sustainability

MDPI

Article

Elephant Crop Damage: Subsistence Farmers' Social Vulnerability, Livelihood Sustainability and Elephant Conservation

Vincent R. Nyirenda [1,*], Bimo A. Nkhata [2], Oscar Tembo [3] and Susan Siamundele [4]

1 Department of Zoology and Aquatic Sciences, The Copperbelt University, Riverside Campus, P.O. Box 21692, Kitwe, Zambia
2 Monash University South Africa, Directorate of Water Research Node, Private Bag X60, Roodepoort 1725, Johannesburg, South Africa; bimo.nkhata@monash.edu
3 Dag Hammarskjöld Institute of Peace and Conflict Studies, The Copperbelt University, Riverside Campus, P.O. Box 21692, Kitwe, Zambia; oscar.tembo@cbu.ac.zm
4 Department of National Parks and Wildlife, Private Bag 1, Chilanga 10100, Zambia; susan.siamundele@mota.gov.zm or susiamunde@yahoo.com
* Correspondence: vincent.nyirenda@cbu.ac.zm; Tel.: +260-977-352-035

Received: 20 August 2018; Accepted: 26 September 2018; Published: 7 October 2018

check for updates

Abstract: African elephants (*Loxodonta africana*) induce considerable crop damage risks, shocks and stresses on subsistence farmers at the wildlife-agriculture interface. In this study, we explored the social dimensions of human-elephant interactions in the wildlife-agrarian landscape. The study aimed at unraveling the associated hazardous conditions and nature of the subsistence farmers' social vulnerability and practices with respect to elephant crop damage, subsistence farmers' livelihoods, and elephant conservation. Applying qualitative thematic content analysis, the sustainable livelihood framework (SLF) and additive generalized linear models (GLMs), this study revealed that the status of relational social capital influences human-elephant conflict (HEC) management and subsistence farmers' responses, regardless of the farmers' social learning and environmental values about the social-ecological system. The strengthening of multiple local stakeholder participation, institutional governance and access to livelihoods assets are needed for human food security and elephant conservation. Adoption of more effective nuanced crop protection counter-measures against elephants at farm level is urgently needed.

Keywords: crop protection; disaster risk reduction; environmental attitudes; *Loxodonta africana*; relational social capital

1. Introduction

Wildlife conservation conflicts arise when people are affected by the enforcement or non-enforcement of conservation measures such as rules, regulations and laws [1]. Conservation conflicts represent underlying disagreements among people, which need to be addressed to support human well-being and biodiversity conservation [2]. Competing claims over land use by various interest groups such as farmers and wildlife agencies particularly in drylands [3], and limited space and resources for humans and wildlife due to increasing human and wildlife populations [4], could be escalating the wildlife conservation conflicts in wildlife-agrarian landscapes. As conservation conflicts negatively impact on humans and wildlife, several conservation organizations seek urgent solutions to manage the increasing wildlife conservation conflicts (e.g., [5–7]). The interventions include those that target the management of human-wildlife conflicts (HWCs), largely involving human behaviors [8]. According to [9], HWCs occur when "wildlife impacts humans negatively (physically, economically, or psychologically), and where humans likewise negatively impact wildlife". Among a range of the key 'problem animals' are the African elephants (*Loxodonta africana*). In particular, human-elephant conflicts (HECs) have potential to cause considerable food insecurity to the affected farmers through crop damage by elephants [10].

Like other wildlife conservation conflicts, the crop damage by elephants is complex, severe, widespread and often a protracted challenge to subsistence farmers, wildlife managers and conservationists (e.g., [11–13]). Several spatio-temporal factors such as seasonality, type of mitigation methods, proximity to protected areas and water, and farm sizes are associated with elephant-caused crop damage (e.g., [14–17]). Based on how farmers make sense of 'problem elephants' [18], crop agriculture in elephant home ranges increases the levels of interactions between subsistence farmers and elephants through farmers' encroachment into elephant habitats [19]. Elephants will often roam about seeking food supplements in crop fields, where they devour crops or trample upon them [20]. Within such HECs, humans themselves, for instance, farmers, conservationists and wildlife practitioners, often conflict with each other over elephant crop damage [21]. The conflicts can have wide-ranging negative socio-economic and environmental impacts on subsistence farmers [22]. As such, public outcries, bad publicity and political overtones ensue, undermining efforts targeted at conserving the elephants, which are vulnerable species [19,23,24].

As HECs occur in complex social-ecological contexts, with multiple social, political, cultural, economic and ecological subcomponents, their nature is multi-dimensional and their effects multi-directional [25,26]. Elephant feeding behaviors are dynamic [15,27,28]. In this apparent dilemma, the subsistence farmers are usually fraught with myriad socio-economic challenges associated with elephant crop damage. Through poaching as a coping strategy by the local communities [29,30], the affected subsistence farmers resort to over-exploitation of natural resources such as elephants to avert food insecurity and hardships [31]. The way in which substance farmers exploit natural resources may lack a set of local rules and sanctions that could allow sustainable use, particularly where collaborative conservation institutions are weak and have low stakeholder participation [32,33]. In the absence of functional institutions and with undue human pressure to overcome livelihood hardships, human resilience to conserve elephants may also eventually collapse [34,35]. The functional institutions of sustainability would encompass various social governance elements *inter alia* functional governance structures, processes, policies, and norms relevant to elephant conservation [36,37].

The purpose of this study is to explore the site-level social dimensions of elephant crop damage, using the sustainable livelihoods framework (SLF) [38], and the theory of social exchange [39], which advances trade-offs of benefits and risks in relationships between parties. Livelihoods imply the available means to individuals to secure the necessities of life [40]. 'Sustainable' denotes a sense of endurance and resilience to shocks and stresses. For instance, sustainable livelihoods may be secured through the ability of subsistence farmers to sufficiently protect their crops from elephants, and cultivate crops less preferred by elephants. Consistent with the 'sustainable' concept, subsistence farmers should make a living out of crop farming without depleting or negatively impacting on the environment within which crops are produced across human generations [41]. A crop farming livelihood is considered sustainable when it is able to cope and recover from shocks and stresses such as elephant crop damage, thereby maintaining its crop farming capabilities and assets for the next generations. Therefore, elephant crop damage can be considered as a livelihood risk [30], exacerbated by ineffective farm-based interventions such as traditional counter-measures (e.g., use of fire, cans and shouting elephants away). However, effective on-farm interactions integrate landscape-based attributes for the coexistence of human-elephants [42,43]. The elephant crop damage induces a wide range of socio-economic and health-related shocks and stresses to the affected subsistence farmers, who usually are unable to cope, and they can also disrupt their livelihoods [44]. As such, the social vulnerability of the subsistence farmers can be expressed as: (1) human exposure; (2) sensitivity; and (3) adaptive capacity to cope or adjust to negative impacts of risks, shocks and stresses [45]. In this study, human exposure is considered as the way humans, particularly their crops, come into contact with elephants. On the other hand, sensitivity refers to what extent and how humans respond to elephant crop damage. The farmers' ability to respond may largely depend on their affluence in terms of socio-economic-political resources at their disposal to deal with crop damage as it arises. This study assumed that the social livelihoods assets such as trust, commitment, cooperation and networking are accessed and influenced through applicable public and private structures and laws, policies, local cultures and institutional processes. As such, legitimate local institutions are intended to support customs, behavioral patterns and rules in natural resource (e.g., elephants) management by local actors [46].

This study is motivated by the contextual nature of local social vulnerability to elephant crop damage that subsistence farmers face and how they respond to such vulnerability, which could also inform regions with similar settings. Whereas many studies have previously been conducted on biological and physical aspects of elephant crop damage [47,48], this study interrogates site-level interventions by further exploring the social perspectives of subsistence farmers' vulnerability. This study addresses the research question: what are the elephant crop damage-related social vulnerability factors experienced by subsistence farmers?

2. Materials and Methods

2.1. Study Site

The study was conducted in March–May, 2016 in the Lupande Game Management Area (GMA) (4840 km^2) in the Luangwa Valley, eastern Zambia (Figure 1). Given that social vulnerability is dynamic, site-specific and contextual, the long-term interactions between subsistence farmers and African elephants in the Luangwa Valley, Zambia [49], as a study site had potential to provide valuable lessons on farmer-elephant relationship. The area has six chiefdoms (Jumbe, Kakumbi, Malama, Mnkhanya, Msoro and Nsefu) under customary tenure, where land is issued to subsistence farmers by the traditional leadership per farmers' need but recipients do not necessary own it (i.e., *res nullius*). Infestation of sleeping sickness trypanosomiasis-causing tsetse flies (*Glossinapallidipes*) does not seem to discourage the growing farmer population in the Luangwa Valley; essentially *refugia* for multiple wildlife species [50]. The Luangwa Valley has savannah vegetation and tropical climatic conditions [51] and with over 70% of elephants inhabiting the area, it is considered Zambia's stronghold of elephants [52].

