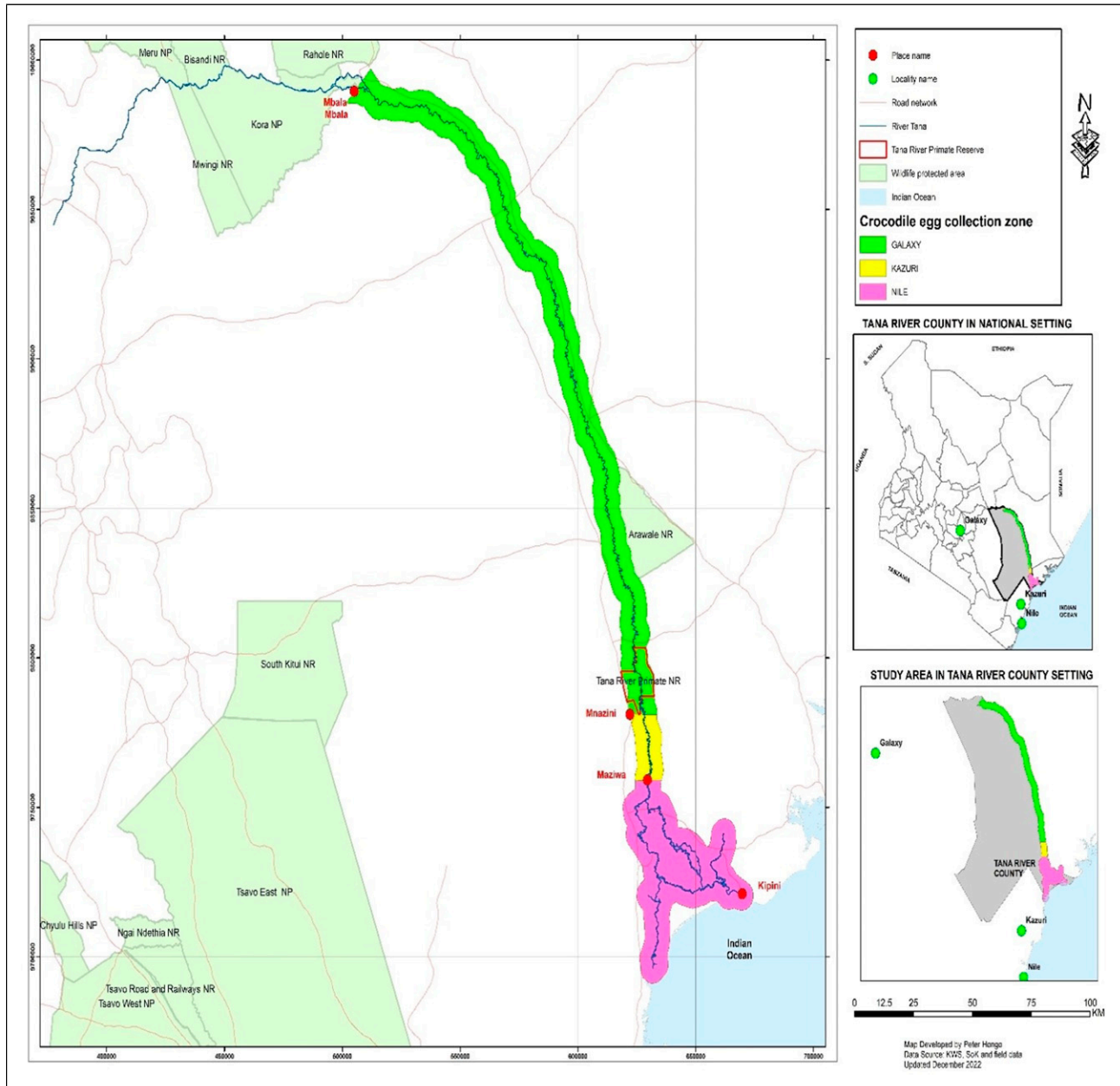


Figure 1. Map of the study area showing the different egg collection zones and location of the crocodile ranches.

occupy the lower part of the river and are mainly Christians (Githui, 2020; Joshua Project, 2019; Ylvisaker, 1982).

The Pokomo practice farming, fishing and sand harvesting, while the Wardei and Orma combine livestock keeping with some shifting cultivation (GoK, 2018a; Mohamed, 2015; Terer et al., 2004). The Watta, originally hunters and gatherers, have now transitioned to harvesting and selling forest wood products and engaging in small-scale farming (National Gender and Equality Commission [NGEC], 2014). The Ilwana community practice farming, beekeeping and livestock keeping (GoK, 2018b). Other ethnic groups in the region include the Munyoyaya who practice farming and

beekeeping, and the nomadic-pastoral Somalis (from the neighboring Garissa County) who utilize the river basin for pasture and water during dry periods (Food and Agriculture Organization [FAO], 2017; Mohamed 2015).

Target Population

The target population comprised households in villages located within 2km and 5km of the river bank at the non-delta segment and delta segments of the river, respectively. These villages were selected because of their proximity to the river and the associated high likelihood of their residents to interact

with crocodiles. The selected villages contained a total of 4,363 households, representing approximately 12% of the total number (35,099) of households in the entire Tana River County (KNBS, 2019).

Sampling Procedure and Data Collection

We conducted the study from February to March 2019, using a combination of quantitative and qualitative data collection techniques. Specifically, we conducted a household survey, seven key informant interviews (KIIs) and four focus group discussions (FGDs). The household survey involved 365 households randomly selected from ten villages situated adjacent to the river. Four, two and four of these villages were located within the egg collection zones for Galaxy, Kazuri and Nile, respectively (Supplemental 1). The overall sample size was proportionately distributed among the villages based on number of households. To obtain a random sample from each village, we used a household list prepared with the help of the village elder.

We conducted the household survey through face-to-face administration of a semi-structured questionnaire to each of the selected household heads or their adult representatives. The questionnaire comprised two parts; the first part elicited information on the respondents' sociodemographic characteristics, while the second part focused on their crocodile utilization practices. Crocodile utilization was categorized into three: "legal", "illegal" and "non-utilization". A participant was considered to be involved in legal practices if he or she reported engagement in one or more crocodile utilization activities not prohibited by Kenyan law. These activities included collecting crocodile eggs for ranches, locating crocodile egg nests for ranches, incubating crocodile eggs and selling hatchlings to ranches, training egg collectors and working at a ranch or field incubation unit. Conversely, a participant was deemed to be involved in illegal practices if he or she indicated engagement in one or more activities prohibited by the law such as eating crocodile eggs obtained from the wild, eating wild crocodile meat, hunting crocodiles, using crocodile meat as fishing bait, selling crocodile eggs to villagers, selling crocodile meat to villagers and selling crocodile meat to fishermen. Non-utilization referred to non-involvement in either legal or illegal crocodile utilization practices.

We conducted KIIs and FGDs using interview schedules and prompts. The key informants were managers of the three crocodile ranches, and relevant Kenya Wildlife Service (KWS) and Tana River County officials. The FGDs consisted of six to eight discussants each. Two of the four FGDs consisted of household heads (both men and women), whereas the rest consisted of egg collectors, all of whom were men. For in-depth focus, the KII and FGD participants were selected on the basis of their knowledge, experience and role in crocodile ranching and conservation in the study landscape. The themes covered in the KIIs and FGDs included

local community benefits from ranching-based crocodile utilization, crocodile utilization beliefs and practices, human activities along the river, and potential anthropogenic threats to crocodiles.

