TADDEO RUSOKE

Born on the 27th of April 1985 in Kyenjojo District Uganda, Dr. Taddeo Rusoke is a Senior Lecturer of biodiversity conservation sciences and tourism at Nkumba University, Visiting Fellow at the University of Pretoria Mammal Research Institute (South Africa) and Visiting Research Fellow at the African Wildlife Economy Institute at Stellenbosch University (South Africa). He holds a Ph.D. in Natural Resources Management (2021), MSc. In Environmental Health (2012), and BSc. Wildlife Management Sciences (2010) from Nkumba University in Uganda. He possesses 14 years of experience in inclusive sustainable conservation modeling, research, integrated natural resources planning and management, capacity building, and human-wildlife conflict mitigation and has attained certifications from Arizona State University – College of Public Administration and Community Solutions (USA) and the United Nations Environment Programme (UNEP). Taddeo is a Global Academic Chair of human-wildlife co-existence, livelihoods, and crop protection at Global Sustainable Futures Network (UK). He has won the Global Sustainability Promotion and Sustainable Collaboration award from the UK SPSC service. Dr. Rusoke is a distinguished media campaigner/ Amplifier of People for Nature-based Solutions at the Partnership for Environment and Disaster Risk Reduction (PEDRR) and the United Nations Environment Programme (UNEP).

Dr. Taddeo Rusoke is the co-author of the book "The Great Kingdom of Tooro" and is a Former Research Fellow of Tobacco Control Policies at Sefako Makgatho University, Pretoria South Africa, and founder of Africa One Consult Limited (AOC-LTD). AOC-LTD is a biodiversity research consultancy incorporated in Uganda. Taddeo led research on "The linkage between wildlife and culture of the people in south-western Uganda" which guided the establishment of the Igongo Museum in Mbarara Uganda. Taddeo developed the Buffer Crop Farmers Model (BCFAM), an applied ecological model that helps farmers bordering Kibale National Parks to mitigate crop loss to wild animals by growing buffer crops based on the acreage of land owned and distance from the park boundary. Taddeo has developed research policy briefs, contributed to drafting of the Tobacco Control Act 2015 for Uganda, and reviewed Nkumba University Charter. He is a member of the editorial board of the Sustainability and Biodiversity Conservation Journal at Koc University in Istanbul Turkey.

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BUFFER CROPS FARMING

AGAINST WILD ANIMAL DAMAGE ON CROPS IN UGANDA.

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A Banana Farm and Tea Plantation at the edge of Kibale Forest NP, Uganda (Source: Author, 2019).

Taddeo Rusoke (Ph.D.)

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FOREWORD I

This book titled "Buffer Crops Farming against Wild Animal Damage on Crops in Uganda" by Dr. Taddeo Rusoke presents invaluable information on farmers living adjacent to protected areas in Uganda earning their living through growing high-value buffer crops that are unpalatable to wild animals to deter them from damaging other valuable crops of the farmers. The book presents important insights and findings on how farmers mitigate/minimise crop damage. The publication reveals how enhancing farmer's knowledge to protect their crops from wild animal damage through buffer cropping can directly support and complement the attainment of Sustainable Development Goals: 1, Poverty alleviation; 2, Zero Hunger; 3, Good health and well-being; 13, Climate action/mitigation, and 15, Protecting life on land.

I would recommend this book to conservation managers, planners, practitioners, researchers, and academia for great ideas and recommendations on enhanced management of wildlife, conflict management, and community engagement along protected area boundaries. The book provides ideas and approaches that complement ongoing efforts to address human-wildlife conflicts through the novel Buffer Crop Farmers Model (BCFAM) which the author developed. The model is based on effective planning by individual farmers, identification of common crop-damaging wildlife species, and strategic location of the crop farm.

The book further identifies and presents buffer crop varieties and their resilience and adaptation to damage by particular wild animals as well as potential losses. The Author reveals that the growing of buffer crops indeed mitigates crop damage by wild animals by 68%. These findings are important for planners and conservation practitioners as we strive to identify long-term solutions to wildlife-crop damage, reduce Human-Wildlife Conflicts and improve relations with local communities.

I congratulate the Author, Dr. Taddeo Rusoke, for the great publication. The invaluable findings will greatly contribute to Conservation Planning and Wildlife Management in Uganda.

Mr. George Owoyesigire
Ag. Commissioner Wildlife Conservation
Ministry of Tourism, Wildlife and Antiquities, Uganda

FOREWORD II

Congratulations Taddeo! I first met Taddeo in May 2008 when he was a volunteer at the Uganda Wildlife Education Conservation Centre (UWEC), Entebbe. In him, I saw a young man passionate about Environment Conservation, so hardworking that he was willing to make a significant contribution to Wildlife Conservation in Uganda. Indeed, it is a blessing to come across as young, self-driven, and passionate people who are willing to make a positive contribution to the advancement of society.

Taddeo loves sharing knowledge through research and publication. I am happy that through this publication, he is disseminating critical solutions to Human-Wildlife Conflicts, a great challenge in our communities neighboring National Parks in Uganda. With the growth of the human population, Human-Wildlife Conflict is set to grow. Finding space for both people and wildlife to co-exist is the ultimate conservation challenge. Successful wildlife Conservation must put people at the Centre. Wildlife threatens lives and livelihoods and there is a need to develop actions to ensure that people and wildlife can both thrive within the same environment.

This book highlights how effective the growing of buffer crops (plants which are not or least damaged by wild animals) acts as a mitigation measure, to crop damage by wild animals, of farmers crops bordering the Kibale National Park forest edge.

Management of wild animal damage on crops by growing buffer crops is a critical solution to Human-Wildlife Conflicts in Uganda, and I would like to thank Dr. Taddeo Rusoke for this great work that will bring relief to communities and promote coexistence between wildlife and communities.

I congratulate Dr. Taddeo Rusoke for this great piece of work that is going to support wildlife conservation efforts in Uganda and beyond using the good practices that will be picked and learned from implementing the proposed solutions to Human-Wildlife Conflicts as proposed by Taddeo.

I wish you nice reading and I am sure the book will impact our communities positively by implementing the proposed solutions to mitigate Human-Wildlife Conflicts.

James Musinguzi, PhD
Executive Director, UWEC.
Chairman, Pan African Association of Zoos and Aquaria,
Chairman Chimpanzee Trust Board of Trustees.

ACKNOWLEDGEMENT

This book would not have come to fruition, had it not been for the generous support from the following categories of people, whom I henceforth appreciate: Mr. Talibita Moses and Mr. Aggrey Rwetsiba, I thank you for the endless academic and professional opportunities you have always exposed me to in Uganda & South Africa; Professor Robin Attfield of Cardiff University, I appreciate your generosity made in your comments, especially on the philosophical and historical chapter of this book; more so, Dr. James Musinguzi the C.E.O of Uganda Wildlife Authority, and Mr. George Owoyesigire Ag. Commissioner Wildlife Conservation, Ministry of Tourism, Wildlife and Antiquities, Uganda, you are appreciated for accepting to foreword this book.

I would like to appreciate farmers bordering Kibale National Park for your willingness to participate in interviews that boosted my morale to document your stories in this book. Lastly, I would like to thank my wife, and children Malcolm Birungi Rusoke and Mirabelle-Felistus Musiime for your support.

I would like to acknowledge on a special note Professor Robin Attfield, Professor Emeritus of Philosophy at Cardiff University, Professor Faustino Orach-Meza of Nkumba University and Dr. Renuka Thakore who edited the book.

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Senior Lecturer of Conservation Studies (Nkumba University, Uganda) and Research Fellow at the African Wildlife Economy Institute (AWEI), Stellenbosch University Republic of South Africa.

DEDICATION

Thirteen years ago, the late Prof. Eric L. Edroma (R.I.P) introduced me to conservation research in Uganda. Together we conducted the first study on the "Linkage between Wildlife & Culture of the People in South-Western Uganda" this study guided the establishment of Igongo Museum and Cultural Centre in Mbarara Western Uganda.

I dedicate this book to him posthumously.

LIST OF ACRONMYS

BCFAM:	Buffer Crop Farmers Model
BINP:	Bwindi Impenetrable National Park
CARE:	Cooperative Assistance and Relief Everywhere
CCW:	Community Conservation Warden
C.E.O:	Chief Executive Officer
FAO:	United Nations Food and Agriculture Organization
GDP:	Gross Domestic Product
GMP:	General Management Plan
HWCs:	Human Wildlife Conflicts
KNP:	Kibale National Park
MAAIF:	Ministry of Agriculture Animal Industries and Fisheries
MWTA:	Ministry of Tourism Wildlife and Antiquities
NAADS:	National Agriculture Advisory Services
OFT:	Optimal Foraging Theory
OWC:	Operation Wealth Creation
PA:	Protected Areas
PhD:	Doctor of Philosophy
QECA:	Queen Elizabeth Conservation Area
S/CPCD:	Sub-County Production Coordinator
SDGs:	Sustainable Development Goals
UNDP	United Nations Development Programme
USA:	United States of America
USD:	United States Dollars
UWA:	Uganda Wildlife Authority
UWEC:	Uganda Wildlife Conservation and Education Centre
VBN:	Value Belief Norm Theory
WCS:	Wildlife Conservation Society
WDM:	Wildlife Damage Management

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PREFACE

Where Protected Area boundaries stop, farming begins. Most crops grown by farmers form part of the diet for wild animals. This book provides information for Protected Area Managers, Conservation Planners, Policy makers, and other Conservation Stakeholders on how to reduce crop damage by wild animals straying from National Parks into crop farms of adjacent protected area communities in Uganda. It provides findings and lessons learned from farmers growing buffer crops at the border with Kibale National Park in Western Uganda to protect their farms from nine (09) major crop damaging wild animal species namely: Elephants (*Loxodonta africana*), Red-tailed monkeys (*Cercopithecus ascanius*), Olive Baboons (*Papio anubis*), Buffaloes (*Syncerus caffer*), Chimpanzees (*Pan troglodytes*), Wild Pigs (*Sus scrofa*), Squirrels (*Sciuridae*), Ugandan Kobs (*Kobus kob thomasi*), and Hippopotamus (*Hippopotamus amphibious*). The forms of wild animal damage include, losses incurred when farmers do not grow buffer crops, and losses mitigated when farmers grow buffer crops. A new model – Buffer Crop Farmers Model (BCFAM), was suggested that farmers can adopt to increase buffer crop growing based on size of land owned, distance from the protected area boundary, major food crop grown and main wild species that damage the crops.

The major food crops that are damaged by wild animals straying from protected areas are bananas, maize, sweet potatoes, cassava and beans. Farmers around Kibale National Park (KNP), with help from Uganda Wildlife Authority (UWA), try to stop and/or

reduce crop damage by wild animals by planting buffer crops, guarding crop gardens against wild animals damaging species, planting scare crows in gardens, digging trenches around gardens and at the park boundary, setting of beehives fence lines and UWA scare shots that drive strayed wild animals back to Kibale National Park. Wild animals such as monkeys, elephants and chimpanzees, are reported to damage crops as compared to other wild animals.

The concept of buffer cropping (Smith and Nijman (2017) consist of planting less-palatable crops which create a low-conflict barrier between farmers and wild animals. Such crops enrich the protected area boundary, and obscure and/or entice wild animals such as primates to remain in the forest since buffer crops shield off crop farms. Most buffer crops planted are beneficial to both farmers and wild animals. Buffer crops refer to plants and crops both cash and non-cash crops which are not wholly or fully damaged by wild animals (fauna), but of agricultural significance to farmers around Kibale National Park. Such crops include tea, coffee, simsim, cotton, and khat. Crop damage by wild animals can be described as a process where wild animal damage part of the plant, whole plant by trampling and/or breaking stems of the crops grown in gardens. In this way, farmers lose agricultural livelihood through wild animals foraging, feeding, breaking stems, and/or trampling on their crops.

Wildlife damage on crops is rampant among farmers bordering protected areas in Uganda and world over. This book highlights

how effective growing of buffer crops (plants which are not or least damaged by wild animals) acts as mitigation measure to crop damage by wild animals among farmers i.e. crop farmers bordering the Kibale National Park forest edge. Chapter One provides facts about the effect of wild animal damage on yields of major food crops grown, Under Chapter Two, the book describes the different types of buffer crops grown by farmers to mitigate wild animal damage around Kibale National Park, and Chapter Three provides information on how farmers participated in planting buffer crops as a mitigation measure to crop damage by wild animals. Chapter Four provides insights on historical, philosophical and theoretical perspectives on management of crop damage by wild animals. Chapter Five presents a model that guides farmers participation in growing of buffer crops as a mitigation measure to crop damage by wild animals, and Chapter Six, as the last chapter of the book, presents information on policies, practices, implications and recommendations on wild animal's crop damage management in Uganda. Having presented the implications of farming on the forest edges of protected areas in Uganda, and the buffer cropping effect on mitigation of crop damage by wild animals among farmers bordering Kibale National Park, I recommend that farmers should be sensitized about the value of buffer crops and for those farmers growing buffer crops should be helped to access market for buffer crops such as tea which had started losing market by the time this book was written. Sensitizing farmers and helping them find markets for their produce from buffer crops and to increase farmer's participation in planting of buffer crops.

Crop damage by wild animals around KNP is partly mitigated through farmers growing effective buffer crops such as tea, coffee and simsim as guided by the Buffer Crop Farmers Model (BCFAM). Effective buffer crops mitigate crop yields loss among farmers. Growing buffer crops around Kibale National Park as mitigation measure to crop damage by wild animals is enhancing KNP management efforts through interventions such as digging new trenches, and setting beehive fence lines.

Taddeo Rusoke (PhD, MSc, BSc)
Founder, Africa One
Consult Limited (Uganda).