Inhabiting the Lupande GMA is a human population estimated at 68,918 people in 13,196 households, with an annual average rate of population increase of 3.8% ([53], p. 19). The area is increasingly under pressure from influx of people for tourism-related jobs, and widely practiced subsistence crop agriculture [29,49]. However, elephant crop damage is pervasive in the area [54]. Furthermore, human habitat encroachment and illegal killings of elephants are an increasing threat to elephant persistence [29]. Local stakeholder participation in HEC interventions is through various structures such as clans (family ties), traditional leaderships, Community Resources Boards (CRBs) and Village Action Groups (VAGs), tour operators, farmer cooperatives, and local hunters. The government and cooperating partners such as the World Food Program provide the affected subsistence farmers in the Luangwa Valley with 'relief food' to help the subsistence farmers cope with food deprivation. Maize (*Zea mays*) is a staple food in the area. Food insecurity is heightened by the area being located in agro-ecological zone III with frequent severe droughts that result in crop failures [5] coupled with elephant crop damage. Currently, the Lupande GMA in particular and Zambia in general have no compensation schemes such as crop insurance against losses to elephants.

2.2. Data Gathering Protocols

Field data collection was preceded by research authorization and ethics clearance from Department of National Parks and Wildlife, and Copperbelt University, respectively. The semi-structured questionnaires, with open and closed questions (Appendix A), were administered at household level to 281 randomly sampled subsistence farmers, based on Mambwe District records. According to [55], the open and closed questions in semi-structured questionnaires complement each other in deriving qualitative and quantitative responses. The respondents, who were either elderly male or female heads of their households, were randomly drawn from 73 villages in 26 representative VAGs of 42 of the six chiefdoms of Lupande GMA in Mambwe District. Furthermore, 30 focus group ethnographic interviews were adopted in accordance with [56] and applied to traditional leadership, members of CRBs and VAGs, tour operators, farmer cooperatives, and local hunters. The topics covered in open ethnographic discussions triangulated the questionnaires and included: (1) perceived predictors of social vulnerability; (2) local enablers and inhibitors of social vulnerability; (3) adaptive capacities to manage crop damage; and (4) local stakeholder participation in HEC interventions. No null responses were received from participants (i.e., 100% response rate).

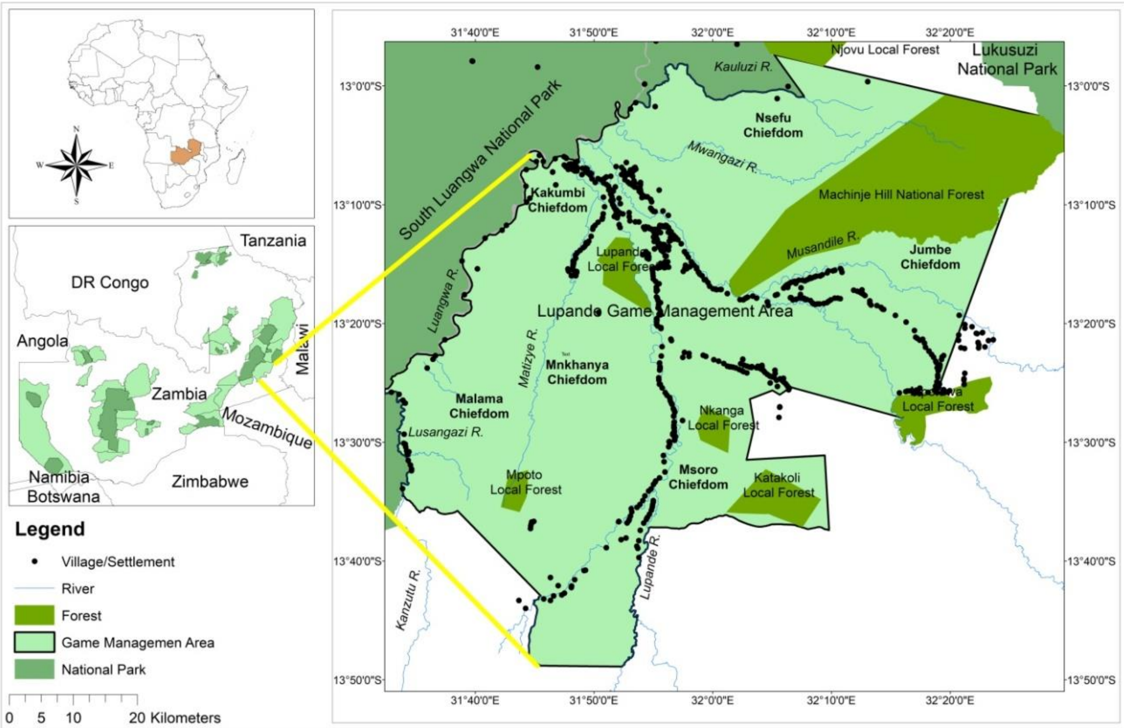

Figure 1. The study site of Lupande Game Management Area (GMA) in the Luangwa Valley, eastern Zambia.

2.3. Analyses

Prior to administering the questionnaires and conducting focus group interviews, in-depth search of linkages and issues about social vulnerability and practices by the subsistence farmers was made through a literature review (Table 1). During the interviews, a qualitative thematic content-analysis technique was applied on focus group discussion-based data in accordance with protocols suggested by [57], where the explanations given by the participants were confirmed and classified according to the identified themes. A *priori* set of hypotheses was developed during focus group discussions (Table 1). The key question that was answered and discussed by the participants during the focus group discussions was: what do you perceive as factors influencing people's social vulnerability to crop raiding? Furthermore, Minitab version 14 statistical package was applied using frequentist statistics, involving chi-square tests of association of crop damage (i.e., with or without crop damage) with selected social demographics given in Table 2. The data for chi-square tests were based on the preliminary interview questions of Appendix A (Q1–10). In the case of a frequentist approach to the use of chi-square, a 5% standard level of significance (α = 0.05) was applied. As resistant measures of the statistical populations [58], medians of perceived levels of subsistence farmers' capitals in

Lupande GMA were adopted and determined from a Likert-type scoring system of values between 0 and 5, where 0 and 5 represent absent and high respectively (Figure 2, for interview question refer to Appendix A-Q20). Similarly, analysis of specific interview questions in Appendix A is given in respective sub-sections of the results section. Furthermore, the SLF was adopted for its rigor as it highlighted in detail diverse aspects of livelihoods [59], which was the basis for identification of capacity indices [60] during the focus group discussions. From the focus group discussions, each type of capital was initially treated as a composite factor, which was further broken down into identified dimensions for analyses and narratives (Figure 2).

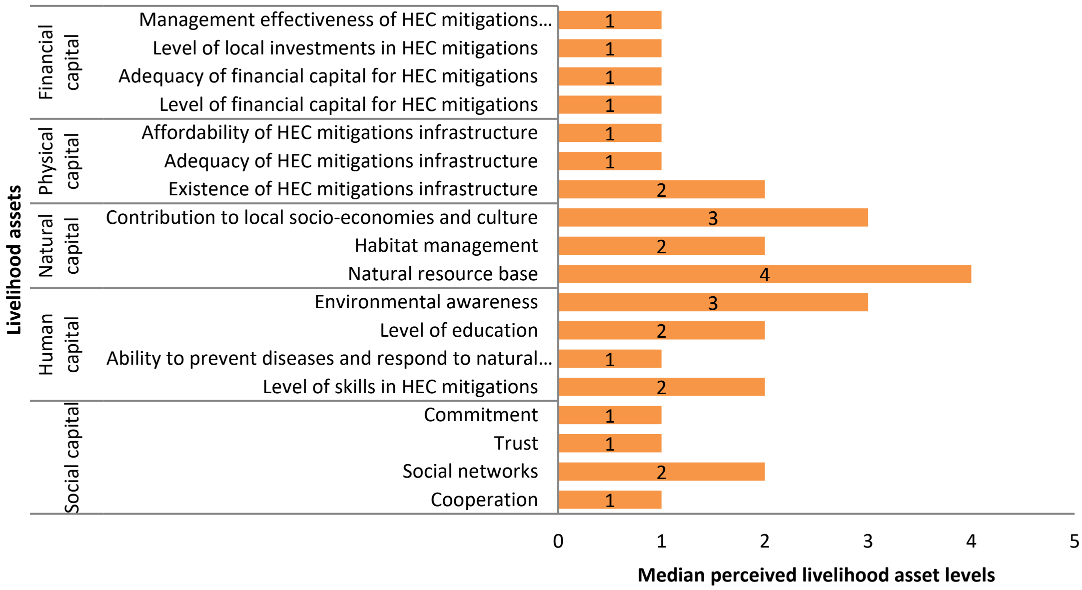

Figure 2. Median perceived levels of livelihood assets by subsistence farmers in Lupande GMA, Luangwa Valley, eastern Zambia, March–May 2016, measured in relation to human-elephant conflict (HEC) and their ability to respond.

We subjected the quantitative data of independent variables from interviews (Appendix A: Q23) to correlation tests to avoid multicollinearity [61,62]. Due to multicollinearity problem, variables such as external financial remittances and skills development were correlated, and consequently at this stage we retained only five non-correlated variables (Tables 1 and 3). The five selected social vulnerability indices (Table 3) were generated from literature and interviews in focus group discussions, and then integrated in Appendix A (Q23) for ranking by participants during the interviews. The indices were the explanatory variables which were deductively analysed using model selection and ranking techniques [61,63]. The response (dependent) variable was the percentage (%) of loss to elephants, in maize (staple food) in the crop field/food storage facility. Subsistence farmers estimated crop/food losses by number of bags, and potential over- and under-estimations by farmers were minimized by clarifying the research objectives at the beginning of the interviews. Furthermore, the analysis framework for model selection and calculations of model weights, and evidence ratios for ranking followed [63,64]. The additive generalized linear models (GLMs) were generated to determine the model that best fits the data relative to other models [61,62,65,66]. The Akaike information criterion (AIC), a measure of model fit in relation to other models built using the same data, was adopted in accordance with [63]. The lowest AIC values were indicative of the best model to determine the social vulnerability factors associated with elephant crop damage. The evidence ratio(ER) for model i provided a measure of how much more likely the best model is than model i, and was calculated as: $ER = \exp(-0.5\triangle\mathrm{AIC}_{best})/\exp(-0.5\triangle\mathrm{AIC}_i)$, where $\triangle\mathrm{AIC}_{best}$ is the delta Akaike information criterion for the best model while $\triangle\mathrm{AIC}_i$ is delta Akaike information criterion for the ith model [67]. R-statistical software version 3.4.1 [68] was used for the statistical analyses in model building.