Data Analysis

Quantitative data were analyzed using the Statistical Package for Social Sciences (SPSS) computer program version 20 (International Business Machines Corporation [IBM], 2011). We summarized these data using descriptive statistics, particularly frequencies and percentages. In addition, we fitted a multinomial logistic regression model to investigate the influence of various sociodemographic factors on participants' involvement in different crocodile utilization practices. The dependent variable contained three levels of crocodile utilization, namely, "legal", "illegal" and "non-utilization", with the latter serving as the reference category. The sociodemographic factors included in the model were age, level of formal education, annual income, gender, ethnic group, religion, main source of livelihood and egg collection zone. The factors age, income and education level were used as covariates (after categorization and ordering of their respective categories), whereas all other factors were used as nominal variables. For each explanatory variable, the selected reference category was the category in which the lowest (or lower) proportion of participants reported involvement in illegal utilization. The reference categories for the different explanatory variables are presented in Table 1.

We analyzed qualitative data thematically using the Max Software for Qualitative Data Analysis (MAXQDA), in accordance with (Kuckartz & Stefan, 2019). The analysis entailed looking for similarities and differences between the texts and summarizing the results. To achieve this, we first organized the data into two documents (KIIs and FGDs) and then conducted a systematic study of the files to understand the whole text. Finally, we categorized contents into codes (themes), assigning a unique color to each code.

Results

Sociodemographic Characteristics of Household Survey Participants

Most (68%) of the household survey participants were male. The age categories 30-39 and 40-49 years were the most frequent, each accounting for 23% of the participants. A majority (61%) of the participants were Muslims (Table 2 and Supplemental 2). Pokomo was the most dominant ethnic group, accounting for 63% of the participants (Table 2 and Supplemental 2). Slightly less than half (47%) of the participants had attained primary level of formal education, while less than 10% of had tertiary education. Most (49%) of the participants indicated that farming was their main source

Table 1. Reference categories for explanatory variables.

Explanatory variable	Response categories	Reference category
Gender	Male Female	Female
Ethnic group	Pokomo Watta Ilwana/ Malakote Orma	Orma
Religion	Christian Muslim	Muslim
Main source of livelihood	Farming Employment Business Others Livestock keeping	Livestock keeping
Egg collection zone	Galaxy Nile Kazuri	Kazuri

Table 2. Household participants' sociodemographic characteristics by crocodile use category.

Sociodemographic characteristics		Crocodile use category					
		Non-utilization		Illegal use		Legal use	
		N	%	N	%	N	%
Age category	19-29	43	71.7	10	16.7	7	11.7
	30-39	58	69.0	24	28.6	2	2.4
	40-49	47	56.0	31	36.9	6	7.1
	50-59	35	55.6	26	41.3	2	3.2
	>=60	46	62.2	28	37.8	0	0.0
Level of formal education	None	77	87.5	8	9.1	3	3.4
	Primary	115	66.9	47	27.3	10	5.8
	Secondary	25	34.7	45	62.5	2	2.8
	Tertiary	12	36.4	19	57.6	2	6.0
Annual income category (US \$)	Below 2,336	161	63.1	82	32.2	12	4.7
	2,336- 4,673	49	69.0	19	26.8	3	4.2
	4,674- 7,009	11	47.8	10	43.5	2	8.7
	Above 7,009	9	52.9	8	47.1	0	0.0
Gender	Male	149	59.8	84	33.8	16	6.4
	Female	80	69.0	35	30.1	1	0.9
Ethnic group	Pokomo	107	46.6	116	50.4	7	3.0
	Orma	75	90.4	0	0.0	8	9.6
	Watta	32	88.8	2	5.6	2	5.6
	Ilwana	15	93.7	1	6.3	0	0.0
Religion	Christian	35	24.8	104	73.8	2	1.4
	Muslim	194	86.6	15	6.7	15	6.7
Main source of livelihood	Farming	96	53.9	71	39.9	11	6.2
	Employment	31	57.4	23	42.6	0	0.0
	Business	26	66.7	12	30.8	1	2.5
	Others	34	68.0	13	26.0	3	6.0
	Livestock keeping	42	95.5	0	0.0	2	4.5
Egg collection zone	Galaxy	81	69.8	31	26.8	4	3.4
	Kazuri	20	56.6	1	38.5	2	4.9
	Nile	128	56.6	87	38.5	11	4.9

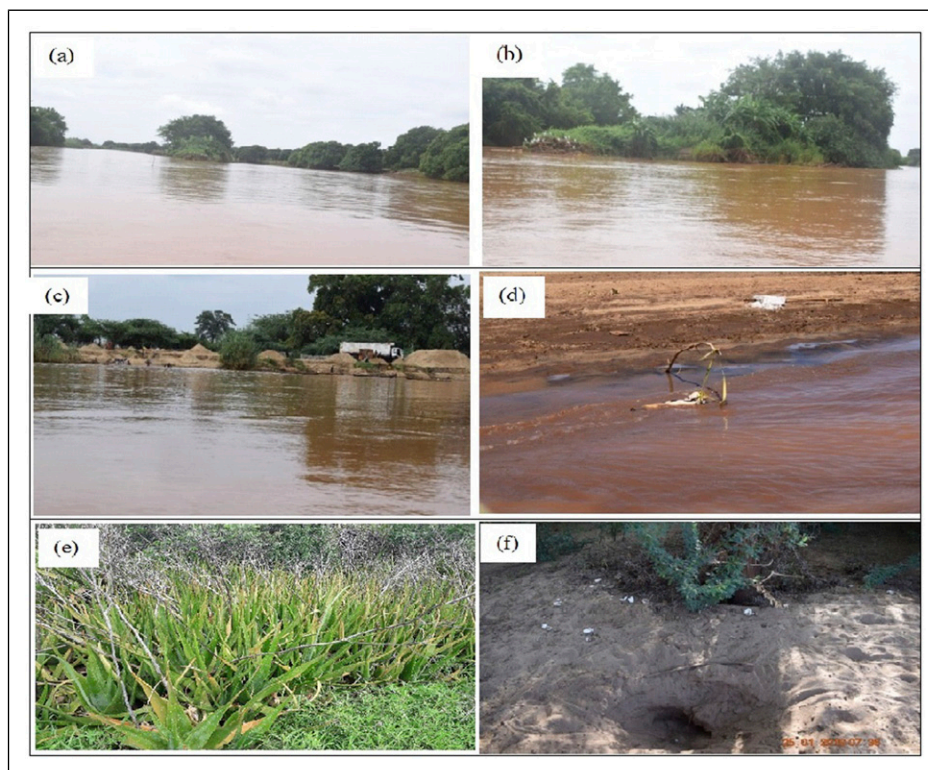


Figure 2. An illustration of human activities harmful to crocodiles along lower River Tana. In (a) and (b) an island on the river now encroached for crop cultivation but hitherto considered a refuge for crocodile breeding; (c) sand harvesting at the river; (d) poison wrapped in goat skin at the riverbank targeted at crocodiles; (e) *Aloe ruspoliana* plant, locally called “rasai” used to poison crocodiles; and (f) crocodile nest destroyed by machettes. Photos by Mosse.

of income. A majority (70%) participants had annual income levels lower than US dollars 2,336 (Table 2 and Supplemental 2).