CHAPTER ONE

WILD ANIMAL DAMAGE ON MAJOR FOOD CROPS GROWN IN UGANDA

Loss of Crops to Wildlife Animal Damage in Uganda

Crop damage by wild animals is a threat to agricultural livelihoods of farmers around protected areas (Hill, 2009). For instance, 85% of crops damaged in the year 2011 around Kibale National Park in Uganda, was attributed to five major wild animal species which included Olive baboons (*Papio anubis*), wild pigs (*Scrus scrofa*), red-tailed monkeys (*Cercopithecus ascanius*), chimpanzees (*Pan troglodytes*), and elephants (*Loxodonta africana*). Such crops included bananas, cassava, maize, sweet potatoes, Irish potatoes and beans.

This continued loss of agricultural livelihoods creates resentment towards wildlife among farmers, a phenomenon that facilitates escalation of human-wildlife conflicts (Fulconis and Gross, 2011; Shaurabh and Sindhu, 2017). Most of the literature suggests measures of dealing with wild animals that damage crops, (Akampulira *et al.*, 2015) but none has evaluated why farmers around protected areas are not adopting cultivation of effective buffer crops against crop damage by wild animals. There are still information gaps relating to crop damage valuation and its relevance to protection of wild animals.

Mackenzie and Ahabyona (2011) observed that crop damage by wild animals led to financial losses of US$74 (an equivalent of 1.5% median household capital asset wealth) and this damage was experienced within 5000m of Kibale National Park (KNP) forest boundary. Sudip *et al* (2015) emphasize the identification and quantification of crop damage but quickly assert that the means used for crop protection and their effectiveness is limited. The development of non-agricultural activities on land directly adjacent to the forest can reduce wild animal damage on crops. Around KNP where farmers live close to protected areas, the development of non-agricultural activities in an agriculturally dominated economy might not be feasible (L'Roe and Naughton-Treves, 2017). Hence examining effectiveness of buffer crops as mitigation measure to crop damage could provide amicable solutions, alongside enhancement of protected area crop protection interventions.

Modification of farming practices (Akankwasah, 2008) such as planting of crops which are less palatable or appealing to wild animals, or planting of crops that are commonly damaged by wild animals beyond a buffer of unappealing crops or habitat, may present a more effective and sustainable solution to crop damage by wild animals (Hockings and Hulme, 2009). Akankwasah (2008) supports the growing of buffer crops as mitigation to crop damage by wild animals because of their potential economic value. Other techniques of managing crop damage by wildlife such as digging and maintenance of trenches, planting Mauritius thorn fences and/or reliance on

guarding crop gardens by dogs (Hill, 2012) can be complemented by growing of buffer crops.

Growing of Buffer Crops and other Mitigation Measures to deter by Wild Animals Damage on Crop

Where protected areas end, crops and gardens begin (Sieler and Robbins, 2015). Sieler and Robbins (2015) found tea to be an effective deterrent/buffer crop against gorillas. The implication is that gorillas dislike crossing through the tea plantations and do not feed on the crop. Planting buffer crops and establishing particular varieties of buffer crops to plant have the ability to mitigate crop damage by wild animals (Akankwasah, 2008; Akampulira *et al*., 2015).

Woodroffe *et al*., (2005) and Hill (2012) enlist several techniques for deterring wild animals that damage crops such as guarding, lethal removal, and chasing wild animals that damage crops with help of domestic dogs can be complemented by growing buffer crops. The enlisted techniques require constant human presence, growing effective buffer crops does not require so. The use of firecrackers with help of fire launches by crop protection teams in Tanzania is also used to mitigate crop damage by wild animals, though the use of firecrackers in Sri Lanka was associated with human and elephant hearing impairment (Sivakumar *et al*., 2013; Damian, 2018). Therefore, use of firecrackers cannot be promoted as suitable mitigation measure and the other mentioned techniques require constant

human presence, hence this book explores identification of effective buffer crops as mitigation to crop damage by wildlife.

Literature from countries such as Zambia suggests that farmers plant several varieties of beans with bitter leaves as buffer to antelopes and cape hares (Akampulira *et al.*, 2015). While Akankwasah (2008) noted that planting buffer crops has the potential to cause significant reductions in the diversity of food crops produced; there are no studies to proving that planting buffer crops result in reductions in the diversity of food crops produced. Hill (2012) established that non-staple crops can also be used as buffers depending on their level of deterring wild animals that damage crops.

Akampulira *et al* (2015), Sean (2016) gauged growing of tea and Mauritius thorns as buffer crops around Bwindi Impenetrable National Park and both studies reveal that tea and Mauritius thorns deterred gorillas and other primates respectively from damaging crop farms. The question still lingers as to why farmers around other protected areas are not adopting and planting such buffer crops to mitigate crop damage by wild animals. The finding on Mauritius thorns as a buffer to deter primates such as monkey is also supported by Mackenzie and Graham (2012) who discovered that the bio-fence deterred primates around Queen Elizabeth National Park. Farmers need to be enlightened on which buffer crops to grow to mitigate crop damage by wild animals.

Around Bwindi Impenetrable National Park (BINP), farmers are engaged in growing of high-value buffer crops such as Tea, Lemongrass, and Artemisia (Nkuringo Buffer Zone – GMP, 2015-19). However, fewer studies, if at all none, have been conducted to determine how buffer crops mitigate crop damage by wild animals. Though it can be noted that growing of these buffer crops, creates employment, improves incomes, and enhanced livelihoods of farmers around BINP (Akampulira *et al.*, 2015). Kalpers *et al* (2010) noted that the Mauritius thorn hedges around Nkuringo were effective in deterring primate raids since members of the community were involved in their maintenance.

Since piloting of tea as a buffer crop around Bwindi Impenetrable National Park in Uganda, mixed observations have been enlisted. Tea a high-value crop that can act as a buffer, when fully established can help control crop damage by wild animals and contribute to community livelihoods (UWA, 2015). Tea proves as an effective buffer crop only when it is fully maintained, free of other indigenous plants and shrubs which can attract wild animals (Akampulira *et al.*, 2015). If not, fully maintained buffer crops can harbour wild animals that eventually damage crops. When the tea is fully established as a buffer crop, the open tea plantation deters crop damaging wildlife species such as chimpanzees from crossing into community gardens (BINP GMP 2007-2012).

In Rwanda, crop damage by wild animals was mentioned as the reason why farmers bordering National Parks preferred to grow

trees since they were not damaged by wild animals (McGuiness, 2016). Growing trees reduced incidence rates of damage by wild animals and provided an opportunity for farmers to plant commercial tree species such as eucalyptus. The growing of eucalyptus as short-term commercial tree species ensured quick economic returns since exotic trees are rarely foraged upon by wild animals (Nyirenda *et al.*, 2013).

Foraging by wild animals escalates incidence rates of crop damage by wild animals that is counteracted in most cases by guarding and that most farmers try to protect their gardens by guarding. Crop damage by wild animals can result in increased school dropouts (Hill, 2017). Children do not attend school as they have to guard crops against wild animals from damaging crops. Growing pasture, Artemisia, lemon grass, and tea as non-palatable crops to reduce incidence rates of crop damage in Nkuringo (Kalpers *et al.*, 2010) seemed to relieve children of the burden of missing out on schooling. Buffer crops might also mitigate human-wildlife conflicts (Hockings, 2009; Fulconis and Gross, 2011; Hill, 2020).

Loss of Crop Yields to Crop Damaging Wild Animal Species

Monkeys are associated with the destruction of fruit crops and plantain. For instance, the Japanese monkeys (*Macaca fuscata*) are considered agricultural pests. The monkeys destroy gardens of sweet potatoes, wheat, and pea-nuts (Firoj *et al.*, 2010). Whereas in Zambia, crop damage by wild animals is majorly associated with elephants (Nyirenda *et al.*, 2011). Elephants are

responsible for damaging large fields of maize and plantain. In Tanzania, farmers have employed several crop techniques by forming crop protection teams. Crop protection teams use fireworks, chili powder, and flashlights to safely redirect elephants off farmlands, but the damage caused by elephants is immense (Damian, 2018).

Umashankar (2017) found that 71% of the households around wild animal's reserves in India had suffered crop damage by wild animals. It is urged that investment in mitigation efforts could look in alternative crop households can grow. Some 85% of crop damage events around KNP were associated with six species, namely baboons, elephants, red tail monkeys, bush pigs, and chimpanzees (Naughton-Treves, 2017). Maize and cassava were occasionally destroyed. Crop damage by wild animals is happening amid protected area management investing heavily in the digging of trenches, planting Mauritius thorns (West *et al.*, 2006).

In comparison to studies in Asia, Gail *et al.*, (2012) noted that some 73% of incidents of crop damage by wild animals in Sumatra were on fruit crops. Farmers on average lost their jack fruits at 38%, iengkol at 15%, 13% rubber, 4% durian, and 3% petai. All these crops were lost to orangutans an arboreal ape native to Sumatra. Kibale National Park's (KNP) six of the 13 primates are crop known to damage crops, thus the damage occasioned by primates could as well be six times for farmers living near the National Park. As noted by Bloomfield *et al.*, (2020) crop damage reduces support for conservation efforts.

Some staple crops grown by farmers suffer maximum or total damage by wild animals (Rao *et al.*, 2012). Monkeys and boars in Himalaya accounted for 50-60% of crop damage. Food-grains and horticultural crops such as apples suffered maximum damage (Rao *et al.*, 2012). Gardens of potatoes suffered 43.6% of crop damage by wild animals, the projected loss in crop yields by 2002 in four villages found within Garhwal Himalaya wild animals reserve accounted for US$15,389.

Around Kibale National Park, the major food crops lost were maize (*Zea mays),* sweet potato *(Ipomea batatas),* and beans *(Phaseolus vulgaris).* In a study by Naughton-Treves *et al.*, (2011), crop fields lying within 500 m of KNP, farmers on average completely lost 4-7% of their cassava and maize crops. These are some of the causes of resentment of wild animals by farmers as noted by Lichtenfeld *et al.,* (2014).

Hill (2017) reported that 70% of farmers bordering the Budongo Forest in Uganda associated crop losses to baboons and bush pigs (Hill, 2017). Trends in crop damage by wild animals show increase in damage with increasing distance to protected area boundaries. Naughton-Treves (2008) notes that farmers bordering Kibale National Park on average lost 3.5% of banana fields by area, 6.8% of cassava fields, and 5.5% of maize fields. This poses a threat to agricultural livelihoods despite the existence of some deterrent methods such as guarding (Hill, 2012), trenches, planting Mauritius thorns (West *et al.,* 2006). Crop damage by wild animals creates hostility and resentment among farmers (Lichtenfeld *et al.,* 2014). Crop damage takes

several forms such as trampling, foraging, and whole plant ingestion by wild animals. Crop damage by wild animals could put household food security at risk (Davari, 2000). Around Queen Elizabeth Conservation Area (QECA), wild animals damaging crops such as maize and beans was an excuse given for poaching by some members of the community (CARE, 2005).

Crop damage by wild animals creates a competitive nutritional intake between humans and non-human primates (Feuntes *et al.*, 2005). Crop damage by wild animals is a global concern (Hill, 2010; Naughton-Treves *et al*, 2011). Crop damage happens at different crop growth and development lifecycles [crop phenology – Onojeghuo *et al.*, 2018]. Since crops are damaged at different stages of growth, management of crop damage by wild animals is a complex issue. Alongside growing buffer crops, other interventions such as digging elephant trenches, setting up beehive fences and encouraging farmers to diversify livelihoods minimizes losses of agricultural livelihoods.

Naughton-Treves *et al.*, (2011) noted that crop damage by wild animals was associated with residing and growing crops closer to the forest edge. Farmers around Budongo Forest lost maize to baboons and cassava to bush pigs. Guarding crops (Hill, 2012) against bush pigs was presumed dangerous as some farmers lost their lives to wounded bush pigs. Buffer crops might offer a remedy to crop damage by wild animals as the technique does not require a human presence.

Apart from elephants (*Loxodonta africana*) studies conducted by Krithi and Sahila (2017) show that monkeys and wild boars alone accounted for 40-60% of crop damage of most horticultural crops in India. The study notes that preventing crop loss for farmers promotes conservation and mitigates human-wildlife conflicts (Fulconis and Gross, 2011). A wide range of wild animal species has been previously implicated in crop damage, ranging from large mammals destroying crops and agricultural infrastructure (Chiyo and Cochrane, 2005). These require multiple strategies to deter them from damaging crops. Encouraging farmers to grow buffer crops is one of them.

Human-Wildlife Conflicts from Crop Damage by Wild Animals

Crop damage by wild animals is a potential source of conflict between humans, animals, and protected area management as farmers lose livelihoods to wild animal species (Kaggwa *et al* 2009). For instance, Kaggwa *et al*., (2009) observed that wild animals continue to destroy crops, a major source of resentment towards wildlife among farmers bordering protected areas. Where farmers are unable to mitigate crop damage by wild animals adequately, and in absence of effective compensation schemes, retaliatory killing of wild animals are common. Effectively, there is a need to identify effective buffer crops farmers can grow to mitigate crop damage by wild animals. It has also been noted by Food and Agriculture Organization (FAO) that by 2050, global food production must increase by 60% to feed over 9.5 billion people. Globally the livelihood of 2.5 billion people shall be dependent on agriculture (UN-FAO,

2016). Accordingly, securing livelihoods of farmers bordering protected areas is key to ensure food availability.

Loss of crops to wild animals is a potential source of human-wildlife conflicts (Hockings, 2009), as farming in proximity to the forest edge is a predictor of crop damage by wild animals (Naughton-Treves *et al.*, 2011). Hill (2012) discovered that guarding crops against wild animals during the day proved effective but requires constant human presence. Where farmers are unable to guard their farms and at the same time do not grow buffer crops, and are not compensated for crops lost, during compensation, farmers exaggerate compensation claims. Growing effective buffer crops could provide an alternative to compensation for crops lost. This consequently mitigates Human Wildlife Conflicts fueled by loss of agricultural livelihoods among farmers in proximity to protected area boundaries. Tea as a physical buffer crop inhibits human encroachment on the park and crop damage by wild animals on smallholder crops (Brad and Jon, 2004).