Table 1. Social vulnerability factors identified from literature and focused group discussions.

Social Vulnerability Factors (Covariates)	Link to Crop Damage	Literature	Focus Group Discussions	Examples of Literature Sources
Social coherence (X_1)	Elephant crop damage is less likely in the communities that socially collaborate.	X	X	[11,69]
Skills development (X_2)	Elephant crop damage is more likely in unskilled communities.	X	X	[54]
Access to innovations (X_3)	Elephant crop damage is more likely in less innovative community that relies on traditional methods.	X	X	[47,70]
Traditional ecological knowledge (X_4)	Elephant crop damage can be avoided by learning from each other how to coexist with elephants.	X	X	[71,72]
Crop diversification (X_5)	Food aversion by elephants through avoidance of certain crops can reduce the probability of crop damage.	X	X	[13,73]

X Potentially applicable.

Table 2. Demographic features of interviewees in the Lupande GMA in the Luangwa Valley, eastern Zambia.

Variable	Variable Components	Frequency	Percentages (%)
Gender (male- or female headed households)	Male	177	63
	Female	104	37
Marital status	Single	15	5.3
	Married	246	87.5
	Widow	10	3.6
	Widower	7	2.5
	Others	3	1.1
Household size	5 and below	67	23.8
	6–10	214	76.2
Education	Primary school	183	65.1
	Secondary school	98	34.9
Length of residence (years)	5 and below	19	6.8
	6–10	67	23.8
	11–15	85	30.2
	16–20	39	13.9
	21 and over	71	25.3
Farm size (m^2)	<4800	69	24.6
	4800–8600	159	56.6
	>8600	53	18.9
Number of livestock	5 and below	181	64.4
	6–10	53	18.9
	11–20	39	13.9
	21 and above	8	2.8

3. Results

3.1. Exposure and Sensitivity

The interviewees with larger household sizes, small-sized farms and low attained levels of education, as aggravating factors to crop damage and not causal factors, were associated more with crop damage events. Based on data from interviews, all the respondents (100%, n = 281) experienced crop damage at least two times (range: 2–5, medium = 3) in the previous five farming seasons and the majority of them (93.95%, n = 264) perceived an increase in exposure to marauding elephants.

Elephants devoured a wide range of crops such as maize, cotton (*Gossypium hirsutum*), rice (*Oryza sativa*), millet (*Eleusine* sp.), sorghum (*Sorghum vulgare*), beans (*Phaseolus vulgaris*), pumpkins (*Curcubita maxima*) and sweet potatoes (*Ipomoea batatas*) on which they depend for their survival. Furthermore, interviewees (89.32%, n = 251) attributed the increasing risk of crop damage to human encroachment into elephant habitats, and ineffective HEC counter-measures. There was an insignificant difference in the number of crop damage events between male- and female-headed households (χ^2 = 5.971, df = 4, p = 0.108) and ages of the head of the household (χ^2 = 22.460, df = 12, p = 0.507). The marital status of the interviewees insignificantly influenced the number of elephant crop damage events (χ^2 = 15.211, df = 16, p = 0.257). However, the household and farm sizes, and attained level of education were significantly associated with the number of elephant crop damage events (χ^2 = 10.003, df = 4, p = 0.010); χ^2 = 6.452, df = 8, p = 0.007; χ^2 = 8.517, df = 4, p < 0.001), respectively. The lengths of residence over which the interviewees cultivated rain-fed crops were insignificantly associated with the number of crop damage events (χ^2 = 18.100, df = 16, p = 0.536). The number of livestock owned by interviewees was significantly associated with the number of elephant crop damage events experienced on their respective farms (χ^2 = 13.648, df = 12, p < 0.001). The more affluent individuals were in terms of livestock, the better prepared they were to protect their crops. Subsistence farmers perceived elephant restraining fences as more effective than other counter-measures against elephant crop damage (Figure 3), even for farms in proximity to the park where some marauding elephants originated.

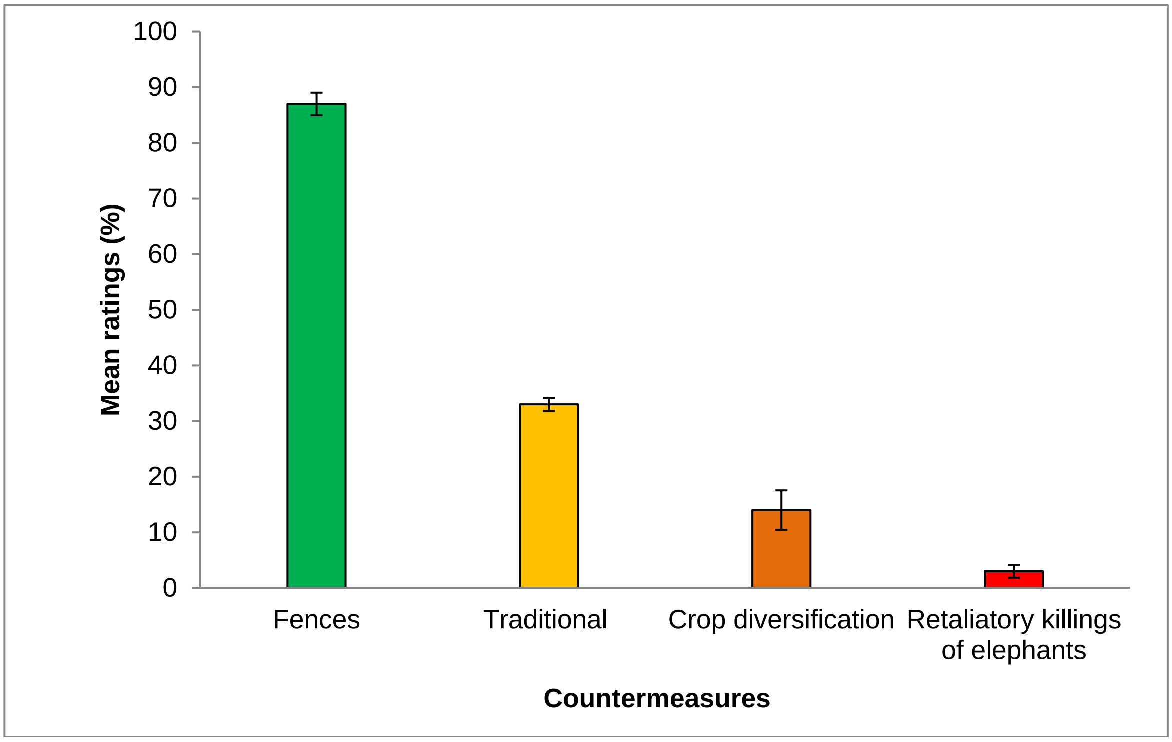

Figure 3. The mean percentage for rankings by subsistence farmers in the six chiefdoms of the LupandeGMA, eastern Zambia (the error bars represent standard errors, SE).

3.2. Local Enablers of Social Vulnerability

Based on the focus group discussions, the following were discussed in response to what local enablers of social vulnerability were.

Social capital—there were low levels of social capital (i.e., cooperation, trust, commitment and social network) among subsistence farmers for effective crop protection (Figure 2). The interviewees conceived that low social capital negatively contributed to low maintenance of other capital (i.e., human, natural, physical and financial) for crop protection. Furthermore, the area was managed without a management plan due to failure by traditional leadership and local communities to collaborate in its formulation, an initiative that had started in the late 1990s and remained unaccomplished hitherto. Human capital—the interviewees perceived environmental awareness as key factor influencing their ability to respond to elephant crop damage. Natural capital—the interviewees indicated that despite existence of a resource base, benefits from resource utilization such as financial remittances from trophy hunting to local communities via CRBs, and ongoing conservation efforts by multiple stakeholders, there were several crop protection and elephant conservation-linked challenges. The challenges included the negative impacts of climate change, habitat encroachment, and illegal killings of elephants. CRBs and the wildlife agency have insufficient capacity to deal with the crop damage challenges in the Luangwa Valley due to paucity of input resources and weak governance structures. Physical capital—the interviewees also perceived lack of infrastructure such as elephant restraining solar and electric-powered fences, mobile phones and transportation facilities for HEC management in the Luangwa Valley. Financial capital—the interviewees perceived that due to high poverty levels among the subsistence farmers, local financial capital was low. They highlighted that they occasionally received revenues and logistical assistance from safari hunting operations and philanthropic organizations such as the Adventist Development and Relief Agency (ADRA), Community Markets for Conservation (COMACO), Conservation South Luangwa (CSL), and Awely.