Anthropogenic Threats to Crocodiles

The KII and FGD participants highlighted multiple human-induced threats to crocodiles (Figure 2a-f). One frequently mentioned threat was expansion of agriculture into the riparian zone, which is an important crocodile nesting habitat. Although the participants indicated that the condition of crocodile habitat was still healthy in some areas like the Tana Delta, they expressed fear that this situation would not last for long because of continued expansion of crop cultivation into the riparian zone, which results in land clearance and hence the destruction of this critical crocodile habitat.

Another frequently mentioned threat was retaliatory killing of crocodiles and the destruction of their eggs as a result of human-crocodile conflicts. In particular, it was revealed that Wardei and Somali livestock keepers, especially in the upper segment of the river basin, often take such actions to retaliate against livestock losses caused by crocodiles. Conversely, it was revealed that Orma livestock keepers were more tolerant to crocodiles because of their belief that their god (“Allah”) protects people and livestock from crocodile

attacks. It was also reported that most local community members do not benefit from the existing crocodile ranching program. They also indicated that, contrary to the provisions of Kenya’s Wildlife Conservation and Management Act, 2013 (GoK, 2013), compensation for crocodile-related livestock losses is rarely provided, which further exacerbates human-crocodile conflict in the region. Notably, participants highlighted that due to these factors, local community members continued to engage in various practices that are harmful to crocodiles. For instance, some of the discussants revealed that crocodiles are commonly poisoned using *Aloe ruspoliana* plant (locally called “rasai”). Specifically, they reported that the leaves of this plant are usually cut into small pieces and wrapped in animal skin to form a bait, which is then strategically placed in areas frequented by crocodiles such as their basking sites.

The participants also identified consumption of wild crocodile meat and eggs by some local community members as a major threat to crocodiles in the region. Furthermore, they indicated that the number of eggs available for harvesting by crocodile ranches continues to decline partly due to these practices. This view was captured by one crocodile ranch manager who stated, “I now have less and less to do with the Pokomo because there are no eggs available for collection in their areas”. The participants held the general

opinion that the number of breeding crocodiles had declined over the years. One of the key informants asserted, "In the year 2005, it was possible for one egg collector to get 2000 eggs per season but now even an intense search may not yield 300 eggs". Another threat mentioned was the engagement of some community members in practices such as capturing wild crocodiles using fishing rods, killing them and using their meat as fishing bait.

Level and Sociodemographic Determinants of Crocodile Utilization

Overall, 5% and 32% of the household survey participants reported involvement in legal and illegal crocodile utilization, respectively; the remaining (63%) reported non-involvement. Limited involvement was observed in various forms of legal crocodile utilization, with no more than 3% of the participants reporting engagement in harvesting crocodile eggs for ranches, locating nests for ranches or working at field incubation units (Table 3). Eating wild crocodile meat and eggs were the most common illegal utilization practices, with 31% and 27% of the participants indicating engagement in these

activities, respectively (Table 3). However, the other illegal utilization practices were far much less common, with less than 3% of participants reporting engagement in each of them (Table 3).

The model indicates that age, annual income, gender, ethnic group, religion and main source of livelihood significantly shaped ($\chi^2 > 9.359$, $df=1$, $p \leq 0.018$) participants' involvement in different crocodile utilization practices but not ($\chi^2 > 2.326$, $df=1$, $p > 0.285$) education and egg collection zone (Table 4). Specifically, increasing age increased the likelihood of engaging in illegal crocodile utilization practices by a factor of 1.5, whereas it decreased the likelihood of engaging in legal practices by one-half (both $\chi^2 > 6.433$, $df=1$, $p < 0.011$; Table 5). Increasing annual income doubled ($\chi^2 = 8.052$, $df=1$, $p = 0.005$) the likelihood of engaging in illegal practices but did not significantly alter ($\chi^2 = 0.428$, $df=1$, $p = 0.513$) the likelihood of engaging in legal practices (Table 5). Key informants and focus group discussants revealed that, compared to younger people, older individuals tend to engage more in illegal crocodile utilization activities because of their greater traditional knowledge of crocodile utilization and greater willingness to take risks associated with such practices. They also indicated that younger people

Table 3. Number of households engaged in various categories of crocodile utilization practices.

Category of crocodile use	Type of use	Response	N	(%)	
Legal uses	Collecting eggs for ranch at a fee	No	353	96.7	
		Yes	12	3.3	
	Locate nests for ranch at a fee	No	356	97.5	
		Yes	9	2.5	
	Incubate eggs and sell hatchlings to ranchers	No	365	100.0	
		Yes	0	0.0	
	Ranch hatchlings to sell meat	No	365	100.0	
		Yes	0	0.0	
	Employed at field incubation unit	No	358	98.4	
		Yes	6	1.6	
	Train egg collectors	No	361	98.9	
		Yes	4	1.1	
	Lease land to crocodile ranch	No	365	100.0	
		Yes	0	0.0	
Overall Legal uses	Yes		17	4.7	
	No		348	95.3	
Illegal uses	Eat crocodile eggs obtained from the wild	No	252	69.0	
		Yes	113	31.0	
	Eat crocodile meat obtained from the wild	No	268	73.4	
		Yes	97	26.6	
	Use crocodile meat as bait in fishing	No	356	97.5	
		Yes	9	2.5	
	Sell eggs obtained from the wild to villagers	No	361	98.9	
		Yes	4	1.1	
	Sell meat obtained from the wild to villagers to eat	No	362	98.9	
		Yes	3	0.8	
	Sell meat obtained from the wild to fishermen	No	359	98.4	
		Yes	6	1.6	
	Overall Illegal uses	Yes		119	32.6
		No		246	67.4

Table 4. Likelihood Ratio Tests.

Effect	Model Fitting Criteria-2 Log Likelihood of Reduced Model	Likelihood Ratio Tests		
		Chi-Square	df	Sig.
Intercept	244.210	.000	0	.
Age	262.275	18.065	2	.000
Annual income	253.569	9.359	2	.009
Education	246.536	2.326	2	.313
Gender	260.180	15.970	2	.000
Religion	270.918	26.708	2	.000
Main source of livelihood	262.620	18.409	8	.018
Egg collection zone	249.233	5.023	4	.285
Ethnic group	270.401	26.191	9	.000

Table 5. Effects of various sociodemographic factors on the likelihood of involvement in different categories of crocodile use.