Major food crops damaged by Wild Animals in absence of Buffer Crops

The major food crops that were usually damaged by wild animals were established and the loss of yields as a result of wildlife damage among 366 farmers was determined in October 2019. Of these farmers, 106 farmers grew bananas, 85 farmers planted maize, 70 farmers planted sweet potatoes, whereas 65 farmers grew cassava, and 40 farmers grew beans as shown in Table 1.1.

Table 1.1: Major food crops grown around Kibale National Park

Major food crop grown	Percentage of farmers n (%)
Bananas (*Musa spp*)	**106 (29)**
Maize (*Zea mays*)	85 (23)
Sweet potatoes (*Ipomea batatas*)	70 (19)
Cassava (*Manihot esculenta*)	65 (17)
Beans (*Phaseolus vulgaris*)	40 (12)

According to Hill (2017) these major crops damaged by wild animals are included in diet of most wildlife species found in Kibale National Park (KNP). Farmers bordering KNP mainly grow bananas. Banana growing was predominant in Hakibaale, Bigodi and Rwimi sub-counties in Kabarole, Kamwenge and Bunyangabu districts respectively. Bananas were mainly damaged by elephants. Beans were the least crops grown in Nyabuharwa in Kyenjojo district. Other crops were cassava grown mainly in Busoro and Ruteete sub-counties and sweet potatoes were mainly grown in Kiko and Busiriba sub-counties. Farmers revealed that bananas were grown both as cash and staple crop.

The major wild animal species which damage crops around Kibale National Park

The major wild animals that damaged crops as mentioned by respondents around the park were elephants (*Loxodonta africana*) which accounted for 30% of all the crop damage as shown in Figure 1.1. The least crop damaging wild animals reported by 366 farmers was hippopotamus (*Hippopotamus amphibious)* at 3% (Figure 1.1) Hippopotamus were mainly reported by respondents from Rurama parish in Ruteete Sub-County. The hippopotamus lived in nearby crater lakes of Nyabikere and majorly damaged gardens of beans by grazing during night.

Damage to crops is associated to the location of the crop farm from the party boundary. For instance from person observations and using a handheld GPS it was found that most farmers that grew maize their farms were located in less than 500 metres from the Kibale National Park boundary, however all banana farmers had their gardens located within 500 metres from the park boundary, this was the case with farmers who grew beans and maize in Kamwenge district. Location of crop farmers in close proximity to the boundary of the park exposes their crops to damage by wild animals especially when farmers are not growing buffer crops. Such farmers need to be sensitized to adopt and grow effective buffer crops to deter damage from wild animals residing in Kibale National Park.

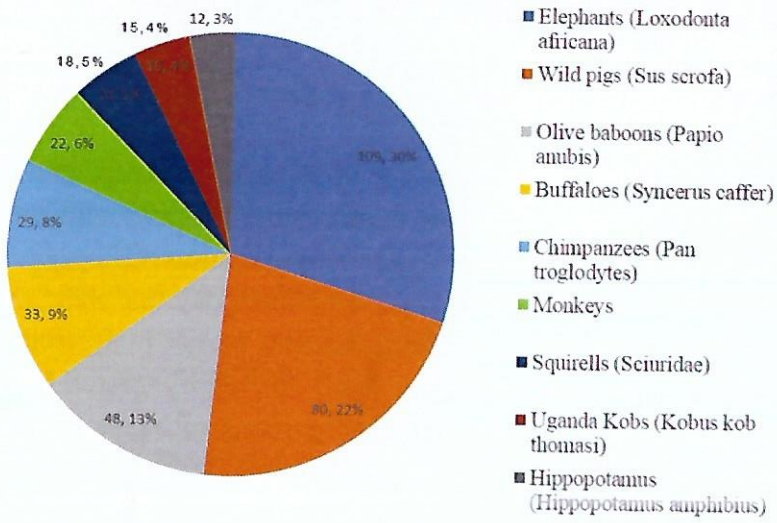

Figure 1.1: Major Wild animal species that damage crops as reported by farmers bordering KNP

Perceptions of Farmers on Crop Damage by Wild Animals

Farmers bordering Kibale National Park suffered wild animal damage as shown in Table 1.2. In terms of single crop damage, elephants damaged 106 or 29% of the bananas. Wild pigs damaged 17% of the cassava planted, chimpanzees 8% of sweet potatoes, of all the wild animals crop damaging species, hippopotamus accounted for the lowest damage on crops by 3%. Hippopotamus majorly damaged beans. Banana farmers are majorly affected by elephant depredation around Kibale National Park.

Table 1.2: Wild Animal Species and the Major Food Crops they damage around KNP (n=366)

Crop damaging wild animals	Major food crops grown per household				
	Bananas	Cassava	Maize	Sweet potatoes	Beans
Elephants (*Loxodonta africana*)	**106**	3	0	0	0
Red-tailed monkeys (*Cercopithecus ascanius*)	0	5	17	0	0
Olive baboons (*Papio anubis*)	0	0	**48**	0	0
Buffaloes (*Syncerus caffer*)	0	0	20	13	0
Chimpanzees (*Pan troglodytes*)	0	0	0	29	0
Wild Pigs (*Sus scrofa*)	0	**57**	0	23	0
Squirrels (*Sciuridae*)	0	0	0	5	13
Ugandan Kobs (*Kobus kob thomasi*)	0	0	0	0	15
Hippopotamus (*Hippopotamus amphibious*)	0	0	0	0	12

Form of Wild Animal Damage on Major Food Crops

The major forms of damage on crops by wildlife from Kibale National Park are feeding on the whole crop by wild animals, wild animals trampling and breaking stems of crops, wild animals feeding on shoots of crops, feeding on tubers, feeding on raw banana fingers and inflorescence, uprooting planted crops and chewing tender leaves, feeding on maize cobs, and feeding on ripening bananas. Animal feeding behaviour influences the form of damage inflicted on crops grown.

Therefore, this book presents information on form of damage by a particular wild animal.

Form of Wild Animal Damage on Bananas

Elephants destroyed 67 of 366 or (18.3%) of banana plants by feeding or destroying the whole banana plant as reported by respondents in Table 1.3. Several types or forms of damage by other wild animal species are also shown in Tables 1.3 – 1.8. Crops are damaged differently by different wild animals, bananas are wholesomely destroyed by elephants through feeding on the entire crop. Trampling by elephants can also result in total loss of yields of bananas among farmers digging near the park.

Table 1.3: Form of Wild Animal Damage on Bananas (n=366)

Wild animal species	Form of damage by wild animals on bananas grown				
	Feeding/ destroying the whole plant/crop	Trampling and breaking stems	Feeding on shoots	Feeding on ripening fingers	Feeding on raw banana fingers/ Inflorescence
Elephants	67	8	5	0	28
Monkeys	5	11	2	2	1
Olive baboons	14	20	0	12	2
Buffaloes	11	22	0	0	0
Chimpanzees	0	22	7	0	0
Ugandan Kobs	14	1	0	0	0

Form of Wild Animal Damage on Cassava

Cassava was mainly grown in Busoro and Ruteete sub-counties in Kabarole district as shown in Figure 2.1. From interviews it was reported that cassava is grown as both a commercial and staple crop among households around Kibale National Park. The form of damage by wild animals on cassava is shown in Table 1.4.

Table 1.4: Form of Wild Animal Damage on Cassava (n=366)

Wild animal specie	Form of damage by wild animals on cassava			
	Feeding/ destroying the whole plant/crop	Trampling & breaking stems	Feeding on shoots	Feeding on tubers
Elephants (*Loxodonta africana*)	**32**	**35**	**18**	**24**
Monkeys	24	21	2	5
Olive baboons (*Papio anubis*)	0	36	0	1
Buffaloes (*Syncerus caffer*)	0	7	14	0
Chimpanzees (*Pan troglodytes*)	0	20	0	9
Wild pigs (*Sus scrofa*)	0	0	0	22
Squirrels (*Sciuridae*)	0	0	0	16
Uganda kobs (*Kobus kob thomasi*)	0	0	15	0

Form of Wild Animal Damage on Sweet Potatoes

121 or 33% of the sweet potatoes' farmers around Kibale National Park reported that their sweet potatoes gardens were damaged by elephants (Table 1.5) by destroying or feeding on

the whole crop. The type of damage on sweet potatoes depends on animal feeding habits. Elephants are known to traverse or walk long distances in search of food (Hill, 2017).

A total of 4/366 respondents reported that elephants trampled on sweet potato gardens destroying sweet potatoes ridges and vines, breaking stems, and 20 of the 366 reported that elephants occasionally ate sweet potato tubers (Table 1.5). Olive baboons were second to elephants in damaging sweet potatoes by feeding on tubers as mentioned by 61 of the 366 farmers (Table 1.5).

Table 1.5: Counts on Form of damage by wild animals on Sweet Potatoes (n=366).

Crop damaging wild animal species	Type of Wild Animal Damage on sweet potatoes			
	Feeding/ destroying the whole plant/crop	Trampling and breaking stems	Feeding on shoots	Feeding on tubers
Elephants (*Loxodonta africana*)	121	64	6	20
Red-tailed monkeys (*Cercopithecus ascanius*)	18	1	9	4
Olive baboons (*Papio anubis*)	6	0	3	61
Buffaloes (*Syncerus caffer*)	0	0	4	8
Chimpanzees (*Pan troglodytes*)	0	0	0	36
Squirrels (*Sciuridae*)	0	0	0	1
Uganda kobs (*Kobus kob thomasi*)	0	0	4	0

Form of Wild Animal Damage on Maize

Forty-five percent (165 of 366) of the maize farmers around Kibale National Park mentioned that elephants completely fed and destroyed their maize gardens in a single depredation (Table 1.7). Maize farmers were mainly from Busiriba and Bigodi sub-counties in Kamwenge District, with a few farmers from Kitswamba Sub-County in Kasese District and Rwimi Sub-County in Bunyangabu District.

Maize as a food and cash crop is damaged at different stages of growth and development. Monkeys are recorded to feed on planted seeds by removing soil and feeding on the seeds, at germination level, monkeys can uproot and feed on tender shoots of maize. Elephants can feed on maize stalks and cobs thus destroying the whole crop.

Red-tailed monkeys and Olive baboons can still feed on maize cobs, whereas Buffaloes and Uganda kobs were reported to graze on maize plants. Maize was mainly damaged by elephants and red-tailed monkeys.

Maize is grown both as a staple and cash crop among farmers around KNP. The crop forms the core of the agricultural system within the community. Schools, refugee camps, and households were the major markets for the produce. From observations made, maize was majorly grown in Kitswamba and Karusandara sub-counties.

Wild animal damage on maize poses challenge to food security since it is grown both as a food and cash crop around Kibale National Park. Maize damage by wild animals was rampant in areas where there were no interventions by the park to mitigate crop damage such as elephant trenches and beehive fences. There was neither elephant trenches nor beehive fences in sub-counties of Karusandara and Kitswamba. Absence of effective buffer crops and crop damage management interventions by the park explains damage by wild animals among maize farmers. Statistics on the type of damage by the several species of wild animals around Kibale National Park are shown in Table 1.6

Table 1.6: Forms of Wild Animal Damage on Maize (n=366).

Crop damaging wild animal species	Form of wild animal damage on maize			
	Feeding/ destroying the whole plant/crop	Trampling and breaking stems	Feeding on shoots	Feeding on maize cobs
Elephants (*Loxodonta africana*)	**165**	**18**	**1**	**17**
Red-tailed monkeys (*Cercopithecus ascanius)*	16	0	0	6
Olive baboons (*Papio anubis*)	10	5	4	91
Buffaloes (*Syncerus caffer*)	0	0	0	16
Chimpanzees (*Pan troglodytes*)	0	1	0	3
Squirrels (*Sciuridae*)	0	0	1	2
Uganda kobs (*Kobus kob thomasi*)	0	0	10	0

Form of Wild Animal Damage on Beans

Beans were the least grown crop around Kibale National Park (KNP) by 40 (11%) of farmers in less than half a kilometre from KNP boundary. Elephants and Olive baboons were reported to mainly damage beans grown by farmers bordering KNP. All 40 of the 366 farmers were owning bean gardens in less than 500m to the park boundary and were prone to more loss of yield comparable to farmers digging quite a distance.

Elephants can trample on bean gardens destroying stems, olive baboons were reported to uproot and feed on tender leaves as reported by 70 of 366 of the farmers as shown in Table 1.7. Trampling by elephants as reported by (82 of 366) at the stage when beans bear pods were reported to least affect yields of beans in kilogrammes around Kibale National Park.

As mentioned by respondents uprooting and chewing tender leaves of bean plants by baboons was the most common form of damage on beans. Uprooting and chewing of tender leaves results in total loss of yields as beans are destroyed at infant stages of growth and development. In instances where the olive baboons did not uproot the planted beans, they destroyed bean plants by chewing tender leaves of the crop. Feeding on tender leaves may not result in total loss of yields.

Therefore, interventions for crop damage management such as growing of buffer crops could provide solutions as buffer crops are plants and crops which are either partially or wholly not damaged by wild animal species.