3.3. Local Inhibitors of Social Vulnerability

The following were derived from focus group discussions in response to what local inhibitors of social vulnerability were.

Social capital—most of the subsistence farmers (81.49%, n = 229) perceived cooperative action among farmers as an important strategy against HEC in the Luangwa Valley. Collective guarding against marauding elephants and collaborative construction of elephant-safe grain stores, training and social learning were deemed helpful by the subsistence farmers. Furthermore, they perceived that existing collective actions and environmental values such as collective crop protection, without having to kill 'problem elephants', had the potential to inhibit social vulnerability in the area.

3.4. Variable Selection and Model Building

The variable selection and model building was based on quantitative data from interviews. The predictors of local social vulnerability in this study's models were social coherence, skills development, and access to innovations (Table 3). The strength of evidence of these three predictors was provided by evidence ratio, ranging from 1.00 to 2.97 in the model ranks (Table 3). The evidence ratio increased with AIC values, as the model with the lowest AIC had an evidence ratio of 1.0. For further inferences, they also have relatively higher AIC weights and likelihoods than other models, validating that they are relatively better models than others (Table 3). From the focus group discussions, the subsistence farmers evinced that relational social capital caused togetherness in families and clans, and amplified their collective adaptive capacities to face elephant crop damage. They perceived that such collective action lowered the cost of counteracting crop damage within their limited means as other members participated in protecting their neighbors' crops in addition to theirs. The subsistence farmers highlighted existing ties among themselves within and across neighboring villages through collaborative counter-measures. Furthermore, it was demonstrated that conservation organizations operating in the Luangwa Valley potentially helped to reduce the chances and events of experiencing elephant crop damage through technical and financial support.

The second predictor (presence or absence of skills development) was discursively tackled by participants in the focus group discussions. The interviewees believed that the skills development in on-farm based livelihoods strategies such as tourism had potential to enhance their financial capital. Financial assets were essential inputs into the implementation of counter-measures.

Table 3. Ranked models for multimodel inferences of predictors of subsistence farmers' social vulnerability to elephant crop damage incidences in the Luangwa Valley, eastern Zambia.

Model	Model Notation	AIC	ΔAIC	AIC Weight	Model Likelihood	Evidence Ratio
Social coherence (X_1)	$\beta_0 + \beta_1X_1$	261.92	0.00	0.24	0.97	1.00
Skills development (X_2)	$\beta_0 + \beta_2X_2$	264.35	1.33	0.15	0.71	1.94
Access to innovations (X_3)	$\beta_0 + \beta_3X_3$	266.07	2.18	0.11	0.68	2.97
Traditional ecological knowledge (X_4)	$\beta_0 + \beta_4X_4$	267.48	2.39	0.06	0.40	3.30
Crop diversification (X_5)	$\beta_0 + \beta_5X_5$	270.24	2.52	0.06	0.28	3.53
$X_1 + X_2$	$\beta_0 + \beta_1X_1 + \beta_2X_2$	270.96	3.09	0.05	0.24	4.69
X_1 + (X_3	$\beta_0 + \beta_1X_1 + \beta_3X_3$	273.43	3.34	0.05	0.21	5.31
$X_1 + X_4$	$\beta_0 + \beta_1X_1 + \beta_4X_4$	274.01	3.88	0.04	0.16	6.96
$X_1 + X_5$	$\beta_0 + \beta_1X_1 + \beta_5X_5$	274.72	4.23	0.04	0.15	8.29
$X_2 + X_3$	$\beta_0 + \beta_2X_2 + \beta_3X_3$	274.95	4.25	0.03	0.15	8.37
$X_2 + X_4$	$\beta_0 + \beta_2X_2 + \beta_4X_4$	275.77	5.10	0.02	0.11	12.81
$X_2 + X_5$	$\beta_0 + \beta_2X_2 + \beta_5X_5$	276.48	5.63	0.02	0.08	16.69
$X_3 + X_4$	$\beta_0 + \beta_3X_3 + \beta_4X_4$	276.80	6.14	0.02	0.08	21.54
$X_3 + X_5$	$\beta_0 + \beta_3X_3 + \beta_5X_5$	277.36	6.26	0.02	0.06	22.87
$X_4 + X_5$	$\beta_0 + \beta_4X_4 + \beta_5X_5$	277.95	6.45	0.01	0.05	25.15
$X_1 + X_2 + X_3$	$\beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3$	278.41	6.61	0.01	0.05	27.25
$X_1 + X_2 + X_4$	$\beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_4X_4$	278.67	7.37	0.01	0.03	39.85
$X_1 + X_2 + X_5$	$\beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_5X_5$	279.83	8.05	0.01	0.03	55.98
$X_1 \times X_2$	$\beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_{1,2}(X_1 \times X_2)$	279.91	8.38	0.01	0.02	66.02
$X_1 \times X_3$	$\beta_0 + \beta_1X_1 + \beta_3X_3 + \beta_{1,3}(X_1 \times X_3)$	282.01	8.56	0.01	0.02	72.24
$X_1 \times X_4$	$\beta_0 + \beta_1X_1 + \beta_4X_4 + \beta_{1,4}(X_1 \times X_4)$	282.46	8.79	0.01	0.02	81.04
$X_1 \times X_5$	$\beta_0 + \beta_1X_1 + \beta_5X_5 + \beta_{1,5}(X_1 \times X_5)$	282.63	8.99	0.01	0.02	89.57
$X_2 \times X_3$	$\beta_0 + \beta_2X_2 + \beta_3X_3 + \beta_{2,3}(X_2 \times X_3)$	282.74	9.03	0.00	0.01	91.38
$X_2 \times X_4$	$\beta_0 + \beta_2X_2 + \beta_4X_4 + \beta_{2,4}(X_2 \times X_4)$	282.99	9.19	0.00	0.01	98.99
$X_2 \times X_5$	$\beta_0 + \beta_2X_2 + \beta_5X_5 + \beta_{2,5}(X_2 \times X_5)$	283.25	9.47	0.00	0.01	113.86
$X_3 \times X_4$	$\beta_0 + \beta_3X_3 + \beta_4X_4 + \beta_{3,4}(X_3 \times X_4)$	283.43	9.69	0.00	0.01	127.10
$X_3 \times X_5$	$\beta_0 + \beta_3X_3 + \beta_5X_5 + \beta_{3,5}(X_3 \times X_5)$	283.51	9.74	0.00	0.01	130.32
$X_4 \times X_5$	$\beta_0 + \beta_4X_4 + \beta_5X_5 + \beta_{4,5}(X_4 \times X_5)$	283.84	9.92	0.00	0.01	142.59

AIC, Akaike information criterion; ΔAIC, delta AIC.

The third predictor (access to innovations such as crop insurance, and infrastructure such as elephant-restraining fences, use of mobile phones as an early warning system, and elephant-safe grain stores) was also explained in the focus group discussions. By introducing and implementing novel techniques and knowledge to protect crops, the subsistence farmers experienced reduced crop damage. They linked reduction in elephant crop damage, in such cases, to lowered local social vulnerability as novel interventions potentially enhanced farmers' adaptive capacities and improved their responses to crop damage. Some farmers grouped themselves into farmer cooperatives where the use of mobile phones is encouraged among members to communicate and report the presence of marauding elephants so that the neighboring communities mobilize effectively and timely help is given to act against the elephants. Once the crops are harvested, they are stored in traditional granaries made of mud and wood, or in improved elephant-safe grain stores made of cement brick concrete. None of those that use cement brick concrete experienced elephant invasions.

The rest of the parameters (i.e., diversification of crops such as turmeric, ginger, lemon grass, sunflower and sesame, and economic activities such as tourism, levels of traditional ecological knowledge, and external financial remittances to local farmers) were insignificant predictors in accordance with AIC-based model selection. Diversification of non-attractive crop varieties to elephants is relatively new in the study area and its efficacy is unclear to subsistence farmers. Limited numbers of subsistence farmers (<1% of interviewees) are afforded opportunities to work in tourism ventures that would supplement their faming livelihoods. Traditional ecological knowledge has been embedded in the existing traditional counter-measures but is proving ineffective to subsistence farming as they allow persistent elephant crop damage due to elephants tolerating or learning to overcome a stimulus. Financial remittances from associates such as relatives and friends were reported to be insufficient and erratic for effective contributions against elephant crop damage.

3.5. Local Attitudes, Adaptive Capacities and Responses

Based on data from interviews and focus group discussions, almost all subsistence farmers (95.02%; n = 267) perceived that frequent crop damage events were severe, and short recovery times in between crop damage events and rain-fed crop farming seasons when most crop damage occurs, compromised their resilience. The interviewees explained that they are left with very limited time to mobilize resources through their social networks to overcome the impacts of elephant crop damage. Although cooperative crop guarding remained important as a crop protection strategy, many subsistence farmers (87.19%; n = 245) considered it insufficient. They also perceived 'food for work' (a food security policy strategy) by government and non-governmental organizations such as the World Food Program as inadequate. They resented travelling long distances in search of additional food supplies. For several subsistence farmers (81.49%, n = 229), receiving financial aid from town-dwelling relatives, and a few skills development scholarships, empowered them with alternative incomes towards sustaining farming livelihoods. Furthermore, subsistence farmers (96.80%; n = 272) indicated that insular retaliatory killings of elephants for crop damage through wildlife agency-executed 'elephant control' or illegally by themselves were common, exacerbated by perception that they possessed no proprietary rights over elephants.