Category of crocodile use	Sociodemographic factors	Coefficient	Std. Error	Wald χ^2	Sig.	Odds Ratio
Legal use	Age	-.763	.272	7.887	.005	.466
	Annual income	-.233	.356	.428	.513	.792
	Gender (Male)	2.463	1.116	4.870	.027	11.736
	Religion (Christian)	.753	1.156	.425	.515	2.124
	Main source of livelihood (Farming)	2.089	.964	4.694	.030	8.079
	Main source of livelihood (Employment)	-17.586	5962.637	.000	.998	2.31x10 ⁻⁸
	Main source of livelihood (Business)	.283	1.372	.043	.836	1.327
	Main source of livelihood Others)	2.426	1.178	4.243	.039	11.313
	Ethnic group (Pokomo)	-1.975	1.485	1.767	.184	.139
	Ethnic group (Watta)	-1.296	.967	1.797	.184	.274
Illegal use	Ethnic group (Ilwana)	-20.673	.000	.	.	1.05x10 ⁻⁹
	Age	.399	.157	6.433	.011	1.491
	Annual Income	.783	.276	8.052	.005	2.189
	Gender (Male)	1.318	.447	8.698	.003	3.736
	Religion (Christian)	2.735	.565	23.405	<.001	15.412
	Main source of livelihood (Farming)	16.229	3107.155	.000	.996	1.12x10 ⁷
	Main source of livelihood (Employment)	15.782	3107.155	.000	.996	7.15x10 ⁶
	Main source of livelihood (Business)	16.255	3107.155	.000	.996	1.15x10 ⁷
	Main source of livelihood Others)	15.475	3107.155	.000	.996	5.26x10 ⁶
	Ethnic group (Pokomo)	16.290	2609.858	.000	.994	2.39x10 ⁸
Ethnic group (Watta)	16.643	2609.858	.000	.995	1.69x10 ⁷	
Ethnic group (Ilwana)	18.992	2609.858	.000	.994	1.77x10 ⁸	

Reference category for category of use is "Non-utilization".

tend to have more socio-economic opportunities away from the area where they become more exposed to external influence, thereby making them less likely to participate in illegal crocodile utilization activities. Finally, they opined that as the need for higher income to take care of increasing family responsibilities increases with age, older people are more likely to engage in illegal utilization practices.

With regard to gender, a male participant was 12 and three times more likely ($\chi^2=4.870$, $df=1$, $p=0.027$ and $\chi^2=8.698$, $df=1$, $p=0.003$) than a female participant to be involved in legal and illegal crocodile utilization, respectively (Table 5). The KII and FGD participants revealed that activities such as harvesting crocodile eggs from the wild and hunting crocodiles are deemed risky and are hence largely performed by

men. In particular, they revealed that men generally tend to be more willing than women to risk being attacked by crocodiles and other wild animals while travelling on water by canoes in search of crocodile nests. In addition, the participants disclosed that all the canoes used in searching for crocodile nests in the region are exclusively owned and operated by men.

Regarding religion, a Christian participant was 15 times more likely than a Muslim participant ($\chi^2=23.405$, $df=1$, $p<0.001$) to be involved in illegal (but not legal [$\chi^2<0.425$, $df=1$, $p=0.515$]) crocodile utilization (Table 5). The KII and FGD participants revealed that Muslims are prohibited from practices that are harmful to crocodiles. A Muslim FGD discussant from Sala summarized this view by stating, "According to Islam, killing crocodiles is "haram"

(proscribed) and therefore we are neither allowed to kill them nor eat their meat and eggs". With regard to the role of main source of livelihood, crop farmers were eight times more likely ($\chi^2=4.694$, $df=1$, $p=0.030$) than livestock keepers to be involved in legal (but not illegal [$\chi^2 < 0.1$, $df=1$, $p=0.996$]) crocodile utilization (Table 5).

Although the overall effect of ethnic group was statistically significant, a comparison of the Orma (reference group) against each of the other ethnic groups did not show any significant difference ($\chi^2=1.767$, $df=1$, $p>0.184$; Table 5). However, KII and FGD participants indicated that the traditional indigenous knowledge, beliefs and cultural practices of the Orma promote human-crocodile coexistence. They also revealed that the Orma believe that their prosperity is associated with the river and its animals and, therefore, play a role in protecting the river ecosystem. Furthermore, they indicated that greater coexistence between the Orma and crocodiles is demonstrated by the presence of undisturbed crocodile habitat and high abundance of these reptiles and their nests in areas occupied by this ethnic group. Conversely, it was revealed that practices such as hunting crocodiles and eating their meat and their eggs were particularly common among a section of the Pokomo ethnic group called "Mila Chini". The KII and FGD participants further revealed that the "Mila Chini" Pokomos engage in these practices for nutritional, medicinal and cultural purposes. One egg collector from Galaxy stated, "Not all Pokomos eat crocodile meat and eggs. It is the "Mila Chini" Pokomos who live in Garsen and downstream areas of the river who eat these products".

Discussion

Anthropogenic threats to crocodiles

The observed multiple anthropogenic threats to crocodiles in the lower River Tana basin, where a ranching program has been in place for decades, suggests that human-crocodile conflict still persists in this landscape, contrary to a recent report (CITES, 2019). Availability of suitable nesting sites is known to be important for ensuring great reproductive success of crocodiles and persistence of their populations (Calverley & Downs, 2017; Refsnider, 2016; Somaweera & Shine, 2013). Therefore, the revealed continued expansion of agricultural activities into the riparian zone of our study region is of major concern because such activities can reduce the quality and quantity of habitat available to crocodiles for nesting, thereby lowering their reproductive performance and destabilizing their population (Somaweera et al., 2019; Utete, 2021).

Our finding that key informants and discussants associated increased consumption of wild crocodile meat and eggs with a decline in the number of crocodile eggs available for ranching is consistent with other studies indicating that such practices may be detrimental to the survival and sustainable

utilization of crocodiles (Kahler et al., 2013; Lindsey et al., 2013). Further, the revealed retaliatory killing of crocodiles and destruction of their nests by livestock keepers can undermine sustainable utilization and conservation of crocodiles (Raley, 2016; Treves & Bruskotter, 2014). Specifically, such practices can suppress crocodile populations by decreasing the number of breeding adults and impairing net recruitment, thereby decreasing the quantity of eggs available for ranching operations.

Our finding that failure to financially compensate local community members for crocodile-induced livestock losses aggravated retaliatory killing of crocodiles agrees with other studies indicating that effective compensation schemes can help mitigate human-wildlife conflict (Hazzah et al., 2014; Treves & Bruskotter, 2014). However, such schemes should be implemented with caution in multicultural landscapes such as the lower River Tana basin where, due to differences in cultural beliefs and practices; some communities (e.g. Orma) are more tolerant to crocodiles than others. Specifically, blanket implementation of compensation without being cognizant of the roles played by different communities in tolerating and promoting crocodile conservation can result in inequitable distribution of compensation funds among communities, thereby breeding inter-community conflicts (Nyhus et al., 2005). Therefore, there is need to increase focus on promoting human-crocodile coexistence by adopting preventive measures such as constructing crocodile barriers at livestock watering points and piping water from the river to villages for domestic use (Frank, 2016; Than, et al., 2020; van der Ploeg et al., 2011). In addition, socio-economic incentives such as community projects should be provided to increase local communities' level of tolerance to crocodiles. Finally, there is need to promote livestock husbandry practices that minimize livestock depredation by crocodiles.

Level and Sociodemographic Determinants of Crocodile Utilization Practices

Our study suggests that the local communities in lower River Tana have largely not been successfully incentivized to derive livelihood benefits from the existing long-term crocodile ranching program. The observed positive association between age and involvement in illegal practices of crocodile utilization is consistent with previous studies elsewhere (Akinsorotan et al., 2020; Lopez-Feldman, 2014; Mogomotsi et al., 2020). This pattern can be explained by our qualitative data indicating that older people have more knowledge of traditional crocodile utilization practices, greater family responsibilities and greater willingness to take risks, thereby making them more predisposed to engage in illegal practices. Notably, at face value, our finding that younger people were less involved in illegal practices suggests that younger people are less focused on hunting and fishing activities. However, our finding that younger people were more involved in legal

practices suggests that younger people are more likely to embrace practices that are compatible with crocodile ranching. These findings are indicative of potentially positive prospects for sustainable utilization and conservation of crocodiles in such landscapes.