Table 1.7: Counts regarding forms of Wild Animal Damage on beans

Crop damaging wild animal species	Form of wild animal damage on beans			
	Feeding on whole crop	Trampling & breaking stems	Feeding on shoots	Uprooting/chewing tender leaves
Elephants (*Loxodonta africana*)	39	82	3	11
Red-tailed monkeys (*Cercopithecus ascanius*)	18	29	19	14
Olive baboons (*Papio anubis*)	4	14	24	70
Buffaloes (*Syncerus caffer*)	0	0	4	5
Chimpanzees (*Pan troglodytes*)	0	0	5	8
Wild pigs (*Sus scrofa*)	0	0	7	0
Uganda kobs (*Kobus kob thomasi*)	0	0	5	0
Hippopotamus (*Hippopotamus amphibious*)	2	0	3	0

Effect of Wild Animal Damage on yields of Bananas

Fifty four percent (54%) are the respondents who grew bananas but did not harvest any bananas after the plantations were damaged by wild animals (Table 1.8). The major crop damaging wild animals for bananas were elephants, which damaged 106 or 28.9% of the bananas grown by farmers bordering KNP (Table 1.8). From interviews it was noted that sometimes all the banana plants were not wholly damaged by wild animals, though in some instances, where Kibale National Park authorities' rangers

scare-shoot crop damaging wild animals species, some banana farmers harvested better yields of bananas.

Farmers who severely suffered banana damage by wild animals were majorly those from Rwimi Sub-County where bananas were mainly grown, but the park had crop protection interventions such as elephant trenches which could deter crop damaging species such as elephants and buffaloes from crossing into plantations.

Animals such as elephants moved seasonally hence not damaging crops in other areas. Banana farmers from Kiko Town Council reported that unlike monkeys and olive baboons, elephants and buffaloes can damage the entire banana garden in a single night of depredation when they escape from the park.

Damage on bananas by elephants was more severe during the rainy season, when farmers were not able to light fire to keep watch of elephants at night. Elephants could further feed at night when farmers retired to sleep (Hill, 2017). This statistic shows that in absence of permanent interventions such as trenches and beehive fences, farmers continue to suffer crop damage and losses occasioned by wild animals.

Table 1.8: Effects of Wild Animal Damage on yields (Kgs/Ha) of bananas (n=366).

Yields of undamaged bananas		Yields of damaged bananas	
Yields (kgs)/ha.	n (%)	Yields (kgs)/ha.	n (%)
		0	201(54)
<500	51 (14)	<500	129 (35)
501-1000	112 (31)	501-1000	21 (6)
1001-2000	50 (14)	1001-2000	2 (1)
>2001	**153 (41)**	**>2001**	**13 (4)**

Effect of Wild Animal Damage on yields of Cassava

When cassava gardens were not damaged by wild animals, 43.8% of cassava farmers would harvest at least five bags (500kgs) of dry cassava. But after wild animals had damaged their gardens, there was reduction in terms of yields of cassava harvested by 5% (from 43.8% to 38.8%) as shown in Table 1.9.

Elephants damaged cassava crops by trampling and breaking stems destroying the whole crop, wild pigs and red-tailed monkeys ate tubers, buffaloes browsed on shoots, chimpanzees broke down cassava stems, whereas Uganda kobs fed on tender shoots and leaves of the cassava plant (Table 1.9).

Table 1.9: Effects of Wild Animal Damage on yields of Cassava (n=366)

Yields of undamaged cassava		Yields of damaged cassava	
Yields (kgs)/ha.	n (%)	Yields (kgs)/ha.	n (%)
		0	175(47.8)
<500	158 (43.2)	<500	142 (38.8)
501-1000	99 (27)	501-1000	42 (11.5)
1001-2000	24(6.6)	1001-2000	6(1.6)
>2001	**85(23.2)**	**>2001**	**1(0.3)**

Effect of Wild Animal Damage on yields of Maize

Farmers lost maize yields as shown in Table 1.10. About 38.3% of the farmers who harvested >2001kgs when their gardens had not been damaged by wild animals, after their gardens had been damaged by wild animals, none of them harvested maize produce (Table 2.10).

Table 1.10: Effects of Wild Animal Damage on yields of Maize (n=366).

Yields of undamaged maize		Yields of damaged maize	
Yields (kgs)/ha.	n (%)	Yields (kgs)/ha.	n (%)
		0	217(59.3)
<500	87(23.8)	<500	118(32.2)
501-1000	71(19.4)	501-1000	24(6.6)
1001-2000	67(18.3)	1001-2000	7(1.9)
>2001	**140 (38.3)**	**>2001**	**0(0)**

Effect of Wild Animal Damage on yields of Sweet Potatoes

Forty five percent (45%) of the sweet potato farmers who harvested five bags (<500kgs) when wild animals had not damaged their sweet potato gardens, after gardens had been damaged by wild animals, only 24.6% of them could have the same yields around Kibale National Park (Table 1.11).

Growing of sweet potatoes supports livelihoods of most farmers bordering Kibale National Park. Sweet potatoes were regarded as both staple and commercial crops from interviews conducted. By 2021, a sack of 100kg of sweet potatoes costed about sixty thousand Ugandan shillings (60,000/=). Any damage by wild animals on sweet potatoes exposed farmers to loss of income and increased their vulnerability to food insecurity.

The major crop damaging wild animal species that damaged sweet potatoes were elephants which fed on shoots and tubers, and destroyed sweet potatoes gardens by trampling to break their vines. Olive baboons (*Papio Anubis*) were reported to feed on tubers of sweet potatoes. (Table 1.11). Loss of yields of major food crops to wild animals can be attributed to the form of damage by wild animals imposed by particular wild animal specie.

Table 1.11: Effects of Wild Animal Damage on yields of Sweet Potatoes (n=366).

Yields of undamaged Sweet potatoes		Yields of damaged sweet potatoes	
Yields (kgs)/ha.	n (%)	Yields (kgs)/ha.	n (%)
		0	250 (68.3)
<500	**164(44.8)**	**<500**	**90(24.6)**
501-1000	90(24.6)	501-1000	18(4.9)
1001-2000	80(21.9)	1001-2000	8(2.2)
>2001	32(8.7)	>2001	0(0)

Effect of Wild Animal Damage on yields of Beans

There was significant loss of yields among farmers growing beans around Kibale National Park. 33.1% of the farmers who harvested >2000kgs of beans when their crops had not been damaged by wild animals, after their crop gardens were damaged, only 0.3% could still harvest >2000kgs. 58.5% of farmers growing beans totally lost their bean gardens to wild animals, these did not harvest any yields when wild animal damage has been experienced (Table 1.12).

Beans were mainly damaged by Uganda kobs, Squirrels, Elephants, Olive baboons and Hippopotamus. The several crop damaging wild animals species damaged crops differently by

grazing, trampling, uprooting, and chewing on tender leaves of beans planted by farmers bordering Kibale National Park.

Table 1.12: Effects of Wild Animal Damage on yields of Beans (n=366).

Yields of undamaged beans		Yields of damaged beans	
Yields (kgs)/ha	n (%)	Yields (kgs)/ha.	n (%)
		0	214 (58.5)
<500	158(43.2)	<500	143(39.1)
501-1000	40(10.9)	501-1000	5(1.4)
1001-2000	47(12.8)	1001-2000	3(0.8)
>2001	**121(33.1)**	**>2001**	**1(0.3)**

Other factors influencing Crop Damage by Wild Animals

Qualitative findings and observations made explain several other factors that influenced crop loss and damage around Kibale National Park. For instance, maintaining trenches by widening and increasing their depth was associated with deterring elephants, wild pigs and buffaloes crossing to damage farmers crops. Since 71.3% of the respondents did not grow buffer crops, these park interventions were very helpful in mitigating crop loss to wild animals in areas such as Hakibaale S/C in Kabarole District where farmers did not grow buffer crops at all.

In some sub-counties bordering Kibale National Park, where trenches are dug to deter wild animals from crossing into farmland were not maintained (widened to 2 metres and deepened to 3 metres) crop damage was reported among major ungulates such as elephants and buffaloes. This fact was confirmed from the Warden Community Conservation (WCC). Seasonal movement of wild animals also influenced damage by wild animals, such farmers noted that sometimes their crops were not damaged since at times wild animal species that damage crops such as elephants had moved to other parts of the Kibale National Park. Such facts as seasonal movement of wild animals are supported by the Optimal Foraging Theory (OFT) by Osborn and Park (2003) who associated crop damage by wild animals to seasonality.

Multivariate Regression Model on Cassava Damage by Wild animals around KNP

The author performed Regression Analysis to determine other factors associated with crop damage by wild animals. It was discovered that as a farmer grows older, chances of his/her farm being damaged by wild animals are higher (β= -.173, P=0.002). This concept explains social vulnerability to crop damage by wild animals. Whereas, increasing level of knowledge was associated with more protection of crop farms (β= .152, P=0.009). There was increasing damage by wild animals on farms nearer the forest edge (β=-.123, P=0.031) as shown in Table 1.13.

Table 1.13: Multivariate Regression Model on cassava damage by wild animals

Model	Standardized Coefficients	T	Sig.
	Beta		
(Constant)		4.944	.000
Gender	.101	1.804	.072
Age	-.173	-3.111	.002
Education	.152	2.626	.009
Occupation	.056	.970	.333
Farm distance from the park	-.123	-2.162	.031
Farmland owned in hectares	.077	1.366	.173
a. Dependent Variable: Wild Animal Damage on cassava			

Multivariate Regression Model on Sweet potatoes Damage by Wild animals

The larger the farm size, the less wild animal damage on crops (β=0.206, *P*=0.00), however, the closer the sweet potatoes garden was to the park, the higher the chances of damage by wild animals (β=-0.133, *P*=0.023) as shown in (Table 1.14). Almost 40 to 60% of the farmers bordering KNP grow crops on small farms which are heavily damaged by wild animals, whereas the rest are involved in providing cheap labour as tea pluckers in tea plantations.

Table 1.14: Multivariate Regression Model on Sweet Potato damage by Wild animals

Model	Standardized Coefficients	T	Sig.
	Beta		
(Constant)		4.012	.000
Gender	-.024	-.417	.677
Age	-.015	-.260	.795
Education	.102	1.684	.093
Occupation	.060	.995	.321
Farm distance from the park	-.133	-2.278	.023
Farmland owned in hectares	.206	3.493	.001
a. Dependent Variable: Wild Animal Damage on sweet potatoes			

Multivariate Regression Model on Bean damage

The Multivariate Regression Model shows that age, education, and distance negatively influence beans damaged around KNP. Age (β = -.126, *P*=0.00); education (β= -.024, *P*= 0.00); and, farm distance from the park boundary (β= -.185, *P*=0.02 for farm distance from the park (Table 1.15). The more a farmer was not educated, closer to the park and elderly in age, the more damage they experienced in terms of damage to beans.

Social and biophysical vulnerability of farmers to crop damage is still evident around Kibale National Park for farmers involved in growing beans. Age, education, and location of bean gardens from the park boundary was associated with increasing damage by wild animals as shown in Table 1.15.

Table 1.15: Multivariate Regression Model on Bean damage by Wild animals

Model	Standardized Coefficients	T	Sig.
	Beta		
(Constant)		6.478	.000
Gender	.015	.254	.800
Age	-.126	-2.155	.032
Education	-.024	-.402	.688
Occupation	.060	.985	.326
Farm distance from the park	-.185	-3.110	.002
Farmland owned in hectares	.099	1.678	.094

a. Dependent Variable: Wild Animal Damage on beans

Coping Methods and Strategies by Farmers against Wild Animal Damage on crops

Guarding crop farms against elephants (*Loxodonta africana*) and wild pigs (*Sus scrofa*) depredation was regarded as the most effective measure complementing buffer crop growing mentioned by 26.5% of the farmers around Kibale National Park (Table 1.17). Coping measures included maintaining of trenches as shown in Plate 1. Well maintained trenches at three metres deep and 2 metres wide were reported to deter elephants from crossing into farmlands (Plate 2) as compared to poorly maintained trenches (narrow and shallow) as shown in Plate 3 and Plate 4.

Table 1.16: Coping with Crop Damage by Wild Animals among Farmers bordering Kibale National Park (n=366).

**Guarding crop farms against elephant (Loxodonta africana) and wild pigs (Sus scrofa) depredation was regarded as the most effective measure in absence of buffer crop growing around Kibale National Park.*

Coping measure	Wild animals species								
	Elephants	Red-tailed monkeys	Olive baboons	Buffaloes	Chimpanzee	Wild Pigs	Squirrels	Uganda Kobs	Hippopotamus
Adopting mixed farming	24	0	10	6	11	31	0	0	3
Started bee keeping	15	5	16	12	4	7	0	2	2
Hiring land away from boundary	27	2	5	0	3	0	17	6	3
Joined retail business	2	1	2	0	1	3	0	0	0
Maintaining trenches at a fee	7	3	1	4	9	10	0	0	4
Involved in goat rearing	2	0	0	4	0	0	0	0	0
Employed in a tea company	1	1	0	0	0	2	0	0	0
Guarding of crop farms	**31***	**10**	**14**	**7**	**1**	**27***	**0**	**7**	**0**

Plate 1: Community participation in maintenance of trenches, Kahangi Parish, Hakibaale Sub-County in Kabarole District

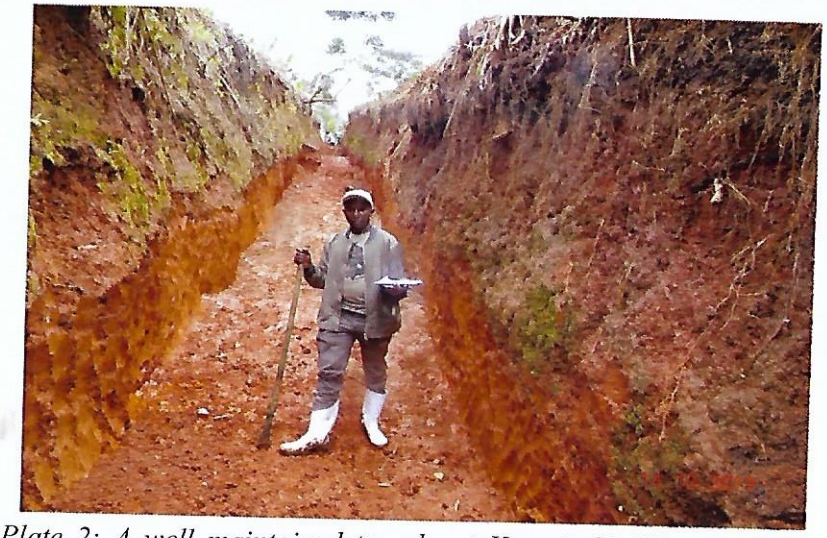

Plate 2: A well maintained trench, at Kyansimbi Village, Kahangi Parish in Hakibaale Sub-County, Kabarole District.