4. Discussion

The large and growing families of many subsistence farmers in the Luangwa Valley, eastern Zambia, compelled them to seek several fertile small-sized manageable parcels of land for rain-fed crop farming. However, placement and expansion of unfenced crop fields in the originally reserved elephant habitats increased exposure of crops to damage by elephants, in addition to usual post-harvest elephant crop damage in unsecure granaries. As the marauding elephants tolerated or learned to overcome a stimulus associated with particular crop protection, they accessed and damaged the targeted crops. Thus, the emergent HEC conflicts needed constant creation, adoption and application of innovations [47]. Implementing appropriate land-use plans could militate against conflicting land uses of agriculture and wildlife [74], occurring in Lupande GMA where such land-use plans are non-existent. There is a need for managing the marauding elephants, using specified norms and standards [75]. Furthermore, many of the subsistence farmers had levels of education relatively too low to effectively implement crop protection measures against elephants. As such, they commonly resorted to the application of traditional methods that included use of watchtowers, fires, cans and metals, shouting, drumming, clapping, and chilli pepper, with low demand of technical knowledge and investment. However, awareness by the subsistence farmers of elephant crop raiding behavior and applicable HEC counter-measures can play a critical role. According to scholars in pest management (e.g., [76,77]), information sharing can positively change farmers' perceptions on dealing with risks associated with crops, and positively contribute to individual farmer performance.

Sustained livelihoods assets are critical for an effective livelihoods strategy [78]. In the case of Luangwa Valley, such livelihoods assets are *inter alia* social coherence, skills, fertile soils and crop protection infrastructure (e.g., elephant restraining fences). Crop protection requires effective social exchanges among the actors such as the wildlife agency, conservation NGOs, and community leadership that promote various forms of exchanges such as ideas (e.g., new technologies against elephant invasions) and materials (e.g., less vulnerable crop varieties) [79]. Such social exchange has the potential to supplement the existing traditional methods, largely based on traditional ecological knowledge (e.g., a variety of traditional counter-measures) for crop protection. Through integration of traditional ecological knowledge with other methods [71,72], crop protection against crop-raiding elephants needs attention by actors. Social learning and partnerships among actors such as subsistence farmers and conservation agencies can catalyze crop production and elephant conservation by reducing livelihood and conservation transaction costs [80–82]. Furthermore, as the collective action, for instance through partnerships, is influenced by individual's disposition at site level [25], the implementation of adaptive counter-measures to crop damage at farm level should be emphasized, taking into account farmers socio-economic limitations.

The crop farming-based livelihoods depend on supportive processes such as culture of sustaining institutions in form of resource governance structures [34,36] such as the local CRBs and VAGs which would be useful for crop protection and elephant management. This study revealed that such processes were feeble and largely restricted to family ties and clans. For instance, while the flow of technical information among the local communities can facilitate the adoption of novel practices ([83], p. 179), low social capital in the Luangwa Valley has disadvantaged the subsistence farmers in their fight against elephant crop damage. The enhanced communication through popularized and appropriate use of mobile phones can cement relational social capital and be an effective management tool [84]. Within the framework of relational social capital, subsistence farmers in Luangwa Valley can take advantage of emerging crop diversification programs from maize mono-cropping to other crop varieties and cultivars such as lemon grass and ginger, which are deemed less attractive to elephants [73]. Furthermore, there is need for promoting on-farm investments in crop protection supported by collaborative effort towards conservation agriculture, and policies that support internalization of associated environmental costs such as elephant crop damage [85]. Notwithstanding the need for appropriate implementation of HEC counter-measures, the financial well-being of the subsistence farmers are critical in the reduction of crop damage incidences.

Sustainable livelihoods occur when livelihoods systems become resilient to external factors, such as elephant crop damage, without undermining long-term productivity [86]. Failure by subsistence farmers to resolve crop damage results in their resentment and loss of peace of mind [18]. Consequently, subsistence farmers often ignore elephant crop-raiding behaviors [13], and retaliate by killing marauding elephants ([29], this study). Poverty, a hazardous condition for elephant crop damage, among the subsistence farmers in the Luangwa Valley escalates subsistence farmers' vulnerability [87] and like elsewhere in the elephant home range poverty contributes to retaliatory killings of elephants for bushmeat and ivory [88]. Unsustainable harvesting through illegal killings of elephants has the potential to drastically reduce elephant populations and negatively impact on tourism [89,90], which would otherwise be a source of revenues for crop protection. The disaster risk reduction of crop damage also depends on the ability of the subsistence farmers and stakeholders to deal with hazardous conditions such as poverty, individually and collectively [91,92]. Although farmer compensation schemes against elephant crop damage can significantly socially and economically militate against crop losses and even help attract local support for wildlife conservation [76], they require good planning, implementation and monitoring that overcome the potential myriad of challenges associated with their application at the farm level [14,93].

Furthermore, positive interrelationships among humans and also with their local natural resources such as elephants can inform rural livelihood development policies. Settlements and other land uses are to be permissible only in designated areas and under certain conditions that set limits of use to achieve dual objectives of rural development and environmental management. In the case of the Luangwa Valley, property rights under the customary proprietary regime in eastern Zambia are breeding increasing livelihood pressure and novel inter-human conflicts due to frail traditional systems in the face of escalating human population [94]. In addition to migration challenges by subsistence farmers in search of land for crop agriculture, conflicts over access to agrarian lands between the local subsistence farmers and the *Chewa* speaking immigrant ethnic groups from the neighboring chiefdoms in the Luangwa Valley are emerging. According to [95], such human migrations could be an expressed demographic behavior of livelihoods strategy by 'local' emigrants, resulting in novel conflicts in new-found lands.

Implications of Social Vulnerability for Elephant Conservation

In the case of Luangwa Valley, subsistence farmers are an integral part of HEC and inter-human conflicts, impacting on themselves and elephants. Understanding of levels of livelihood assets, local settings and practices of subsistence farmers may help to formulate or adopt suitable livelihood strategies. There is a need to promote elephant-compatible agriculture [47] and environmental sustainability [96], through environmental management compliance by principally the subsistence farmers, who form a resource-dependent community [97]. Elephants will increasingly use and raid crops in the agrarian-wildlife landscapes to compensate for habitat fragmentation [98]. While the elevation of benefits to the local communities living with elephants are deemed important for the sustenance of support to elephant conservation in the Luangwa Valley [99], the subsistence farmers need to transform their approaches to crop protection. However, the elephant-restraining fences, which are deemed more effective than other counter-measures, are unaffordable for implementation and maintenance by individual subsistence farmers who also poses low technical knowledge for implementation and monitoring [100]. Such electric fences are made of wire strands, strengthened by metal poles and powered by solar panels and backup batteries.

There is a need to strengthen transformative cognitive interventions such as collaborative approaches, traditional ecological knowledge, community-based monitoring, local-level integrated land-use planning and institutional governance [32,70]. Integrated approaches for resolving HEC and inter-human conflicts that encompass clear HEC policies, positive perceptions, and systematic data gathering on HEC situations are essential. Integrating farmer perceptions and actual causation of crop loss is critical in HEC management [101]. According to [102], farmer action to militate against crop damage is influenced by their perceptions towards wildlife. Continued cognitive research which will cover various aspects of the human and elephant mind which inform their actions in causing or responding to crop damage, and equitable benefit sharing from resource utilization, should be fostered for effective interventions against crop damage [48,103]. Thus, the cognitive research and its applications should be an integral part of the socio-psychological aspects [11], in addition to conflict-management processes [1].

5. Conclusions

The subsistence farmers' exposure to marauding elephants and experiences of a plethora of crop damage in the Luangwa Valley provide several lessons to assist in rethinking policies and strategies against elephant crop damage. The prevailing social vulnerability to elephant crop damage has a potential to compromise subsistence farmers' resilience, which can otherwise be sustained by strengthening social coherence, skills development, and access to innovations. Enhancing the social capital applied in resolving elephant crop damage is likely to improve other livelihood assets through collective actions, which in turn would substantially improve the adaptive capacities of subsistence farmers. In particular, future interventions should encourage increased multiple stakeholder participation, local institutional governance, access to livelihood assets, human security and elephant conservation. Given that the traditional counter-measures were ineffective, future interventions ought to target innovating and adopting novel counter-measures in addition to contemporary awareness creation and the use of traditional methods for crop protection against elephants. Furthermore, this study has the potential for application at a broader scale, contributing to shaping strategic policy directions for resolving persistent elephant crop damage facing the African and Asian regions and resultant food insecurity.

Author Contributions: Conceptualization, V.R.N. and B.A.N.; Methodology, V.R.N. and O.T.; Analysis, V.R.N.; Investigation, V.R.N., O.T. and S.S.; Resources, V.R.N., O.T. and S.S.; Draft Preparation, V.R.N.; Internal Review and Editing, V.R.N. and B.A.N.; Visualization, V.R.N.; Project Administration, V.R.N. and S.S.; Funding Acquisition, V.R.N. and S.S.

Funding: This research was funded by African Elephant Fund Grant No. 2015-32EAP-SB-00676-1126-14AC0004 and The APC was self-financed by the authors.

Acknowledgments: The Zambia's Department of National Park and Wildlife authorized the study and provided hospitality during the field data gathering. We are also grateful to Eva Gross for her constructive comments on our initial manuscript. Furthermore, this study received support from numerous participants during data collection.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; and in the decision to publish the results.