Previous studies have reported that people with low income levels can be highly dependent on natural resources for their survival, making them more predisposed to engaging in illegal extraction of such resources (Harrison et al., 2015; Kämpel et al., 2010; MacMillan & Nguyen, 2014). Conversely, however, the observed positive association between income level and engagement in illegal crocodile utilization practices suggests that being relatively poor does not necessarily increase overdependence on such practices. The observed gender disparity in engagement in crocodile utilization can be explained by our qualitative data indicating that men exclusively own the requisite equipment (canoes). This finding is consistent with other studies indicating that women tend to be underrepresented in consumptive wildlife utilization activities (Akinsorotan et al., 2020; Anthony et al., 2004; Kämpel et al., 2010; Loibooki et al., 2002; Sunderland et al., 2014).

Our qualitative findings indicated that the Orma have cultural beliefs and practices that protect crocodiles, whereas the Pokomo traditionally consider practices such as eating wild crocodile meat and eggs as normal, despite the fact that the law prohibits them. Consistent with the latter finding, the Pokomo are known to attach great nutritional, medicinal and cultural identity values to eating wild crocodile meat and eggs (Pooley, 2016). This finding underscores the significant role of cultural beliefs and practices in influencing crocodile utilization practices in such landscapes, thus aligning with previous studies (Cuni-Sanchez et al., 2016; Kiffner et al., 2015).

The observed disparity between Christians and Muslims in engagement in illegal crocodile utilization underscores the role of religion in influencing natural resource use patterns among communities (Baker et al., 2014; Brackhane et al., 2019; Reuter et al., 2018). We attribute this disparity to religious differences in practices and norms regarding crocodile utilization, and particularly to the revelation from our KII and FGD that Islamic religion (unlike Christianity) prohibits its followers from engaging in illegal crocodile utilization. Thus, our finding suggests that religious beliefs, practices and norms can play a role in deterring people from engaging in practices that are harmful to crocodiles. Livelihood source has been reported as an important factor influencing people's natural resource conservation and utilization decisions (Akinsorotan et al., 2020; Kiffner et al., 2015; Li et al., 2016). The observed disparity between livestock keepers and farmers in involvement in legal crocodile utilization is interesting because livestock keepers bear the brunt of coexisting with crocodiles yet they are less likely to participate in and benefit from such utilization. We posit that livestock

keepers possibly do not have sufficient time to engage in time-consuming crocodile utilization tasks (e.g., searching for nests) since they spend much of their time looking after livestock.

Conservation Implications and Recommendations

In this study we have shown the existence of multiple anthropogenic threats to crocodiles in Kenya's lower River Tana basin despite the presence of a long-term crocodile ranching program. Furthermore, only a tiny proportion of the local inhabitants do participate in and hence derive livelihood benefits from ranching-based (legal) crocodile utilization in this landscape. Finally, there are marked sociodemographic disparities in crocodile utilization, with legal utilization being skewed in favor of males, younger people, and farmers, and illegal utilization favoring males, Christians, high income earners and older people. Taken together, these findings suggest that crocodile ranching, as practiced in this landscape, is largely ineffective in realizing the intended socioeconomic and conservation goals.

Our study provides important insights into the complexities of and opportunities for ranching-based crocodile utilization and conservation programs in such human-dominated multicultural tropical landscapes. For better outcomes, such programs should be tailored for the local circumstances and socio-cultural contexts. Concerted efforts should be directed at developing strategies tailored for various sociodemographic groups to increase local community participation in various aspects of the crocodile ranching value chain, while minimizing involvement in practices that are detrimental to the crocodiles. Specifically, tailor-made awareness raising and capacity building initiatives should be developed for women, Muslims, older people and livestock keepers to increase their participation in ranching-based crocodile utilization. Additionally, such initiatives should be targeted at males, Christians, older people and high income earners with a view to minimizing their involvement in illegal utilization and increasing their adoption of sustainable utilization of crocodiles.

Acknowledgements

We thank all the community members, crocodile ranch managers and Kenya Wildlife Service officers for their collaboration. The support of Calvince Ngaji in data analysis is appreciated. We thank Dr. Norah Mose for proofreading the manuscript and Benson Ibrahim for logistical support during field work. Last but not least, we thank all the anonymous reviewers for their comments and suggestions which greatly improved this paper.

Declaration of Conflicting Interests

The authors declare no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

Ethical Statement

Ethical Approval

This study was conducted in accordance with the national legislation for conducting research (National Commission for Science, Technology and Innovation (NACOSTI; Permit Number NACOSTI/P/19/11428/2775) and approved by Egerton University Research Ethics Review Committee (EUREC; Approval Number EUREC/APP/083/2019). All participants gave their informed consent for inclusion before participating in the study.

ORCID iD

Margaret N. Mosse  <https://orcid.org/0000-0002-4076-7199>

Data Availability Statement

The authors confirm that the data and materials supporting the findings of this study are available within the article, its supplementary materials and in “Figshare” at DOI-10.6084/m9.figshare.23742846.

Supplemental Material

Supplemental material for this article is available online.