Plate 3: Elephant crossing point (when trenches are not maintained).

Plate 4: Poorly maintained (shallow and narrow trench) in Busiriba Sub-County, Kamwenge District

The Effects of Wild Animal Damage on yields of Major Food Crops

From observations made, efforts were being made to stop wild animals from damaging crops grown by farmers bordering Kibale National Park (KNP). For instance, in Kinyantale Village, Kinyantale Parish in Nyabuharwa S/C, Kyenjojo District, children moved around crop gardens sounding empty tins, making alarms, and throwing stones to scare away red-tailed monkeys from maize crop gardens. Despite such efforts of chasing wild animals from farms, farmers around KNP, continued to lose yields of the major food crops grown to wild animal damage. The major food crops grown were bananas, maize, cassava, sweet potatoes, and beans.

From observations made during fieldwork and with aid of photographs captured on camera, commercially, around KNP, bananas were majorly grown in Kabarole and Bunyangabu Districts. Maize was mainly grown in Nyabubaale, Kyabakwerere, Kihoima, Nkingo and Kajumiro villages in Kamwenge District, in Ibuga, Rubalika, Kakooga villages in Kasese District, and Mugoma, Katebe, Kinyantale, Rwabaganda, Kinyantale villages in Kyenjojo District. Cassava, beans, and sweet potatoes were grown in all the fifty-four villages across all districts.

From observation, mixed cropping was mainly practiced in all the five districts: Kabarole, Kyenjojo, Kasese, Kamwenge and Bunyangabu. Mixed cropping of buffer crops such as coffee

with staple crops such as maize was a common sight, Plate 3 and enticed wild animals to cross and damage crops. Farmer education through sensitization on how to grow and on the value of buffer crops as proposed in the Buffer Farmers Model, Figure 3.1 through providing farmers with buffer crop planting materials is imperative in mitigating crop yield loss to wild animals around Kibale National Park.

Farmers who salvaged produce when wild animal damage had occurred, these either continued guarding their crop gardens against wild animals attacks especially those with homesteads nearer the park boundary, or their crops were partially damaged by wild animals (Plate 5 and 7). Some crop farms were not damaged by wild animals and this was partially associated to Kibale National Park management efforts to maintain trenches by widening and deepening them (Plate 2) to stop elephants from crossing into farmlands in Hakibaale S/C, as elephant trenches which were not routinely maintained (narrow and shallow) could easily be crossed by elephants to damage crops in Bigodi Town Council and Busiriba Sub-County (Plate 4).

Through interviews, the researcher sought to understand which species majorly damaged crops, how crops were damaged, how the farmers differentiated wild animal damage from livestock damage, and how farmers made up for losses incurred.

> *"Elephants are our biggest challenge, in our parish, there are no elephant trenches, and we have just been supplied with beehives which are to be*

used to set up beehive fences. In a single raid, elephants can destroy the entire garden of maize or bananas. People are poor because of crop damage. S/CPCD Karusandara Sub-County.

"Here in Karusandara, we have a lot of lands where we can graze cattle, I am appealing to the Kibale National Park management to give us livestock. Money meant for revenue sharing projects should be invested in livestock projects", Farmer from Karusandara S/C.

"I lost half of my maize garden to elephants. The elephants damaged the garden in one night of crop-raiding. I could guard my garden during the day, but in the evening when I retire home to prepare a meal for my children, that's when elephants attack my garden. I am a widow; my late husband helped me to guard our garden in the night before he passed away. It is a big challenge to protect crops from elephant damage especially if you don't have a night guard" Farmer Busoro S/C in Kabarole District.

When farmers were asked to differentiate damage by wild animals from livestock, one farmer said.

"Goats and cattle do not damage crops such as Irish potatoes, olive baboons and monkeys can attack our gardens and destroy banana fingers of

standing crops which is not the case with goats and cattle. Baboons can uproot beans and Irish potatoes. I can no longer raise fees for my children" Reported a Respondent from Bigodi S/C.

Plate 5: Damaged banana plant in Kahangi Parish, Hakibaale S/C Kabarole District (Source: Author, 2019).

Plate 6: A female farmer tends to a tomato garden on the border with Kibale National Park in Kahangi Parish, Kabarole District.

Growing of crops such as tomatoes by farmers bordering Kibale National Park act as attractants to crop-damaging wild animal species (Plate 6). Most primates are attracted to such crops as tomatoes. Though tomatoes were not among the five major food crops grown, beyond tomato damage, such wild animal species that were attracted by tomatoes ended up damaging other crops such as bananas. Smallholder farmers near the Kibale forest boundary suffered more crop damage compared to farmers with larger pieces of farmland (Table 1.13).

Plate 7: A display of a palm-full of damaged Irish potatoe tubers in Busiriba Parish, Kamwenge District.

When respondents were asked, how they made up for losses incurred as a result of wild animal damage on crops, the responses were as follows:

> *"I no longer dig near the National Park. I am hiring land away from the park boundary which is quite expensive. If the park can buy my land near the forest, I could relocate. I am hiring an acre of land between 150,000/= to 200,000/= per season"*
> Farmer from Busiriba S/C.

"I am employed in a Tea Estate, with the money got from the revenue sharing programme, I bought piglets. I continue digging while guarding my garden but on a small scale. I have also started a retail shop for my wife. I appeal to the park to increase revenue sharing funds" Farmer from Kaswa Parish, Busoro Sub-County, Kabarole District.

The Warden Community Conservation,

"Very few households near the Park keep livestock that can damage crops, most of the households are farmers, the few that keep livestock tether it, and crop damage by livestock is not as pronounced compared to wild animals. Farmers report stray wild animals such as buffaloes, our rangers also scare shoot wild animals back to the park"

Wild Animal Crop Damage and Implications on Food Security

When farmers continue losing their crops to wild animals, their food security and nutrition status is impaired. The different types of damage have several effects on yields of major food crops. Trampling and breaking stems of cassava (*Manihot esculenta*) and vines of mature sweet potatoes (*Ipomea batatas*) had minimal effects on yields lost as compared to other types of wild animal damage included grazing and feeding on tender leaves of some crops such beans (*Phaseolus vulgaris*) and maize (*Zea*

mays). Uprooting by olive baboons, and grazing of germinating beans by hippopotamus results in total loss of yields.

Crop damage type is influenced by animal behaviour from observations made on damaged crops such as bananas. The most uprooted crops were Irish potatoes, maize at tender stages of growth by olive baboons. Occasionally, olive baboons can dig out seeds which have just been planted and feed on them. Olive baboons are good at concealing in nearby bushes around the gardens, when farmers retire to their homes after a day's work, on return the next day you can find baboons have uprooted all your crops.

From interviews, the challenge of crop damage depredation by wild animals was severe in sub-counties where there were no beehive fences such as in Hakibaale and having no trenches in Nyabuharwa Sub-County.

It is important to understand the nature of crop-damaging species, to differentiate damage caused by wild animals and livestock. Since both wild animals and livestock pose threats to agricultural livelihoods of farmers living and farming near protected areas edges.

Livestock such as goats, sheep, and cattle which were highly restrained by tethering, could only damage banana fingers on bunches of fallen banana stems in instances when they broke ropes at the tethering points. Farmers around the park were involved in several methods that restricted livestock from accessing gardens. Such measures as tethering cattle, goats, and

sheep, keeping the herds in kraals, or tying livestock in courtyards at night helped to mitigate crop damage by livestock. Given the several measures to reduce livestock from accessing crop gardens, most farmers associated damage on crops to wild animals.

High prevalence of crop damage by elephants can be associated to crop damaging behaviour, since elephants were qualitatively reported to damage crops during day and night fall. A herd of elephants damaging banana stems in a single depredation results in total loss of yields of major food crops grown. Hill (2017) also noted that elephants had the ability to damage crops when farmers left gardens unguarded to go and sleep. Crop damage mitigation without buffer crops was dire among widows, who had lost their husbands that acted as night guards. Farmers from Kasojo village in Kiko Town Council revealed how they spent sleepless nights in their gardens to deter elephants from damaging crops at night, apart from losing crops when a farmer did not guard crops, guarding crops at nightfall also exposes farmers to contracting diseases such as malaria, in addition to human life being attacked by the wild animals.

Buffer crop growing does not require constant human presence as compared to other methods. Elephants destroy and feed on the whole banana crop, while monkeys damaged bunches of bananas by feeding on fingers and/or damaging the inflorescence.

Bananas were least damaged by Uganda kobs (*Kobus kob thomasi*) and hippopotamus (*Hippopotamus amphibious*) as shown in Table 1.3. Hippopotamus and kobs were mentioned as the least crop damaging wild animal species. This was associated to the forested nature of the park which limits grazers, and the distribution of water sources such as crater lakes. The hippopotamuses that damaged beans in Rurama Parish mainly came from Nyabikere Crater Lake in Ruteete Sub-County.

African elephants are the most frequent wild animal's species that damaged crops (Gross *et al.*, 2018). As their home ranges shrink due to the destruction of wild animals habitats, elephants become isolated and migration is inevitable. Elephants can destroy an entire crop garden in single wild animal's depredation. Therefore, the need to complement buffer crops with digging more elephant trenches provides a solution to mitigate damage by elephants.

Wild pigs were responsible for digging up and feeding on 60% of sweet potatoes tubers around Kibale National Park (KNP). In addition to other crop-damaging wild animal's species for sweet potatoes such as monkeys, rodents, and elephants, farmers around KNP were heavily losing agricultural livelihoods. Sweet potatoes are known to be among the major staple crops around KNP (Hill, 2017).

Around Kibale National Park, baboons cause damage on sweet potatoes which is considered both a cash and staple crop. Therefore, in tandem with findings of Lichtenfeld (2014), any

sustained damage to sweet potatoes poses threats to food security and possible resentment of wild animals and conservation efforts around Kibale National Park (KNP), since sweet potatoes were also sold as commercial crops. Encouraging farmers to grow buffer crops around KNP should be completed with enhancement of crop protections interventions such as widening and deepening of elephant trenches, as they deterred other species such as olive baboons from damaging sweet potatoes gardens.

Crop damage by most crop damaging wild animals is associated with the type of staple crops grown around KNP. The study established that farmers in Hakibaale S/C continued to grow crops which enticed wild animal's species that damaged crops into their farms. For example, in Kahangi Parish, Hakibaale Sub-County, farmers grew tomatoes at the edge of the Kibale National Park (Plate 2). Crops such as tomatoes attract most species of monkeys and olive baboons to farms. Eventually primates ended up damaging other crops such as bananas, Irish potatoes, and beans.

Some farmers expressed that they never knew what buffer crops were. There is a need to sensitize farmers about buffer crops, their values, and how buffer crops can be grown to mitigate crop damage by wild animals as proposed in the developed Buffer Farmers Model in Figure 3.1.

Farmers in Nyabuharwa Sub-County in Kyenjojo District were incurring costs of hiring land away from the park leaving behind

their original landholding near the park unproductive. Such farmers were forced to move long distances to hire farmland, losing valuable time. Farmers continue guarding their gardens at night especially against elephants, but when they fall asleep crops are destroyed as reported from Kiko Town Council. Farmers noted that in some instances, they salvaged crops when wild animal species that damaged crops had moved to feed in other parts of the Park.

Since trenches were found to be effective against elephants, buffaloes and wild pigs, the trench network can be expanded around Kibale National Park to specifically guard crop damage from elephants, buffaloes and wild pigs. From the revenue sharing programmes, small-holder farmers can be engaged in alternative projects such as livestock farming and the apiary. Apiary production has a double benefit of deterring elephants through beehive fence lines and income from sales from honey.

The closer the crop farm was to the park boundary, the heavier the damage experienced by an individual farmer. For farmers that grew beans, sweet potatoes, and cassava near the Kibale Forest boundary, more crop losses were incurred. This affects their livelihoods and well-being. Such farmers can be involved in alternative livelihoods such as livestock or can adopt buffer crops that are not damaged by wild animals such as tea and Khat or those which are not wholly damaged by wild animals such as coffee, simsim, and cotton.

Crop damage by wild animals is a potential source of food insecurity, as different species of wild animals destroy crops at

different stages of their lifecycle according to Mackenzie and during field observations, I discovered that sometimes beans are damaged by wild animals at the germination stage through primates uprooting and chewing tender leaves of such plants. For maize damage occasioned by elephants was towards maturation, elephants can destroy the entire garden of maize by feeding on both their stalks and cobs. Primates too can feed on leaves of beans and maize cobs. Crop damaging wild animal species inflicts damage at a different stage of a crop lifecycle, this results in varied loss of yields. Creating awareness among farmers on which buffer crops to grow help them to avoid loss of yields is imperative. Planting of buffer crops that are not damaged by either primates or elephants, alongside enhancement of park crop protection interventions such as digging and expanding the trench network around crop gardens especially against elephants can mitigate wild animal damage on crops.

Gender and age correlates to crop damage mitigation. Underlying factors could be that elderly farmers aged >45 years who accounted for 41% (Table 1.16) were no longer able to protect their farms from crop damaging wild animals especially at night when they retired to sleep and could not constantly guard their gardens. Tales of farmers from Kibale National Park in Uganda also reveal that women are unable to effectively guard their crop gardens against the damaging wild animal species since they often gave up guarding to do other household chores. Hill (2017) observed that farmers around the Budongo Forest in Uganda suffered severe crop depredation at night by elephants when they retired to sleep. Farmers around Kibale National Park

also reported that monkeys were also capable of destroying especially maize gardens at night.