Appendix A. Questionnaire Guide Used in the Interviews with Subsistence Farmers in Lupande GMA, Eastern Zambia

(1) Name
(2) Age
(3) Sex:
    (a) Male
    (b) Female
(4) Marital status
(5) Size of household
(6) Level of education attained
(7) Length of residence
(8) Farm size(s)
(9) No. of livestock
(10) Length of residence

Exposure and sensitivity

(11) Have you experienced crop damage by elephants?
    (a) Yes
    (b) No
(12) If yes to Question 11, do you perceive the threat of crop damage by elephants to be increasing, decreasing or same?
    (a) Increasing
    (b) Decreasing
    (c) Same
(13) Explain your answer to Question 12?
(14) How many times have you experienced crop damage in the last five years?
(15) What methods do you employ to protect your crop?
(16) How effective are the methods you use for crop protection?
(17) What crops do elephants eat?
(18) What is the average percentage (%) loss in maize to elephants when they raid your field or storage in a year?

Local enablers of social vulnerability

(19) What specific elements are responsible for perpetuating social vulnerability in your area?
(20) Please rate the following between 0 and 5 (0 representing absence and 5 high) in respect to crop damage:
    (a) Management effectiveness of crop damage mitigation infrastructure.

(b) Level of local investments in crop damage mitigations.
(c) Adequacy of financial capital for crop damage mitigations.
(d) Level of financial capital for crop damage mitigations.
(e) Affordability of crop damage mitigations infrastructure.
(f) Adequacy of crop damage mitigations infrastructure.
(g) Existence of crop damage mitigations infrastructure.
(h) Contribution to local socioeconomics and culture.
(i) Habitat management.
(j) Environmental awareness.
(k) Level of education.
(l) Ability to prevent diseases and respond to natural disasters.
(m) Level of skills in crop damage mitigations.
(n) Commitment.
(o) Trust.
(p) Social networks.
(q) Cooperation.

Local inhibitors of social vulnerability

(21) What do you consider are the social inhibitors of social vulnerability in your area?
(22) Explain your answer in Question 21?

Social vulnerability variables for crop damage by elephants

(23) Using the 0 to 5 (0 representing absence and 5 high) rate association between crop damage and the following social vulnerability parameters in your area:
(a) Traditional ecological knowledge.
(b) Social coherence.
(c) Skills development.
(d) Diversification of crops.
(e) Access to innovations.
(f) External financial remittances to local farmers.

Local attitudes, adaptive capacities and responses in respect to crop damage

(24) What do you consider as the most important factor influencing your actions in respect to crop damage?
(25) How do you react to the identified factor in Question 24?
(26) What are the coping and mediating strategies you employ against elephant crop damage impacts?

References

1. Gutiérrez, R.J.; Wood, K.A.; Redpath, S.M.; Young, J.C. *Conservation Conflicts: Future Research Challenges*; Springer: Gland, Switzerland, 2016; pp. 267–282. [CrossRef]
2. Peterson, M.N.; Peterson, M.J.; Peterson, T.R.; Leong, K. Why transforming biodiversity conservation conflict is essential and how to begin. *Pacific Conserv. Biol.* **2013**, *19*, 94–103. [CrossRef]
3. Githiru, M.; Mutwiwa, U.; Kasaine, S.; Schulte, B. A spanner in the works: Human-elephant conflict complicates the energy-food-water nexus in drylands of Africa. *Front. Environ. Sci.* **2017**, *5*, 69. [CrossRef]
4. Okello, M.M.; Njumbi, S.J.; Kiringe, J.W.; Isiiche, J. Habitat use and preference by the African elephant outside of the protected area, and management implications in the Amboseli landscape, Kenya. *Int. J. Biodivers. Conserv.* **2015**, *7*, 211–236. [CrossRef]

5. Lewis, D.; Bell, S.D.; Fay, J.; Bothi, K.L.; Gatere, L.; Kabila, M.; Mukamba, M.; Matokwani, E.; Mushimbalume, M.; Moraru, C.I.; et al. Community Markets for Conservation (COMACO) links biodiversity conservation with sustainable improvements in livelihoods and food production. *Proc. Natl. Acad. Sci. USA* **2011**, *108*, 13957–13962. [CrossRef] [PubMed]
6. Redpath, S.M.; Young, J.; Evely, A.; Adams, W.M.; Sutherland, W.J.; Whitehouse, A.; Amar, A.; Lambert, R.A.; Linell, J.D.C.; Watt, A.; et al. Understanding and managing conservation conflicts. *Trends Ecol. Evol.* **2013**, *28*, 100–109. [CrossRef] [PubMed]
7. Lichtenfeld, L.L.; Trout, C.; Kisimir, E.L. Evidence-based conservation: Predator-proof bomas protect livestock and lions. *Biodivers. Conserv.* **2014**, *24*, 483–491. [CrossRef]
8. Baynham-Herd, Z.; Redpath, S.; Bunnefeld, N.; Molony, T.; Keane, A. Conservation conflicts: Behavioural threats, frames, and intervention recommendations. *Biol. Conserv.* **2018**, *222*, 180–188. [CrossRef]
9. Draheim, M.M.; Madden, F.; McCarthy, J.B.; Parsons, E.C.M. *Human-Wildlife Conflict: Complexity in the Marine Environment*; Oxford University Press: Oxford, UK, 2015.
10. Amwata, D.A.; Mganga, K.Z. The African elephant and food security in Africa: Experiences from Baringo District, Kenya. *Pachyderm* **2014**, *55*, 23–29.
11. Hoare, R. Lessons from 20 years of human-elephant conflict mitigation in Africa. *Dimens. Wildl.* **2015**, *20*, 289–295. [CrossRef]
12. Redpath, S.M.; Gutiérrez, R.J.; Wood, K.A.; Young, J.C. (Eds.) *Conflicts in Conservation: Navigating towards Solutions*; Cambridge University Press: Cambridge, UK, 2015; pp. 4–8.
13. Gross, E.M.; Lahkar, B.P.; Subedi, N.; Nyirenda, V.R.; Lichtenfeld, L.L.; Jakoby, O. Seasonality, crop type and crop phenology influence crop damage by wildlife herbivores in Africa and Asia. *Biodivers. Conserv.* **2018**. [CrossRef]
14. Pozo, R.A.; Coulson, T.; McCulloch, G.; Stronza, A.L.; Songhurst, A.C. Determining baselines for human-elephant conflict: A matter of time. *PLoS ONE* **2017**, *12*, e0178840. [CrossRef] [PubMed]
15. Nyirenda, V.R.; Myburgh, W.J.; Reilly, B.K. Predicting environmental factors influencing crop raiding by African elephants (*Loxodonta africana*) in the Luangwa Valley, eastern Zambia. *Afr. J. Environ. Sci. Technol.* **2012**, *6*, 391–400. [CrossRef]
16. Goswami, V.R.; Medhi, K.; Nichols, J.D.; Oli, M.K. Mechanistic understanding of human-wildlife conflict through a novel application of dynamic occupancy models. *Conserv. Biol.* **2015**, *29*, 1100–1110. [CrossRef] [PubMed]
17. Songhurst, A.; McCulloch, G.; Coulson, T. Finding pathways to human-elephant coexistence: A risky business. *Oryx* **2015**, *50*, 713–720. [CrossRef]
18. Bond, J. Making sense of human-elephant conflict in Laikipia county, Kenya. *Soc. Natur. Resour.* **2015**, *28*, 312–327. [CrossRef]
19. Mamboleo, A.A.; Doscher, C.; Paterson, A. Are elephants the most disastrous agricultural pests or the agents of ecological restorations? *J. Biodivers. Endanger. Species* **2017**, *5*, 185.
20. Cook, R.M.; Henley, M.D.; Parrini, F. Elephant movement patterns in relation to human inhabitants in and around the Great Limpopo Transfrontier Park. *Koedoe* **2015**, *57*, 1–7. [CrossRef]
21. Hill, C.M. Perspectives of conflict at the wildlife-agriculture boundary: 10 years on. *Hum. Dimens. Wildl.* **2015**, *20*, 296–301. [CrossRef]
22. Mayberry, A.L.; Hovorka, A.J.; Evans, K.E. Well-being impacts of human-elephant conflict in Khumaga, Botswana: Exploring visible and hidden dimensions. *Conserv. Soc.* **2017**, *15*, 280–291.
23. van de Water, A.; Matteson, K. Human-elephant conflict in western Thailand: Socio-economic drivers and potential mitigation strategies. *PLoS ONE* **2018**, *13*, e0194736. [CrossRef] [PubMed]
24. Thakur, A.K.; Yadav, D.K.; Jhariya, M.K. Socio-economic status of human-elephant conflict: Its assessment and solutions. *J. Appl. Nat. Sci.* **2016**, *8*, 2104–2110.
25. von Rueden, C.; Gavrilets, S.; Glowacki, L. Solving the puzzle of collective action through inter-individual differences. *Philos. Trans. R. Soc. Lond. B Biol. Sci.* **2015**, *370*. [CrossRef] [PubMed]
26. Selier, S.-A.J.; Slotow, R.; Di Minin, E. The influence of socioeconomic factors on the densities of high-value cross-border species, the African elephant. *Peer. J.* **2016**, *4*, 2581. [CrossRef] [PubMed]
27. Owen-Smith, N.; Chafota, J. Selective feeding by megaherbivore, the African elephant (*Loxodonta africana*). *J. Mammal.* **2012**, *93*, 698–705. [CrossRef]