References

- Akinsorotan, O. A., Olaniyi, O. E., Oguntuase, B. G., & Raheem, T. (2020). Dynamics and socioeconomic drivers of illegal hunting of wildlife animal for consumption in Oba Hills Forest Reserve in Southwest Nigeria. *Journal of Applied Sciences and Environmental Management*, 24(2), 287–298. <https://doi.org/10.4314/jasem.v24i2.15>
- Andre, C. P., Thiago, C. G. P., & Adriana, M. (2022). Population ecology and human disturbance effects on two caiman species in the Southern Brazilian Amazon South American. *Journal of Herpetology*, 23(1), 32–41. <https://doi.org/10.2994/SAJH-D-19-00110.1>
- Anthony, M., Knuth, B., & Lauber, T. (2004). Gender and citizen participation in wildlife management decision making. *Society & Natural Resources*, 17, 395–411. <https://doi.org/10.1080/08941920490430179>
- Aust, P., Boyle, B., Fergusson, R., & Coulson, T. (2009). The impact of Nile crocodiles on rural livelihoods in Northeastern Namibia. *South African Journal of Wildlife Research*, 39(1), 57–69. <https://doi.org/10.3957/056.039.0107>
- Baker, L. R., Olubode, O. S., Tanimola, A. A., & Garshelis, D. L. (2014). Role of local culture, religion, and human attitudes in the conservation of sacred populations of a threatened ‘pest’ species. *Biodiversity and Conservation*, 23(8), 1895–1909. <https://doi.org/10.1007/s10531-014-0694-6>
- Brackhane, S., Webb, G., Xavier, F. M. E., Trindade, J., Gusmao, M., & Pechacek, P. (2019). Crocodile management in Timor-Leste: Drawing upon traditional ecological knowledge and cultural beliefs. *Human Dimensions of Wildlife*, 24(4), 314–331. <https://doi.org/10.1080/10871209.2019.1614240>
- Calverley, P. M., & Downs, C. T. (2017). The past and present nesting ecology of Nile crocodiles in Ndumo Game Reserve, South Africa: Reason for concern? *Journal of Herpetology*, 51(1), 19–26. <https://doi.org/10.1670/13-200>
- Convention on International Trade in Endangered Species of Wild Fauna and Flora. (2010). Ranching and trade in ranched specimens of species transferred from Appendix I to Appendix II. In 15th Meeting of the Conference of Parties, *CoP 15*. <https://www.cites.org/eng/res/11/11-16R15.php>
- Convention on International Trade in Endangered Species of Wild Fauna and Flora. (2013). Species information on taxonomy, legislation, distribution and trade in MEA-listed species. *Convention on International Trade in Endangered Species of Wild Fauna and Flora*. https://www.speciesplus.net/species#/taxon_concepts?taxonomy=cites_eu&taxon_concept_query=Crocodylia&geo_entities_ids=&geo_entity_scope=cites&page=1
- Convention on International Trade in Endangered Species of Wild Fauna and Flora. (2019). *Harvest and trade of Nile Crocodiles in Kenya*. CITES and Livelihoods Case Study 2019 (Resolution Resolution Conf. 16.6 (Rev. CoP18)). CITES. <https://cites.org/sites/default/files/document/E-Res-16-06-R18.pdf>
- Conover, M. R. (2001). *Resolving human-wildlife conflicts: The science of wildlife damage management*. CRC Press.
- Corey, B., Webb, G. J. W., Manolis, S. C., Fordham, A., Austin, B. J., Fukuda, Y., Nicholls, D., & Saalfeld, K. (2017). Commercial harvests of saltwater crocodile (*Crocodylus porosus*) eggs by Indigenous people in northern Australia: Lessons for long-term viability and management. *Oryx*, 52(4), 697–708. <https://doi.org/10.1017/S0030605317000217>
- Crocodile Specialist Group. (2004). *Review of crocodile ranching programs*. IUCN/SSC Crocodile Specialist Group (CSG), Sanderson, Australia.
- Crocodile Specialist Group. (2018). *Conservation status of crocodilians*. Crocodile Specialist Group. <https://www.iucnscg.org/pages/Conservation-Status.html>
- Cuni-Sanchez, A., Pfeifer, M., Marchant, R., & Burgess, N. D. (2016). Ethnic and locational differences in ecosystem service values: Insights from the communities in forest islands in the desert. *Ecosystem Services*, 19, 42–50. <https://doi.org/10.1016/j.ecoser.2016.04.004>
- Daltry, J. C., Langelet, E., Solmu, G.C., van der Ploeg, J., van Weerd, M., & Whitaker, R. (2016). Successes and failures of crocodile harvesting strategies in the Asia Pacific. In (eds A. A. Aguirre, & R. Sukumar) *Tropical Conservation*, pp. 345–362. Oxford University Press, New York, USA
- Dzoma, B. M., Sejoe, S., & Segwagwe, B. V. E. (2008). Commercial crocodile farming in Botswana. *Tropical Animal Health and Production*, 40(5), 377–381. <https://doi.org/10.1007/s11250-007-9103-4>

- Evans, L. J., Jones, T. H., Pang, K., Saimin, S., & Goossens, B. (2016). Spatial ecology of estuarine crocodile (*Crocodylus porosus*) nesting in a fragmented landscape. *Sensors*, 16(9), 1527. <https://doi.org/10.3390/s16091527>
- Fergusson, R. A. (2010). Nile crocodile (*Crocodylus niloticus*) (pp. 84–89) [Status Survey and Conservation Action Plan]. IUCN Crocodile Specialist Group. https://www.iucnscg.org/365_docs/attachments/protarea/15_C-cf25967f.pdf
- Food and Agriculture Organization of the United Nations. (2017). *The community land rights of women and youth in Tana River and Turkana Counties: A synthesis report*. <https://www.fao.org/3/i7074e/i7074e.pdf>
- Frank, B. (2016). Human–wildlife conflicts and the need to include tolerance and coexistence: An introductory comment. *Society & Natural Resources*, 29(6), 738–743. <https://doi.org/10.1080/08941920.2015.1103388>
- Fukuda, F., Manolis, C., & Apparel, K. (2014). Management of human-crocodile conflict in the Northern Territory, Australia: review of crocodile attacks and removal of problem crocodiles. *The Journal of Wildlife Management*, 78(7), 1239–1249. <https://www.jstor.org/stable/43188263>
- Gari, A. (2015, February 20). Under siege: Who is killing crocodiles in Tana River? *The Star Newspaper*. <https://www.the-star.co.ke/sasa/lifestyle/2015-02-20-under-siege-who-is-killing-crocodiles-in-tana-river/>
- Githui, P. N. (2020). *Spiritual interreligious dialogue, Kenya: Conflict management among the Wardei and Pokomo communities*. <https://dsc.duq.edu/cgi/viewcontent.cgi?article=1290&context=spiritual-horizons>
- Government of Kenya. (2013). *The Wildlife Conservation and Management Act* (Acts No. 47). <https://kenyalaw.org/kl/fileadmin/pdfdownloads/Acts/WildlifeConservationandManagementAct2013.pdf>
- Government of Kenya. (2018a). *Tana River County: Second County Integrated Development Plan: 2018–2022. Kenya Vision 2030*.
- Government of Kenya. (2018b). *Kenya Social and Economic Inclusion Projects*. <https://documents1.worldbank.org/curated/zh/668051531225018126/FINAL-KSEIP-Social-Assessment-July-9-2018.docx>
- Harrison, M., Baker, J., Twinamatsiko, M., & Milner-Gulland, E. J. (2015). Profiling unauthorized natural resource users for better targeting of conservation interventions. *Conservation Biology*, 29(6), 1636–1646. <https://doi.org/10.1111/cobi.12575>
- Hazzah, L., Dolrenry, S., Naughton, L., Edwards, C. T. T., Mwebi, O., Kearney, F., & Frank, L. (2014). Efficacy of two lion conservation programs in Maasailand, Kenya: Efficacy of lion conservation programs. *Conservation Biology*, 28(3), 851–860. <https://doi.org/10.1111/cobi.12244>
- Hughes, A., Auliya, M., Altherr, S., Scheffers, B., Janssen, J., Nijman, V., Sgpherd, C. R., D’Cruze, Sy, E., & Edwards, D. P. (2023). Determining the sustainability of legal trade. *Journal of Environmental Management*, 341. <https://www.sciencedirect.com/science/article/pii/S0301479723007752>
- International Business Machines Corporation. (2011). *IBM SPSS Statistics 20 Brief Guide*. IBM Corporation. <https://www.manua.ls/ibm/spss-20/manual>
- Jelden, D., Robert, W. G., Jenkins, A. M., & Caldwell, J. (2014). *Crocodylians and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)*. IUCN-Crocodile Specialist Group. https://www.iucnscg.org/365_docs/attachments/protarea/Jeld-b0b18719.pdf
- Jeremiah, C., & Reniko, G. (2018). The human crocodile conflicts and the sustainable conflict resolutions review. *International Journal of Environmental Sciences & Natural Resources*, 13(2), 1–8. <https://doi.org/10.19080/IJESNR.2018.13.555856>
- Joshua Project. (2019). *Watta in Kenya*. https://joshuaproject.net/people_groups/14753/KE
- Jyrwa, J. D., Joshi, B. D., Ghosh, A., Mayi, Y., Nipa, M., Anga, N., Pali, M., Thakur, M., Chandra, K., & Sharma, L. K. (2020). Dimensions of changing perception towards wildlife conservation in East Siang district of Arunachal Pradesh, Eastern Himalayas. *Global Ecology and Conservation*, 24. <https://doi.org/10.1016/j.gecco.2020.e01265>
- Kahler, J. S., Roloff, G. J., & Gore, M. L. (2013). Poaching risks in community-based natural resource management: Poaching and community-based management. *Conservation Biology*, 27(1), 177–186. <https://doi.org/10.1111/j.1523-1739.2012.01960.x>
- Kiffner, C., Peters, L., Stroming, A., & Kioko, J. (2015). Bushmeat consumption in the Tarangire-Manyara Ecosystem, Tanzania. *Tropical Conservation Science*, 8(2), 318–332. <https://doi.org/10.1177/194008291500800204>
- Kenya National Bureau of Statistics. (2015). Spatial dimensions of well-being in Kenya. In *Where are the poor? From Counties to Wards*. Kenya National Bureau of Statistics.
- Kenya National Bureau of Statistics. (2019). *The 2019 Kenya population and housing census* (p. 38). Government of Kenya. <https://www.knbs.or.ke/?wpdmpro=2019-kenya-population-and-housing-census-volume-i-population-by-county-and-sub-county>
- Kuckartz, U., & Stefan, R. (2019). *Analyzing qualitative data with MAXQDA: Text, Audio, and Video*. Springer. <https://link.springer.com/content/pdf/bfm:978-3-030-15671-8/1?pdf=chaptertoc>
- Kümpel, N. F., Milner-Gulland, E. J., Cowlishaw, G., & Rowcliffe, J. M. (2010). Incentives for hunting: The role of bushmeat in the household economy in rural Equatorial Guinea. *Human Ecology*, 38(2), 251–264. <https://doi.org/10.1007/s10745-010-9316-4>
- Kyalo, S. (2008). Non-detriment finding studies on Nile crocodile (*Crocodylus niloticus*): The status of and trade in the Nile crocodile in Kenya. In *NDF Workshop Case Studies, Workshop Case Studies*, 16. https://www.cites.org/sites/default/files/ndf_material/WG7-CS1.pdf
- Li, X., Bleisch, W. V., & Jiang, X. (2016). Effects of ethnic settlements and land management status on species distribution patterns: A case study of endangered musk deer (*Moschus* spp.) in Northwest Yunnan, China. *PLOS ONE*, 11(5). <https://doi.org/10.1371/journal.pone.0155042>