Sweet potatoe loss was more pronounced given the fact that they were grown on a subsistence basis and were affected by more than one crop-damaging wild animal. Almost all primates, ungulates, and elephants damaged sweet potatoes gardens by way of feeding on tubers, grazing or trampling. Maize could easily be destroyed by elephants in single depredation and by monkeys too. The larger the farm size, the higher the chances of an individual farmer to salvage produce. Therefore, small land holder farmers living <500m from the park boundary and practicing subsistence agriculture were more prone to individual loss of yields comparably to individual commercial farmers growing bananas and cassava. Moreover, banana farmers could have either half a bunch damaged by monkeys or cassava gardens were trampled upon and stems broken but they could harvest tubers especially when the cassava was damaged at maturity.

In comparison to a study by Hill (2009) on yields lost to wild animal damage by an individual wild animal species at 94.9%, as the single determinant of crop yields, there seems to be a decreasing trend in crop damage around KNP. This factor can be attributed to park interventions for crop damage management such as digging of trenches, setting elephant deterrent boards and setting up beehive fences at the periphery of Kibale National Park.

Conclusion

Crop damage by wild animals has implications for food and nutrition security as main staple crops such as bananas were damaged mainly by elephants. Nine wild animals species that damaged the five major food crops grown around Kibale National Park (KNP) by feeding or destroying the whole crop, by trampling, by uprooting and chewing, and by grazing. Elephants and monkeys caused the most damage to bananas, maize, sweet potatoes, and cassava. Beans were mainly damaged by grazing especially by Uganda kobs and hippopotamus. There was loss in yields of maize, sweet potatoes, beans and bananas whereby some farmers lose yields to crop damaging wild animal species in absence of buffer crop growing.

CHAPTER TWO

GROWING OF BUFFER CROPS

The Concept of growing Buffer Crops

Growing of buffer crops consist of planting less or non-palatable crops, which create a low conflict barrier; these enrich the forest edge, entice animals that damage crops to remain in the forest (Akampulira *et al.*, 2015). Buffer crops such as tea, simsim, coffee and khat, cotton are beneficial to farmers. The absence of effective buffer crops results in crop damage by wild animals. Individual farmers living close to protected area boundaries continue to suffer agricultural losses as a result of crop damage by wild animals. The growing of buffer crops is suggested as a measure to deal with crop loss, crop damage through feeding, browsing, gnawing, trampling and feeding by wild animals.

Damage by wild animals on crops is a constraint on the co-existence of humans and wild animals as farmers resent wild animals that damage their crops, this results in lack of support for conservation programmes. Mitigating crop damage by wild animals is a constant challenge (WCS, 2018) and causes economic losses to farmers as they lose yields of their crops to wild animals (Imre, 2020). Several means to repel species that damage crops including use of fences, trenches, repellents or scare devices (Delger *et al.*, 2011) have been tried but have

yielded limited success on small and large scale. According to Tweheyo *et al.*, (2012), the major food crops grown around Kibale National Park prone to damage by wild animals included: Beans (*Phaseolus vulgaris*), Cassava (*Manihot esculenta*), Maize (*Zea Mays*), Bananas (*Musa* species), and Sweet potatoes (*Ipomoea batatas*). Farmers grow crops which are not wholly or fully damaged by wild animals to avoid losses.

Most primates feed on maize, bananas, and sweet potatoes, the major crops grown by farmers bordering Kibale National Park as established by Hill (2017). Hill's study identified buffer crops grown by farmers to mitigate damage by wild animals species, analysed the effect of wild animal damage on yields of five major food crops (Beans - *Phaseolus vulgaris*, Bananas - *Musa* species, Maize – *Zea mays*, Sweet Potatoes – *Ipomea batatàs* and Cassava – *Manihot esculenta*) when Wild Animal Damage has not occurred and after wild animals-crop damage has occurred and/or been reported by farmers. In this book, I underscore how farmers' participation in planting of buffer crops can act as a mitigation measure against crop damage by wild animals around Kibale National Park and other protected areas across Uganda.

Damage by wild animals on farmed crops remains an important but underestimated problem especially among farmers bordering protected areas as they are continuously prone to losing livelihoods from crop damaging wild animals (Watve *et al.*, 2015). Wild animal damage to agriculture causes significant economic losses globally and threaten food security (Imre *et al.*,

2020). Evaluating the effect of buffer crops as a mitigation measure to crop damage by wild animals amongst farmers around KNP is expected to reduce agricultural losses. Farmers living close to protected areas are bound to suffer individual crop loss and damage from wild animals (Naughton-Treves *et al.*, 2011). As animals move from their natural habitat to feed on farmers' crops in agricultural fields this can be interpreted as crop damage by wild animals.

Nyirenda *et al.*, (2013) reported that a total of 79.83% of farmers growing crops close to protected area boundaries associate opportunity costs of crop damage by wild animals with loss of sleep and cost of time for other chores, when providing crop protection (Nyirenda *et al.*, 2013). Actual crop losses for mono-specific stands of maize and cotton were reported at 7.7% when animals cause damage to crops (Osborn and Parker, 2003). Crop damage by wild animals can be of several forms such as trampling, browsing, gnawing, or rubbing (Aparna, 2015). In Uganda, this seems to be the first book written regarding planting of buffer crops as mitigation measure to crop damage by wildlife. Studies by Akampulira *et al.*, (2015), and Bitariho *et al.*, (2019) on effectiveness of problem animal management strategies are mainly concentrated around Bwindi Impenetrable National Park in South-Western Uganda.

Crop damage by wild animals can expose households to food insecurity as major food crops are lost to wild animals; this can result in shortages of nutritional supplements and inadequate food reserves (Hill, 2017). As noted by Chapman and Lambert

(2000), of the 13 primates found in Kibale National Park (KNP), six are recorded to cause crop damage. Half of the primates being recorded as crop-feeders continue to threaten farmer's agricultural livelihoods around KNP. Deterrents such as beehive fences (King *et al*, 2011) have proved more effective as compared to Mauritius thorn fences. This book highlights the effectiveness of buffer crops as a mitigation measure to crop damage by wild animals and adds knowledge to the existing deterrents through establishing effective buffer crops such as Khat which is grown in Hakibaale Sub-County, Kabarole District.

Crop damage by wild animals which is a function of distance from the protected area, types of crops grown, types of crop-raiding species, the season of the year, and population density results in loss of agricultural livelihoods, destruction of farm structures and retaliatory killings. Crop damage by wild animals can be solved through growing some buffer crops such as tea (Akampulira *et al*., 2015). Identification of buffer crops, based on knowledge of crop grown by farmers, understanding farm location from the protected area, and appropriate crop growth seasons, buffer crops could prove effective in mitigation of crop damage by wild animals around Kibale National Park.

The Conceptual Framework in Figure 2.1, shows the relationship between crop damage by wild animals which leads to loss of farmers livelihoods in terms of yield and the effect of buffer crops which leads to undamaged crops. Crop damage by wild animals can be mitigated through improving knowledge of

farmers on which buffer crops to grow (intervening variable). Buffer cropping eventually leads to securing farmers livelihoods by mitigating loss in yields of the major food crops grown. Securing livelihoods of farmers requires farmers to grow effective buffer crops such as tea, coffee, simsim and khat whose effectiveness was established through scientific research as illustrated in the Conceptual Framework in Figure 2.1.

Buffer crops are regarded as crops which are not palatable to wild animals, yet of agricultural value to farmers. The choice and type of buffer crops are dependent on farmer's knowledge and sensitization about the values of such crops. Some buffer crops are also known to be traditional crops grown among communities. Akampulira *et al.,* (2015) noted tea on a pilot study was found to be an effective buffer crop against gorillas in Bwindi Impenetrable National Park. Understanding effectiveness of buffer crops as a mitigation measure against crop damage by wild animals explores which buffer crops are grown against which particular wild animals around Kibale National Park to avoid loss of crop yields. The concept of mitigation of crop damage by wild animals is illustrated in Figure 2.1.

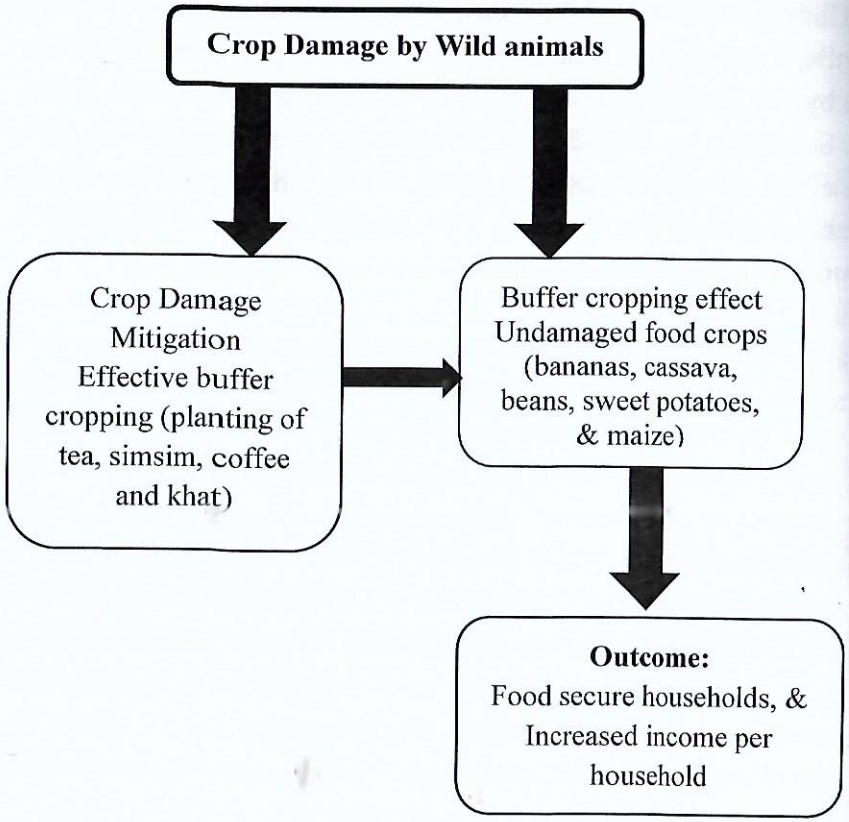

Figure 2.1: Concept of mitigation of crop damage by wild animals.

Damage of Crops by Wild Animals from Kibale National Park

The damage of crops by wild animals from KNP has been perceived the most inopportune of farming close to the protected area. Farmers at the border of the Park in Kabarole, Kyenjojo, Bunyangabu, Kasese and Kamwenge continue to suffer from

loss of yields, yet agriculture forms the baseline to Uganda's economy. The agricultural sector is an important contributor to the Ugandan economy employing about 69% of Ugandans, and a Gross Domestic Product (GDP) contribution of approximately 26% as of 2015 (Uganda Economic Outlook 2016). The statistics show an increase in the contribution to employment. There could be significant losses accrued by farmers around National Parks if agricultural losses are not mitigated.

Farmers continue to lose crops and children especially boys tend not to complete their primary school education around Kibale National Park (Mackenzie, 2015). Boys are preferentially held back by their parents to guard crops. The introduction of buffer crops can improve on chances of children attending school. Buffer crops can also improve nutrition (Johan *et al.*, 2017), promote diversionary feeding for wild animals (Shaurabh and Sindhu, 2017), and promote alternative food sources (King *et al.*, 2017).

Farmers bordering Kibale National Park are primarily subsistence agriculturalists with minimal livestock holdings. Household losses accrued due to living next to KNP have been primarily caused by crop-raiding, with elephants and olive baboons (*Papio anubis*) causing 93.5% of crop damage by area (MacKenzie and Ahabyona 2012). Village population densities were estimated as 70 – 611 people km^2 with 42 – 241 households per village (MacKenzie and Hartter, 2013).

In her book (*Chasing Baboons or Attending Class: protected areas and childhood education in Uganda),* Mackenzie *et al.,* (2015), discovered that households living within 3.5 km of KNP have to guard their food crops against park-protected wild animals. Children and their parents guarded against elephants at night and primates during the day. So, when do they go to school? Most children do not complete primary school. So how can they go to secondary school or university?' (Mackenzie *et al.,* 2015). Forty-one percent of the enrolled children came from households that permitted their children to guard crops against one to seven days per week during high wild animals-damaging seasons (May–July, and November–January); 'We hold children back from school to guard against crop damage by wild animals. If crop damage could be stopped, then our children could go to school' (Mackenzie *et al.,* 2015), such children are likely to turn into poachers later in life. These children move around crop gardens sounding empty tins, making alarms, throwing stones from morning to dusk to scare away wild animals-crop feeders, there is a need to address the damage of crops by wild animals. In some cases, dogs are used to chase away some wild animals' crop-feeders. All these are common sights during the crop fruiting and harvesting seasons around KNP. To remedy the plight of farmers, there is a need to evaluate how buffer crops can mitigate crop damage by wild animals.

About 80% of Ugandans rely on agriculture; most of these are farmers found in the countryside with a sizeable proportion bordering protected areas such as National Parks, wildlife reserves and other conserved areas. These are prone to crop loss

to wild animals' foraging. The deterrent techniques such as 'planting' scarecrow in crop gardens to scare away wild animal species are laborious, time-consuming, and guarding require constant human presence (Hill, 2012). The need to evaluate buffer crops as a mitigation strategy to crop damage by wild animals is imperative to ensure sustained agricultural livelihoods and avoid related consequences such as food insecurity and retaliatory killing of wild animal species involved in crop damage.