28. Garstang, M.; Davis, R.E.; Leggett, K.; Frauenfeld, O.W.; Greco, S.; Zipser, E.; Peterson, M. Response of African elephants (*Loxodonta africana*) to seasonal changes in rainfall. *PLoS ONE* **2014**, *9*, e108736. [CrossRef] [PubMed]
29. Watson, F.; Becker, M.S.; McRobb, R.; Kanyembo, B. Spatial patterns of wire-snare poaching: Implications for community conservation in buffer zones around National Parks. *Biol. Conserv.* **2013**, *168*, 1–9. [CrossRef]
30. Kahler, J.S.; Gore, M.L. Local perceptions of risk associated with poaching of wildlife implicated in human-wildlife conflicts in Namibia. *Biol. Conserv.* **2014**, *189*, 49–58. [CrossRef]
31. Kalaba, F.K.; Quinn, C.H.; Dougill, J.A. The role of forest provisioning ecosystem services in coping with household stresses and shocks in miombo woodlands, Zambia. *Ecosyst. Serv.* **2013**, *5*, 143–148. [CrossRef]
32. Handberg, Ø.N. No sense of ownership in weak participation: A forest conservation experiement in Tanzania. *Environ. Dev. Econ.* **2018**, *23*, 434–451. [CrossRef]
33. Woodhouse, E.; Homewood, K.M.; Beauchamp, E.; Clements, T.; McCabe, J.T.; Wilkie, D.; Milner-Gulland, E.J. Guiding principles for evaluating the impacts of conservation interventions on human well-being. *Philos. Trans. R. Soc. Lond. B Biol. Sci.* **2015**, *370*, 20150103. [CrossRef] [PubMed]
34. Lindenmayer, D. Halting natural resource depletion: Engaging with economic and political power. *Econ. LabourRelat. Rev.* **2017**, *28*, 41–56. [CrossRef]
35. Van Assche, K.; Beunen, R.; Duineveld, M. The will to knowledge: Natural management and power/knowledge dynamics. *J. Environ. Policy Plan.* **2017**, *19*, 245–250. [CrossRef]
36. Sumberg, J.; Yeboah, T.; Flynn, J.; Anyidoho, N.A. Young people's perspectives on farming in Ghana: A Q study. *Food Secur.* **2017**, *9*, 151–161. [CrossRef]
37. Eizenberg, E.; Jabareen, Y. Social sustainability: A new conceptual framework. *Sustainability* **2017**, *9*, 68. [CrossRef]
38. Lienert, J.; Burger, P. Merging capabilities and livelihoods: Analyzing the use of biological resources to improve well-being. *Ecol. Soc.* **2015**, *20*, 20. [CrossRef]
39. Cropanzano, R.; Anthony, E.L.; Daniels, S.R.; Hall, A.V. Social exchange theory: A critical review with theoretical remedies. *Acad. Manag. Ann.* **2016**, *11*, 479–516. [CrossRef]
40. Morse, S.; McNamara, N. *Sustainable Livelihood Approach: A Critique of Theory and Practice*; Springer: New York, NY, USA, 2013; pp. 1–183.
41. Mmbaga, N.E.; Munishi, L.K.; Treydte, A.C. Balancing African elephant conservation with human well-being in Rombo area, Tanzania. *Adv. Ecol.* **2017**, *9*. [CrossRef]
42. Musyoki, C. Crop defense and coping strategies: Wildlife raids in Mahiga B village in Nyeri District. *Afr. Study Monogr.* **2014**, *35*, 19–40.
43. Baskaran, N.; Kannan, G.; Anbarasan, U.; Thapa, A.; Sukumar, R. A landscape-level assessment of Asian elephant habitat, its population and elephant-human conflict in the Anamalai hill ranges of southern western Ghats, India. *Mammal. Biol.* **2013**, *78*, 470–481. [CrossRef]
44. Barua, M.; Bhagwat, S.A.; Jadhav, S. The hidden dimensions of human-wildlife conflict: Health impacts, opportunity and transaction costs. *Biol. Conserv.* **2013**, *157*, 309–316. [CrossRef]
45. Baca, M.; Läderach, P.; Haggar, J.; Schroth, G.; Ovalle, O. An integrated framework for assessing vulnerability to climate change and developing adaptation strategies for coffee growing families in Mesoamerica. *PLoS ONE* **2014**, *9*, e88463. [CrossRef] [PubMed]
46. Rahman, H.M.T.; Song, A.M.; Po, J.Y.T.; Berthet, E.; Brammer, J.R.; Brunet, N.D.; Jayaprakash, L.G.; Lowitt, K.N.; Rastogi, A.; Reed, G.; et al. A framework for analyzing institutional gaps in natural resource governance. *Int. J. Commons* **2017**, *11*, 823–853. [CrossRef]
47. King, L.E.; Lala, F.; Nzumu, H.; Mwambingu, E.; Douglas-Hamilton, I. Beehive fences as a multidimensional conflict-mitigation tool for farmers coexisting with elephants. *Conserv. Biol.* **2017**, *31*, 743–752. [CrossRef] [PubMed]
48. Mosimane, A.W.; McCool, S.; Brown, P.; Ingrebretson, J. Using mental models in the analysis of human-wildlife conflict from the perspective of a social-ecological system in Namibia. *Oryx* **2014**, *48*, 64–70. [CrossRef]
49. Nyirenda, V.R.; Kaoma, C.; Nyirongo, S.; Lwali, C.A.; Chomba, C. Social exchange and structuralist-constructivism approaches for enhanced ecotourism and food security in wildlife-agrarian mosaic landscape: Insights from eastern Zambia. *Int. J. Tour. Policy* **2017**, *7*, 93–109. [CrossRef]

50. Anderson, N.E.; Mubanga, J.; Machila, N.; Atkinson, P.M.; Dzingarai, V.; Welburn, S.C. Sleeping sickness and its relationship with development and biodiversity conservation in the Luangwa Valley, Zambia. *Parasit. Vectors* **2015**, *8*. [CrossRef] [PubMed]
51. Obata, K.; Yamazaki, K. Some plants of South Luangwa National Park, Zambia. *Bull. Ibaraki Nat. Mus.* **2014**, *17*, 59–65.
52. DNPW (Department of National Parks and Wildlife). *The 2016 Aerial Survey in Zambia: Population Estimates of African Elephants (LOXODONTA Africana) in Zambia*; Zambia's Department of National Parks and Wildlife: Chilanga, Zambia, 2016.
53. CSO (Central Statistical Office). *Zambia 2010 Census of Population and Housing: Population Summary Report*; Central Statistical Office: Lusaka, Zambia, 2012; p. 19.
54. Nyirenda, V.R.; Kaoma, C.; Nyirongo, S. Farmer-wildlife conflicts in rural areas of eastern Zambia. *Biodivers. Ecol.* **2018**, *6*, 153–156. [CrossRef]
55. Yin, R.K. *Quantitative Research from Start to Finish*, 2nd ed.; The Guilford Press: New York, NY, USA, 2016; Chapter 3.
56. Walliman, N. *Research Methods: The Basic*; Routledge: New York, NY, USA, 2011; p. 100.
57. Guest, G.; MacQueen, K.M.; Namey, E.E. *Applied Thematic Analysis*; Sage Publications: Thousand Oaks, CA, USA, 2012; Chapter 3–10.
58. Pero-Cebollero, M.; Guardia-Olmos, J. The adequacy of different robust statistical tests in comparing two independent groups. *Psicologica* **2013**, *34*, 407–424.
59. Vedeld, P.; Jumane, A.; Wapalila, G.; Songorwa, A. Protected areas, poverty and conflicts: A livelihood case study of Mikumi National Park, Tanzania. *Forest Policy Econ.* **2012**, *21*, 20–31. [CrossRef]
60. Sujakhu, N.M.; Ranjitkar, S.; Niraula, R.R.; Salim, M.A.; Nizami, A.; Schmidt-Vogt, D.; Xu, J. Determinants of livelihood vulnerability in farming communities in two sites in the Asian highlands. *J. Water Int.* **2018**, *43*, 165–182. [CrossRef]
61. Logan, M. *Biostatistical Design and Analysis Using R: A Practical Guide*; Wiley-Blackwell: Oxford, UK, 2010; Chapters 9 & 17.
62. Thompson, C.G.; Kim, R.S.; Aloe, A.M.; Becker, B.J. Extracting the variance inflation factor and other multicollinearity diagnostics from typical regression results. *J. Basic Appl. Soc. Psychol.* **2017**, *39*, 81–90. [CrossRef]
63. Burnham, K.P.; Anderson, D.R.; Huyvaert, K.P. AIC model selection and multimodel inference in behavoural ecology: Some background, observations, and comparisons. *Behav. Ecol. Sociobiol.* **2011**, *65*, 23–35. [CrossRef]
64. Burnham, K.P.; Anderson, D.R. *Model Selection and Multimodel Inference: A Practical Information-Theoretic Approach*; Springer: New York, NY, USA, 2002.
65. Zuur, A.F.; Leno, E.N.; Walker, N.J.; Saveliev, A.A.; Smith, G.M. *Mixed Effects Models and Extensions in Ecology with R*; Springer: New York, NY, USA, 2009.
66. Imdadullah, M.; Aslam, M.; Altaf, S. Mctest: An R package for detection of collinearity among regressors. *R. J.* **2016**, *8*, 2073–4859.
67. Symonds, M.R.; Moussalli, A. A brief guide to model selection, multimodel inference and model averaging in behavioural ecology using Akaike's information criterion. *Behav. Ecol. Sociobiol.* **2011**, *65*, 13–21. [CrossRef]
68. R Core Team. *R: A Language and Environment for Statistical Computing*; R Foundation for Statistical Computing: Vienna, Austria, 2017.
69. Chakraborty, K.; Mondal, J. Perceptions and patterns of human-elephant conflict at Barjora block of Bankura district in West Bengal, India: Insights for mitigation and management. *Environ. Dev. Sustainability* **2013**, *15*, 547. [CrossRef]
70. Gunaryadi, D.; Sugiyo, S.; Hedges, S. Community-based human-elephant conflict mitigation: The value of an evidence-based approach in promoting the uptake of effective methods. *PLoS ONE* **2017**, *12*, e0173742. [CrossRef] [PubMed]
71. Whyte, K.P. On the role of traditional ecological knowledge as a collaborative concept: A philosophical study. *Ecol. Processes.* **2013**, *2*, 7. [CrossRef]
72. Uprety, Y.; Asselin, H.; Bergeron, Y.; Doyon, F.; Boucher, J.F. Contribution of traditonal knowledge to ecological restoration: Practices and applications. *Ecoscience* **2012**, *19*, 225–237. [CrossRef]
73. Gross, E.M.; McRobb, R.; Gross, J. Cultivating alternative crops reduces crop losses due to African elephants. *J. Pest Sci.* **2015**, *89*, 497–506. [CrossRef]