- Lindsey, P. A., Balme, G., Becker, M., Begg, C., Bento, C., Bocchino, C., Dickman, A., Diggle, R. W., Eves, H., Henschel, P., Lewis, D., Marnewick, K., Mattheus, J., Weldon McNutt, J., McRobb, R., Midlane, N., Milanzi, J., Morley, R., Murphree, M., & Zisadza-Gandiwa, P. (2013). The bushmeat trade in African savannas: impacts, drivers, and possible solutions. *Biological Conservation*, *160*, 80–96. <https://doi.org/10.1016/j.biocon.2012.12.020>
- Loibooki, M., Hofer, H., & East, M. (2002). Bushmeat hunting by communities adjacent to the Serengeti National Park, Tanzania: The importance of livestock ownership and alternative sources of protein and income. *Environmental Conservation*, *29*(3), 391–398. <https://doi.org/10.1017/S0376892902000279>
- Lopez-Feldman, A. (2014). Shocks, income and wealth: Do they affect the extraction of natural resources by rural households? *World Development*, *64*, S91–S100.
- MacMillan, D. C., & Nguyen, Q. A. (2014). Factors influencing the illegal harvest of wildlife by trapping and snaring among the Katu ethnic group in Vietnam. *Oryx*, *48*(2), 304–312. <https://doi.org/10.1017/S0030605312001445>
- Manolis, S. C., & Webb, G. J. W. (2016). *Best Management Practices for Crocodylian Farming*. IUCN-SSC Crocodile Specialist Group. https://www.iucnscg.org/365_docs/attachments/protarea/227c50b2e92bf796cbb1573bdd348b12.pdf
- Madhusudan, M. D. (2003). Living amidst large wildlife: Livestock and crop depredation by large mammals in the interior villages of Bhadra Tiger Reserve, South India. *Environmental Management*, *31*(4) 466–475. <https://doi.org/10.1007/s00267-002-2790-8>
- Meeks, D., Morton, O., & Edwards, D. P. (2024). Wildlife farming/: Balancing economic and conservation interests in the face of illegal wildlife trade. *People and Nature*. <https://doi.org/10.1002/pan3.10588>
- Mogomotsi, P. K., Stone, L. S., Mogomotsi, G. E. J., & Dube, N. (2020). Factors influencing community participation in wildlife conservation. *Human Dimensions of Wildlife*, *25*(5), 1–15. <https://doi.org/10.1080/10871209.2020.1748769>
- Mohamed, A. (2015). *Underlying causes of inter-ethnic conflict in Tana River County, Kenya*. [Unpublished Masters Thesis]. University of Manitoba. <https://mspace.lib.umanitoba.ca/xmlui/handle/1993/30598>
- Musambachime, M. (1987). The fate of Nile crocodile in African waterways. *African Affairs* *86*(343) 197–207. <https://www.jstor.org/stable/722471>
- Mustapha, S. B. A., Bzugu, P. M. B., & Gwary, M. M. (2012). Socio-economic factors affecting participation in farm forestry among farming households in the Sahelian environment of Borno State, Nigeria. *OIDA International Journal of Sustainable Development*, *4*(9), 121–128.
- National Gender and Equality Commission. (2014). *Flares of marginalization among selected minority communities of Kenya*. <https://www.ngeckkenya.org/Downloads/flares-of-marginalization-in-Kenya.pdf>
- Nguyen, T. T., Do, T. L., & Grote, U. (2018). Natural resource extraction and household welfare in rural Laos. *Land Degradation & Development*, *29*(9), 3029–3038. <https://doi.org/10.1002/ldr.3056>
- Ntuli, H., Jagers, S. C., Linell, A., Sjöstedt, M., & Muchapondwa, E. (2019). Factors influencing local communities' perceptions towards conservation of transboundary wildlife resources: The case of the Great Limpopo Trans-frontier Conservation Area. *Biodiversity and Conservation*, *28*(11), 2977–3003. <https://doi.org/10.1007/s10531-019-01809-5>
- Ntuli, H., & Muchapondwa, E. (2018). The role of institutions in community wildlife conservation in Zimbabwe. *International journal of the commons*, *12*(1), 134–169. <https://www.jstor.org/stable/26522950>
- Nyhus, P.J., Osofsky, S.A., Ferraro, P., Madden, F., & Fischer, H. (2005). Bearing the costs of human-wildlife conflict: The challenges of compensation schemes. In R. Woodroffe, S. Thirgood, & A. Rabinowitz (Eds.), *People and Wildlife: Conflict or Coexistence?* (pp 107–121). Cambridge University Press. Cambridge, UK.
- Odhengo, P., Matiku, P., Nyangena, J., Wahome, J., Opa, K., Munguti, B., Koyier, G., Nelson, P., & Mnyamwesi, E. (2014). *Tana River Delta Strategic Environmental Assessment*. Ministry of Lands.
- Ovando, S. (2008, June 2–6). Equitable sharing of benefits in the Caiman Production Network. In Crocodile Specialist Group of the Species Survival Commission. The 19th Working Meeting, Santa Cruz de la Sierra, Bolivia. <https://portals.iucn.org/library/efiles/documents/NS-2008-001.pdf>
- Pooley, S. (2016). A cultural herpetology of Nile crocodiles in Africa. *Conservation and Society*, *14*(4), 391. <https://doi.org/10.4103/0972-4923.197609>
- Pooley, S. (2019). *Using data to improve human-crocodile coexistence*. <https://www.oryxthejournal.org/blog/using-data-to-improve-human-crocodile-coexistence/>
- Raley, B.G. (2016). Endangered and dangerous: How a special exemption from CITES Appendix I classification could counterintuitively protect certain reptile species from extinction. *The Institute for Legal Studies*, *33*(4), 153–173. <https://doi.org/10.18018/HYLR.2016.33.4.153>
- Refsnider, J. M. (2016). Nest-site choice and nest construction in non-avian reptiles: Evolutionary significance and ecological implications. *Avian Biology Research*, *9*(2), 76–88. <https://doi.org/10.3184/175815516X14490631289752>
- Reuter, K. E., Sewall, B. J., & Minin, E. D. (2018). Drivers of present and lifetime natural resource use in a tropical biodiversity hotspot. *Animal Conservation*, *21*(2), 127–136. <https://doi.org/10.1111/acv.12355>
- Revol, B. (1995). Crocodile farming and conservation, the example of Zimbabwe. *Biodiversity and Conservation*, *4*(3), 299–305. <https://doi.org/10.1007/BF00055975>
- Salem, A. H. I. (2013). Habitat vulnerability for the Nile Crocodile (*Crocodylus niloticus*) in Nasser Lake (Egypt). *Transylvanian Review of Systematical and Ecological Research*, *15*(1), 19–32. <https://doi.org/10.2478/trser-2013-0003>
- Sikamani, A., Mashapa, C., Muboko, N., Mutanga, C., N., & Gandiwa, E. (2023). Trends and local perceptions of