In examining buffer crops as mitigation measure to crop damage by wild animals, comprehensive information on crop damage by wild animal species is critical. Therefore, effective strategies for controlling crop damage by wild animals must be formulated, and this book suggests scaling up the growing of buffer crops. Determining the effect of crop damage by wild animals on yields of major food crops grown in the absence of buffer crops gave insights into solutions by farmers that were aimed to reduce crop damage by wild animals.

This book describes buffer crops as plants and crops which are either less-palatable or non-palatable to wild animals (Hoare, 2012). Though some animals such as primates can partially damage fruits of some of these crops such as coffee. It is known that some buffer crops create a low-conflict barrier between people and wildlife, they enrich the forest edge of a protected area, and entice wild animals to remain inside the Protected Area (PA). Buffer crops are plants which are beneficial to farmers in

terms of agricultural yields since some are commercial crops such as tea, coffee and simsim.

This book highlights that when farmers are supplied with buffer crop planting materials, they are encouraged to plant more buffer crops to mitigate damage occasioned by wild animals from Kibale National Park. Through this contribution, the book explains on some of the issues related to crop damage by wild animals such as time spent guarding crops; safeguard agricultural livelihoods and mitigate crop damage by wild animals that occurs at night when farmers retire to sleep (Barnes *et al.,* 2007). Planting of effective buffer crops as mitigation measure to crop damage by wild animals indirectly increases school enrolment as children no longer have to keep guarding gardens from crop damaging wildlife species. Planting of effective crops can help to reduce on revenue shared under compensation to farmers who have lost their crops to wild animals.

Subsistence farmers near Kibale National Park in Uganda fear and resent many wild animal species (Naughton-Treves *et al.,* 2011) due to crop damage by wild animals. This resentment of wild animals (Lichtenfeld *et al.*, 2014) can be mitigated through involving farmers in the use of buffer crops. Buffer crops can reduce crop damage by wild animals and human-wildlife conflicts when carefully studied, adopted, and grown. Since human-wild animals interactions (HWIs) can result in loss of livelihoods as a result of crop damage by wild animals (Fulconis and Gross, 2011; Hill, 2020), it's imperative to involve farmers

at every stage of assessing buffer crops as a mitigation measure. This ensured that farmers understand why they should grow buffer crops and adopt buffer crops as a mitigation measure to crop damage. HWCs are inevitable as long as farmers continue to suffer agricultural losses (Naughton-Treves *et al.,* 2011). It has already been observed that absence of effective mitigation measures and compensations schemes, retaliatory killing of wild animals was common.

Some authors observed that farmers who are closer to protected area boundaries or those who live inside it are more vulnerable to individual agricultural losses (Hill 2017). This shows an increasing trend in crop damage by wild animals. The findings of Naughton-Treves *et al.,* (2011) are supported by Mackenzie (2015) who later analysed crop damage by wild animal species and estimated that their financial cost was increasing between 10% and 30%. Habituated chimpanzees (*Pan Troglodytess schweinfurthii*) were majorly responsible for crop damage. Mackenzie (2015) further recorded November as the month of the year with severe crop damage. Her findings affirmed that crop damage was a function of park distance from the protected area boundary. Farmers bordering National Parks with 1-5-kilometre radius are more prone to crop damage by wildlife.

Studies conducted by Naughton-Treves *et al.,* (2011) noted that 90% of crop damage by wild animals affected farmers who were growing crops between 1200m to 1600m of Kibale National Park boundary. Farming closer to the protected area eventually acts as a buffer for farmers practising agriculture relatively

farther from the park boundary. This remains a challenge to farmers living near protected areas in Uganda and world-over. Importantly to note is that most measures to deal with crop damage by wild animals so far have proved effective with human presence. Methods to deter crop damage by wild animals such as guarding, use of fire, barriers and startle tactics (Rebekah, and Bruce 2015) were only effective with constant human presence. Conover (2009) observed that when wild animals are translocated could even return to areas where they were once captured and damaged crops. Described as a remnant of mid-altitude forest (Chapman and Lambert 2000), Kibale National Park (KNP) contains the highest number of primates that damage crops compared to other parks in Uganda. Six of the thirteen primates in KNP are recorded as crop-feeders (Naughton-Treves *et al.,* 2005). This fact explains rampant damage of crops especially among farmers who do not grow buffer crops.

KNP is primarily bordered by subsistence farmers who grow crops with minimal livestock holdings. Household agricultural livelihood losses accrued due to farming on the forest edge are primarily caused by species such as elephants and baboons (*Papio cynocephalus*) causing up to 93.5% of crop damage (MacKenzie and Ahabyona 2012). Village population densities were 70 – 611 people per km^2 with 42–241 households per village (MacKenzie and Hartter 2013). Olive baboons (*Papio anubis*), wild pigs (*Sus scrofa*), red-tail monkeys (*Cercopithecus ascanius*), chimpanzees (*Pan troglodytes schweinfurthii*), and elephants (*Loxodonta africana*) were responsible for the 85%

crop damage. Traditionally, farmers hunted wild animals in their gardens as a measure to mitigate crop loss. Some measures put in place by UWA such as digging trenches to stop elephants from crossing to farmlands (Mackenzie and Ahabyona, 2011), planting of Mauritius thorns for deterring primates (Lynagh and Urich, 2011; Taylor *et al.,* 2016) have proved effective only when trenches and Mauritius thorn fences are maintained not to act as launching areas for primates.

In Kyenjojo District where part of KNP is located, children often miss attending school since they have to guard crops against wild animal crop damaging species (Mackenzie, 2015). This is most frequent during the crops fruiting season. Based on findings, this book presents a model – Buffer Crop Farmers Model (BCFAM) which indicates ways that can enable and encourage farmers to adopt and grow buffer crops as a mitigation measure to crop damage by wild animals.

How Buffer Crops prevent wild animals from damaging crops

According to observation, tea was majorly grown in Hakibaale S/C, tea and coffee in Ruteete S/C, Cotton, Coffee and Simsim in Karusandara and Kitswamba S/Cs, Coffee only in Nyabuharwa S/C, Bigodi, Kiko, and Busiriba S/C, Tea and Khat in Hakibaale S/C (Plate 8) in Sub-Counties such as Rwimi in Bunyangabù District, farmers do not grow any buffer crops. Apart from buffer crop growing, KNP also had interventions for crop damage management around the Park. Such interventions

included beehive fences, digging of trenches, and scare-shooting. Farmers also continued to guard their crop fields, plant scarecrows in gardens, shout at and sound drums to chase animals from gardens, especially in areas where there were no buffer crop growing and Park interventions.

From observations, smallholder subsistence farmers grew buffer crops on a small scale. Farmers in Busiriba Sub-County intercropped buffer crops with other food crops such as maize (Plate 10). This farming practice attracted wild animal species that damaged crops farms resulting in loss of yields of the major food crops grown.

Tea (46.7%) as a buffer crop sometimes was grown along with coffee (41.9%), whereas 41.9% of the farmers grew Khat (1.9%) 3.8% cotton, and 5.7% simsim (Table 3.1). Two types of coffee were mainly grown, namely: Robusta and Arabica coffee. Wild robusta coffee also grows naturally in Kibale forest national park. Buffer crops such as coffee and simsim were partially damaged by wild animals. Such buffer crops as coffee and simsim were mainly grown in Kasese and Bunyangabu Districts. Specifically monkeys partially damaged coffee and birds destroyed simsim gardens.

Buffer Crops grown to deter wild animal species that damaged crops

Tea was the main buffer crop grown by farmers to mitigate crop damage by wild animals. Tea is sold as green leaf in kilogrammes to factories such as Rwenzori Commodities

Limited and Rwenzori Highlands Tea Company. Apart from acting as buffer crop, tea has ready market. Of the 105 farmers who grew buffer crops, tea was grown by 46.7% (see Table 2.1).

Table 2.1: Common Buffer Crops grown by farmers bordering Kibale National Park

Buffer crop growing	**Number of responses (%)**
Yes	105 (28.7)
No	261(71.3)
Types of buffer crop planted	
Tea (*Camellia sinensis*)	49 (46.7)
Coffee (*Coffea spp*)	44 (41.9)
Simsim (*Sesamum indicum*)	6 (5.7)
Cotton (*Gossypium spp*)	4 (3.8)
Khat (*Catha edulis*)	2 (1.9)

Source: Interview responses from 366 farmers

Thirty seven percent (37%) and 23% of the farmers who grew tea and coffee respectively, owned land which was >10 hectares (Table 2.2). Growing of these effective buffer crops was common among farmers with large pieces of land. Growing of buffer crops among large-land holders has implications on food security. Efforts to increase farmer's participation should consider the size of land owned in hectares. This ensures that some land is reserved for growing other staple crops such as bananas, sweet potatoes, maize, and beans.

Table 2.2: Hectares of Buffer Crops grown by farmers bordering Kibale National Park (n_1=105)

Types of buffer crop grown	Farmland owned in hectares		
	<5 hectares	6-10 hectares	>10 hectares
Tea (*Camellia sinensis*)	5.7	3.8	**37**
Coffee (*Coffea spp*)	4.7	14	**23**
Simsim (*Sesamum indicum*)	1.2	4.7	0
Cotton (*Gossypium spp*)	0	1.2	2.8
Khat (*Catha edulis*)	0	0	1.9

n_1= proportion of the farmers that planted buffer crops

Buffer Crops grown and their level of effectiveness.

Tea was the most effective buffer crop (96%) and the marginally effective buffer crop was cotton (75%) as shown in Table 2.3.

The least effective buffer crop was cotton, ranked as marginally effective at 4% (Table 2.3) by 75% of the farmers that grew cotton as a buffer crop (Table 2.3). Cotton was mainly grown in Kitswamba Sub-County in Kasese District. Cotton was mainly grown in Ibuga and Rugendabara Parishes. Cotton was also grown as a traditional cash crop in Kitswamba Sub-County. Some farmers preferred cotton growing as a buffer crop because cotton ginneries were easily accessed within the community.

Table 2.3: Buffer Crops grown and their level of effectiveness in deterring crop damage by wildlife around Kibale National Park (n_1=105).

Buffer crop grown	*Responses*	*Very effective*	*Fairly effective*	*Marginally effective*
Tea (camellia sinensis)	**49(46.7%)**	**47 (96%)**	**2 (4%)**	**0 (0)**
Coffee (Coffea spp)	44 (41.9%)	35 (79.5%)	9 (20.4%)	0 (0)
Simsim (Sesamum indicum)	6 (5.7%)	1 (16.6%)	5 (83.3%)	0 (0)
Cotton (Gossypium spp)	4 (3.8%)	0 (0)	1 (25%)	3 (75%)
Khat (Catha edulis)	**2 (1.9%)**	**1 (50%)**	**1 (50%)**	**0 (0)**

n_1= proportion of farmers bordering Kibale National Park who planted buffer crops.

Overall buffer crop growing deterred 68.5% of crop damage by wild animals among the 105 (28.7%) farmers who grew them (Table 2.4). Mitigating crop damage by wild animals around Kibale National Park is possible.

It is therefore important to sensitize farmers about the value of buffer crops as mentioned by 208 (56.8%) farmers, helping farmers to find market for buffer crops such as tea requested by 52(14.2%) of the farmers, provide farmers with planting materials of buffer crops (13.4%), encourage Uganda Wildlife Authority to provide incentives for growing buffer crops mentioned at (9.3%), and help farmers to add value to commercial buffer crops as mentioned by 23(6.3%) as shown in Table 3.4.

Table 2.4: Correlation between Buffer Crop growing and Mitigation of Crop Damage by Wild Animals

		Buffer crops planted to mitigate wild animal damage	Crop damaging wild animal species
Type of buffer crops planted to mitigate wild animal damage	Spearman Correlation	1	.685**
	Sig. (2-tailed)		.000
	N	105	105
What type of wild animals (animals) majorly destroy your crop farm?	Spearman Correlation	.685**	1
	Sig. (2-tailed)	.000	
	N	105	366
**. Correlation is significant at the 0.01 level (2-tailed).			

Preference and Choice of Buffer Crop growing among farmers bordering Kibale National Park

Farmers had several reasons on why they chose to plant certain buffer crops as opposed to others. Preference and choice of planting buffer crops is based on the degree of effectiveness against deterring crop damaging wild animals as shown in Table 2.3. Other reasons for choice and preference of buffer crops selected and grown are shown in Table 2.5. The major reasons being buffer crops are commercial crops which attract high market prices, with readily available markets such as tea which was sold to tea growing companies such as Rwenzori Commodities Limited and Rwenzori Highlands. Coffee was also

preferred because it was not wholly damaged by wild animals such as the red-tailed monkeys (*Cercopithecus ascanius*). The most preferred buffer crops were grown by farmers who owned large hectares of land. Results of buffer crop growing per land owned are shown in Table 2.2.

Table 2.5: Mean percentage for preference of Buffer Crops grown/planted (n_1= 105)

Preference of buffer crop grown	Tea	Coffee	Simsim	Cotton	Khat
Buffer crops repel vermin	0	1	1	2	0
Buffer crops are not palatable to wild animals	3	10	2	1	0
Buffer crops are quick to grow	1	0	0	0	0
Commercial crop with ready market	21	12	2	0	2
They are not wholly destroyed by wild animals	24	21	1	1	0

n_1= proportion of the farmers that planted buffer crops around Kibale National Park

Mean percentage of farmers bordering Kibale National Park growing buffer crops.

Of the buffer crops grown, tea was mainly grown in Kiko and Nyabuharwa Sub-Counties in Kabarole and Kyenjojo Districts. Coffee was mainly grown in Ruteete and Busoro Sub-Counties in Kabarole District. Simsim and cotton was mainly grown in Kitswamba Sub-County in Kasese District. Whereas Khat was only grown in Hakibaale Sub-County in Kabarole District (Table 2.6). Preference of choice of growing buffer crops is shown in Table 2.5.