74. Lima, E.A.C.F.; Ranieri, V.E.L. Land use planning around protected areas: Case studies in four parks in the Atlantic forest region of southeastern Brazil. *Land Use Policy* **2018**, *71*, 453–458. [CrossRef]
75. Backmore, A.; Trouwborst, A. Who owns and is responsible for the elephant in the room? Management plans for free-roaming elephant in South Africa. *Bothalia* **2018**, *48*.
76. Chang'a, A.; Souza de, N.; Muya, J.; Keyyu, J.; Mwakatobe, A.; Malugu, L.; Ndossi, H.P.; Konuche, J.; Omondi, R.; Mpinge, A.; et al. Scaling-up the use of chili fences for reducing human-elephant conflict across landscapes in Tanzania. *Trop. Conserv. Sci.* **2016**, *9*, 921–930.
77. Milne, A.E.; Bell, J.R.; Hutchison, W.D.; van den Bosch, F.; Mitchell, P.D.; Crowder, D.; Parnell, S.; Whitemore, A.P. The effect of farmers' decisions on pest control with *Bt crops*: A billion dollar game of strategy. *PLoS Comput. Biol.* **2015**, *11*, e1004483. [CrossRef] [PubMed]
78. Ma, J.; Zhang, J.; Li, J.; Zeng, Z.; Sun, J.; Zhou, Q.B.; Zhang, Y. Study on livelihood assets-based spatial differentiation of the income of natural tourism communities. *Sustainability* **2018**, *10*, 353. [CrossRef]
79. Dolinska, A.; d'Aquino, P. Farmers as agents in innovation systems: Empowering farmers for innovation through communities of practice. *Agric. Syst.* **2016**, *142*, 122–130. [CrossRef]
80. Andrade, G.S.M.; Rhodes, J.R. Protected areas and local communities: An inevitable partnership toward successful conservation strategies? *Ecol. Soc.* **2012**, *17*, 14. [CrossRef]
81. Shaw, A.; Kristjanson, P. A catalyst toward sustainability? Exploring social learning and social differentiation approaches with the agricultural poor. *Sustainability* **2014**, *6*, 2685–2717. [CrossRef]
82. Gavin, M.C.; McCarter, J.; Berkes, F.; Mead, A.T.P.; Sterling, E.J.; Tang, R.; Turner, N.J. Effectivebiodiversity conservation requires dynamic, pluralistic, partnership-based approaches. *Sustainability* **2018**, *10*, 1846. [CrossRef]
83. Chan, C.; Sipes, B.; Lee, T.S. *Enabling Agri-Entrepreneurship and Innovation: Empirical Evidence and Solutions for Conflict Regions and Transitioning Economies*; CABI: Wallingford, UK, 2017.
84. Lewis, A.L.; Baird, T.D.; Sorice, M.G. Mobile phone use and human-wildlife conflict in Northern Tanzania. *Environ. Manag.* **2016**, *58*, 117–129. [CrossRef] [PubMed]
85. Tanentzap, A.J.; Lamb, A.; Walker, S.; Farmer, A. Resolving conflicts between agriculture and the natural environment. *PLoS Biol.* **2015**, *13*, e1002242. [CrossRef] [PubMed]
86. Guo, X.; Kapucu, N. Examining the impacts of disaster resettlement from a livelihood perspective: A case study of Qinling mountains, China. *Disasters* **2018**, *42*, 251–274. [CrossRef] [PubMed]
87. UNDP (United Nations Development Programme). *Zambia Human Development Report: Industrialisation and Human Development-Poverty Reduction through Wealth and Employment Creation*; UNDP: Lusaka, Zambia, 2016.
88. Wittemyer, G.; Northrup, J.M.; Blanc, J.; Douglas-Hamilton, I.; Omondi, P. Illegal killing for ivory drives global decline in African elephants. *Proc. Natl. Acad. Sci. USA* **2014**, *111*, 13117–13121. [CrossRef] [PubMed]
89. Naidoo, R.; Fisher, B.; Manica, A.; Balmfold, A. Estimating economic losses to tourism in Africa from the illegal killing of elephants. *Nat. Commun.* **2016**, *7*, 13379. [CrossRef] [PubMed]
90. Wittemyer, G.; Daballen, D.; Douglas-Hamilton, I. Comparative demography of an at-risk African elephant population. *PLoS ONE* **2013**, *8*, e53726. [CrossRef] [PubMed]
91. Kaeslin, E.; Redmond, I.; Dudley, N. *Wildlife in a Changing Climate*; FAO Forestry Paper 167; FAO: Rome, Italy, 2012.
92. Lawther, P.M. Towards a natural disaster intervention and recovery framework. *Disasters* **2016**, *40*, 494–517. [CrossRef] [PubMed]
93. Morton, H.; Winter, E.; Grote, U. Assessing natural resource management through intergrated environmental and social-economic accounting: The case of a Namibian conservancy. *J. Environ. Dev.* **2016**, *25*, 396–425. [CrossRef]
94. Green, E.; Norberg, M. Traditional landholding certificates in Zambia: Preventing or reinforcing commodification and inequality? *J. South. Afr. Stud.* **2018**, *1*, 1–16. [CrossRef]
95. Simatele, D.; Simatele, M. Migration as an adaptive strategy to climate variability:a study of the Tonga-speaking people of Southern Zambia. *Disasters* **2015**, *39*, 762–781. [CrossRef] [PubMed]
96. van Ittersum, M.K.; van Bussel, L.G.J.; Wolf, J.; Grassini, P.; van Wart, J.; Guilpart, N.; Claessens, L.; de Groot, H.; Wiebe, K.; Mason-D'Croz, D.; et al. Can sub-Saharan Africa feed itself? *Proc. Natl. Acad. Sci.* **2016**, *113*, 14964–14969. [CrossRef] [PubMed]
97. Langat, D.K.; Maranga, E.K.; Aboud, A.A.; Cheboiwo, J.K. Role of forest resources to local livelihoods: The case of east Mau forest ecosystem, Kenya. *Int. J. Forest. Res.* **2016**, 1–10. [CrossRef]

98. Pittiglio, C.; Skidmore, A.K.; van Gils, H.A.M.J.; McCall, M.K.; Prins, H.H.T. Smallholder farms as stepping stone corridors for crop-raiding elephant in northern Tanzania: Integration of Bayesian Expert System and Network Simulator. *Ambio* **2014**, *43*, 149–161. [CrossRef] [PubMed]
99. White, P.A.; Belant, J.L. Provisioning of game meat to rural communities as a benefit of sport hunting in Zambia. *PLoS ONE* **2015**, *10*, e0117237. [CrossRef] [PubMed]
100. Dalal-Clayton, B.; Child, B. *Lessons from Luangwa: The Story of the Luangwa Integrated Resource Development Project, Zambia*; Wildlife and Development Series, 13; International Institute for Environment and Development: London, UK, 2003; p. 168.
101. Hoffmeier-Karimi, R.R.; Schulte, B.A. Assessing perceived and documented crop damage in a Tanzanian village impacted by human-elephant conflict (HEC). *Pachyderm* **2015**, *56*, 51–60.
102. Kross, S.M.; Ingram, K.P.; Long, R.F.; Niles, M.T. Farmer perceptions and behaviors related to wildlife and on-farm conservation actions. *Conserv. Lett.* **2018**, *11*, e12364. [CrossRef]
103. Mumby, H.S.; Plotnik, J.M. Taking the elephants' perspective: Remembering elephant behavior, cognition and ecology in human-elephant conflict mitigation. *Front. Ecol. Evol.* **2018**, *6*, 122. [CrossRef]