- human-crocodile conflicts in Kariba town, northern Zimbabwe. *Human Dimensions of wildlife*. <https://doi.org/10.1080/10871209.2023.2243970>
- Sine, R., David, W., & Godfrid, S. M. (2008). *Community participation in conservation and management of crocodiles through the egg harvest program in the Sepik Region of Papua New Guinea*. Crocodile Specialist Group. <https://portals.iucn.org/library/efiles/documents/NS-2008-001.pdf>
- Solomon, J. N., Gavin, M. C., & Gore, M. L. (2015). Detecting and understanding non-compliance with conservation rules. *Biological Conservation*, *189*, 1–4. <https://doi.org/10.1016/j.biocon.2015.04.028>
- Somaweera, R., Brien, M. L., Sonneman, T., Didham, R. K., & Webber, B. L. (2019). Absence of evidence is not evidence of absence: Knowledge shortfalls threaten the effective conservation of freshwater crocodiles. *Global Ecology and Conservation*, *20*. <https://doi.org/10.1016/j.gecco.2019.e00773>
- Somaweera, R., Nifong, J., Rosenblatt, A., Brien, M., Combrink, X., Eelsey, R., Grigg, G., Magnusson, W., Mazzotti, F., Percy, A., Shirley, M., Tellez, M., van der Ploeg, J., Webb, G., Whitaker, R., & Webber, B. (2020). The ecological importance of crocodylians: Towards evidence-based justification for their conservation. *Biological Reviews*, *95*, 936–959. <https://doi.org/10.1111/brv.12594>
- Somaweera, R., & Shine, R. (2013). Nest-site selection by crocodiles at a rocky site in the Australian tropics: Making the best of a bad lot: constraints on nest-site selection. *Austral Ecology*, *38*(3), 313–325. <https://doi.org/10.1111/j.1442-9993.2012.02406.x>
- Sunderland, T., Achdiawan, R., Angelsen, A., Babigumira, R., Ickowitz, A., Paumgarten, F., Reyes-García, V., & Shively, G. (2014). Challenging perceptions about men, women, and forest product use: A global comparative study. *World Development*, *64*, S56–S66. <https://doi.org/10.1016/j.worlddev.2014.03.003>
- Terer, T., Ndiritu, G. G., & Gichuki, N. N. (2004). Socio-economic values and traditional strategies of managing wetland resources in lower Tana River, Kenya. *Hydrobiologia*, *527*(1) 3-15. <https://link.springer.com/article/10.1023/B:HYDR.0000043332.96368.c5>
- Than, K., Hughes, A., & Zaw, Z. (2020). Integrating local perspectives into conservation could facilitate human-crocodile coexistence in the Ayeyarwady Delta, Myanmar. *Oryx*, *56*(1) 82-90. <https://doi.org/10.1017/S003060532000037X>
- Thorbjarnarson, J. (1999). Crocodile Tears and Skins: International Trade, Economic Constraints, and Limits to the Sustainable Use of Crocodylians. *Conservation Biology*, *13*(3), 465–470. <https://doi.org/10.1046/j.1523-1739.1999.00011.x>
- Treves, A., & Bruskotter, J. (2014). Tolerance for predatory wildlife. *Science*, *344*, 476–477. <https://doi.org/10.1126/science.1252690>
- Utete, B. (2021). A review of the conservation status of the Nile crocodile (*Crocodylus niloticus* Laurenti, 1768) in aquatic systems of Zimbabwe. *Global Ecology and Conservation*, *29*. <https://doi.org/10.1016/j.gecco.2021.e01743>
- van der Ploeg, J., Arano, R. R., & van Weerd, M. (2011). What local people think about crocodiles: Challenging environmental policy narratives in the Philippines. *Journal of Environment & Development*, *20*(3), 303–328. <https://doi.org/10.1177/1070496511416743>
- Wallace, K. M., & Leslie, A. J. (2008). Diet of the Nile crocodile (*Crocodylus niloticus*) in the Okavango Delta, Botswana. *Journal of Herpetology*, *42*(2), 361–368.
- Weber, D. S., Mandler, T., Dyck, M., Van Coeverden De Groot, P. J., Lee, D. S., & Clark, D. A. (2015). Unexpected and undesired conservation outcomes of wildlife trade bans—An emerging problem for stakeholders? *Global Ecology and Conservation*, *3*, 389–400. <https://doi.org/10.1016/j.gecco.2015.01.006>
- Yang, N., Zhang, E., & Chen, M. (2010). Attitudes towards wild animal conservation: A comparative study of the Yi and Mosuo in China. *International Journal of Biodiversity Science, Ecosystem Services & Management*, *6*(1–2), 61–67. <https://doi.org/10.1080/21513732.2010.509630>
- Ylvisaker, M. (1982). Reviewed Work: Islamization among the Upper Pokomo. *The International Journal of African Studies*, *15*(4), 707-709.