Table 2.6: Counts of farmers growing Buffer Crops per sub-county (n=366)

Sub-County	Tea	Coffee	Simsim	Cotton	Khat
Hakibaale	3	5	0	0	2
Busiriba	0	0	0	0	0
Busoro	0	10	0	0	0
Kiko	20	0	0	0	0
Rwimi	0	7	1	0	0
Ruteete	3	9	0	0	0
Nyabuharwa	23	8	0	0	0
Karusandara	0	0	0	0	0
Kitswamba	0	5	5	4	0
Bigodi T/C	0	0	0	0	0

Farmers grew buffer crops they thought deterred crop damaging wild animal species. Khat as a buffer crop was grown in Kahangi Parish, Hakibaale S/C in Kabarole District (Plate 8), tea (Plate 9) are also grown as buffer crops and sold commercially.

Plate 8: Khat (Catha edulis) growing in Kahangi Parish, Hakibaale Sub-County in Kabarole District.

A respondent from Hakibaale S/C (Kahangi Village, Kahangi Parish) said:

> *"I grow Khat because it's not destroyed by any wild animal. Khat is not damaged by elephants, monkeys, baboons, and chimpanzees. It is a commercial crop and highly paying. About fifty grams of fresh Khat leaf costs about 2000/= to 3000/=. I sell khat within my community. The market for fresh khat is readily available"*

Though Khat crop is not legally recognized by the Government of Uganda, about a quarter of Hakibaale residents grow Mairungi (Khat) as a buffer crop and a crop of commercial value as shown in Plate 8.

Similarly, a participant from Hakibaale Sub-County revealed that:

> *"Apart from tea and Khat being grown as buffer crops, these crops are commercial, however, tea and Khat are grown by large holder farmers, if I had a small piece of land, then I don't think I could involve myself in Khat and Tea growing. These crops need a large piece of land. I have six hectares of land, I surround my staple crop gardens of bananas, sweet potatoes, and beans with tea and Khat. However, the park has also dug trenches, and these have helped deter elephants from crossing into gardens and damaging our crops"*

As to why farmers grow more than one buffer crop, some farmers gave the following responses. The S/C production coordinator of Nyabuharwa S/C in Kyenjojo District explained that:

> *"Coffee is not wholly destroyed by monkeys; the crop is marketable and of high commercial value. In our Sub-County, the major crop-damaging species are monkeys and sometimes chimpanzees. Yes, monkeys can feed on coffee beans, but the*

> *damage is minimal as compared to only growing crops that attract wild animals such as maize and tomatoes (Plate 6). Food crops such as beans and maize are most important to us, but when you sell some amount of coffee, you can buy the other foods you need"*

The warden Community Conservation and Development of Kibale National Park indicated that:

> *"Growing buffer crops such as simsim and cotton was also influenced by traditional farming practices, farmers especially in Kitswamba S/C (Kasese District) grew cotton and Simsim because they were the traditional commercial crops grown in the area. Though Simsim sometimes could be trampled on by elephants, the damage on yields was minimal as opposed to farmers who do not grow buffer crops but cultivate crops that entice elephants to gardens such as maize"*

Khat (Plate 8) and Tea (Plate 9) were specifically grown to deter elephants, buffaloes, and hippos from damaging crop farms. Coffee, Simsim, and Cotton were grown to minimize crop damage by primates and Uganda kobs. All buffer crops were supplemented by other park interventions such as the digging of trenches, setting up of beehive fences and through scare-shooting in the air to drive back animals into the National Park.

Plate 9: Tea growing in Kahangi Parish, Hakibaale S/C, Kabarole District, Uganda.

Plate 10: Coffee Garden intercropped with maize near Kibale Forest boundary, Busiriba S/C Kabarole District.

It should be noted that growing of effective buffer crops such as tea, khat, simsim and cotton as reported by respondents minimizes damage by wild animals on the major food crops. Farmers who do not grow buffer crops at all suffered more damage from wild animals. Encouraging farmers to grow buffer crops could help mitigate crop damage by wild animals. In a study I conducted in (2021) on effectiveness of buffer crops to deter wild animal damage on crops around Kibale National Park, I discovered that only 28.7% of farmers around the park grow buffer crops to mitigate wild animal damage on their crops. Tea was mainly grown in sub-counties of Hakibaale and Busoro in Kabarole District. Tea creates a barrier to wild animals damaging species such as elephants, and buffaloes. Tea as a buffer crop is grown by both tea growing companies and individual farmers known as out-growers. Out growers are smallholder farmers who grow tea and sell fresh tea leaf to factories. They don't own factories where they can process their tea, but sell green tea leaf to factories such as Rwenzori Commodities Limited and Rwenzori highlands. Tea was ranked as the most effective buffer crop and tea seedling which were grown by farmers were supplied mainly by the Local Government at 77%, KNP management only supplied 0.96% of the seedlings to the famers, Table 3.2. These findings call for more support to increase farmer's participation in growing buffer crops such as tea to mitigate crop damage by wild animals.

Akampulira *et al.*, (2015) found that tea as a buffer crop was effective at 93.3% to deter gorilla crop damage around Bwindi Impenetrable National Park. In Kibale National Park (KNP),

qualitative findings reveal tea and khat are effective against elephants, hippos and buffaloes, and that farmers grew these crops because they were of commercial value. More farmers need to be encouraged to start growing buffer crops to mitigate crop damage by wild animals.

It should be noted that tea is also grown by individual farmers also known as out-growers. They sell tea to companies such as Rwenzori Commodities Limited. Apart from acting as a buffer crop, tea generates significant revenue to Uganda's economy and is grown as a buffer crop by 46.7% of farmers bordering KNP.

Where tea was grown by individual farmers or companies around Kibale National Park, farmers reported that elephants, wild pigs, and buffaloes rarely crossed tea plantations to damage their crops. Though respondents from Rurama Parish, Kabarole District reported that the price of tea per kilogram had reduced from five hundred shillings (500/=) to two hundred and fifty shillings (250/=) which had affected farmers income status. The researcher probed further why the tea price had reduced by half the price. The Sub-County Production Coordinator of Hakibaale and Busoro Sub-Counties clarified that "due to introduction of mechanical tea plucking using handheld tea-picking machines, this had resulted in picking even unwanted tea branches, hence, poor quality grade of Ugandan tea on the global market". Tea quality and prices is an issue that the agricultural sector should address.

Growing tea as a buffer crop provides useful insights for crop damage mitigation, especially among ungulates. Tea as a buffer

crop does not deter primate crop damage. Tea can only be grown by farmers with big pieces of land to avoid food insecurity since it is a perennial crop. Small farmers need to be discouraged from growing tea as a buffer crop. However, in the case of tea growing, according to observations made and reports from farmers, indicate that the most crop damaging wild animal species such as elephants tend to avoid crossing through the tea bush, and do not feed on tea bush at all. Meaning well-tended tea plantations make a good buffer against elephants.

Akampulira *et al.*, (2015) also discovered that un-attended to tea plantations which had been infested with shrubs around Bwindi Impenetrable National Park attracted gorillas damage. Most tea plantations around KNP belong to tea-growing companies such as Rwenzori Commodities Limited, these were well attended. They never had any weed infestation. Farmers also kept their tea plantations free of over-growth and weeds that would attract crop damaging wild animal species. This could explain why tea was ranked as the most effective buffer crop around Kibale National Park.

Farmers in Kabarole district planted buffer crops such as coffee, and the park also intervened with crop damage management strategies such as digging trenches and setting up beehive fences to stop crop damage by wild animals. This was observed in Busiriba and Bigodi Sub-Counties. Respondents from these areas reported minimal damage to their crops by wild animals. According to interviews, trenches and beehive fences were effective in deterring elephants, buffaloes and wild pigs.

The idea why certain wild animals such as elephants, buffaloes, and chimpanzees, were not damaging crop farms where tea was grown, is tea-growing companies own vast tea plantations which are not easily crossed by elephants, buffaloes, and chimpanzees. Secondly, there is a limited number of staple farmers around the tea growing areas, the few who are there were located quite a distance from the tea plantations.

In Kahangi Parish, Hakibaale Sub-County where tea was grown as a buffer crop or a plantation crop by companies, the park had also set up interventions where the tea bush stopped. For example, in Hakibaale, Kiko, Busoro, and Ruteete Sub-Counties, elephant trenches were dug near tea plantations. This proved efficient in deterring elephants, and minimal damage by wild animals on yields was reported in these sub-counties according to interviews and observation.

Mixed cropping of buffer and non-buffer crops attracts crop damaging wild animal species in Kahangi Parish as per observation made (Plate 1.1), this makes food crops prone to damage by wild animals. There is need to sensitize farmers on buffer crop growing. Buffer crops such as cotton and simsim are not perennial, and this gives a chance to farmers to utilize their land for other sustainable options compared to perennial tea growing. Therefore, some smallholder subsistence farmers owning <5 hectares of land can devote part of non-perennial buffer crop growing. Promoting the adoption of planting buffer crops can improve household income among farmers living near Kibale National Park in Uganda.

KNP management need to acknowledge the direct costs of yield loss to wild animals among farmers and, farmers should be encouraged to grow effective buffer crops to complement the already existing crop damage management interventions such as elephant trenches and beehive fences (Mackenzie *et al.*, 2017). Other mitigation measures include demarcation of boundaries, research and ecological monitoring, community conservation/sharing revenue, and tourism development (UWA, 2015). Among the community conservation programmes, buffer crop growing can be thought of as a strategy to mitigate crop damage, alongside supporting ecotourism and tourism development. Tourism is a significant contributor to the livelihoods of communities around Kibale National Park (Mackenzie *et al.*, 2018).

Conclusion

A considerable proportion of farmers around Kibale National Park grow buffer crops to stop damage from wild animals. Preference and choice of particular buffer crops is influenced by type of food crops grown and the commonest crop damaging wild animal species. Farmers who grew buffer crops deliberately plant them to boost agricultural production and minimize crop damage by wild animals. Most buffer crops are grown at the periphery of the Kibale forest, while some buffer crops such as coffee are intercropped with other crops such as bananas which attracts wild animal species that eventually leads to crop damage. The main source of buffer crop planting materials is Local Government.

CHAPTER THREE

INCREASING FARMERS' PARTICIPATION IN GROWING OF BUFFER CROPS TO DETER WILD ANIMAL DAMAGE

Farmers' participation in cultivation of Buffer Crops as Mitigation Measure against Crop Damage by Wild Animals

Whereas conservation objectives aim to protect wild animals and their habitats, farmer's objectives and aspirations are geared towards the expansion of crop production to ensure food security. Sometimes farmer's aspiration aims to maximize agricultural output by encroaching on wild animals habitats (Nyirenda *et al.,* 2011). To maximize agricultural output, farmers can be involved in growing of buffer crops. Such efforts could mitigate crop damage by wild animals.

Rao *et al* (2012), suggests that farmers can be encouraged to grow medicinal plants. This change cropping and crop composition. Medicinal plants are crops of high economic value, but low volume crops in terms of nutritive value. As earlier noted by Chiyo *et al* (2005), wild animal species mainly select crops of high nutritive value, low nutrient crops such as those with medicinal properties might mitigate crop damage by wild animals.

Studies by Terborgh *et al.*, (2002); Gureja *et al.*, (2002); Sethi (2003); Woodroffe *et al.*, (2005); West *et al.*, (2006); Ogra and Badola, (2008) agree to some extent that damage to crops by wild animals is a natural phenomenon that presumably existed since the origin of agriculture. King *et al.*, (2017) observed that crop damage by wild animals is on the rise and it can no longer be tolerated by farmers. In areas with high animal density, measures to protect crops are met with limited success (Watve *et al.*, 2015). Involving farmers in mitigation of crop damage by wild animals might contribute to the already existing measures, methods, and techniques to deal with crop damage by wild animals.

Farmer involvement in choices of buffer crop growing could save time and costs of human presence in mitigation of crop damage by wild animals. Rebekah and Bruce (2015) noted that use of fires to scare away wild animals around National Parks in Tanzania yielded some limited success in mitigating crop damage by wild animals, throwing away flaming sticks (Sudip and Siddhartha, 2015), guarding crop farms with help of dogs (Hill, 2012; Sudip and Siddhartha, 2015), requires an active human presence.

Crop damage by wild animals significantly remains a challenge to conservationists and leads to loss of agricultural livelihoods close to 90% (Naughton-Treves *et al.*, 2011). Akampulira *et al.*, (2015) established that tea as a buffer crop was an effective intervention against gorilla crop damage around Bwindi Impenetrable National Park. Several types of buffer crops that

can be planted by farmers to deter damage on crops by wildlife around Kibale National Park are stated in the next chapters of this book.

Crop damage by wild animals affects people's livelihoods (Krithi *et al.*, 2017). A study conducted by Tweheyo *et al.*, (2012) show that farmers continue to employ several control measures to mitigate crop damage by wild animals. Methods such as guarding, poisoning, killing, and fencing around Lake Mburo are so tedious and time-consuming. The findings from Tweheyo *et al.*, (2012) study show the types of crops grown may influence attraction to wild animals. Destruction of crops such as beans (*Phaseolus vulgaris*) was reported at 83% (Tweheyo, *et al.*, 2012). The damage was caused by bushbucks (*Tragelaphus imberbis*). Involving farmers in mitigation of crop damage by wild animals to enhance crop yields is imperative.

Farmers involvement in growing Buffer Crops – A case of Kibale National Park

An interaction with 336 farmers bordering Kibale National Park in South Western Uganda revealed that some were involved in growing of buffer crops to deter crop damage by wild animals. Farmers showed readiness to adopt and grow crops. Their responses are shown in Table 3.1. Fifty six percent (56%) of the respondents' express readiness to buy and plant buffer crops (Table 3.1). The remainder 44% who were not ready to buy buffer crops mentioned several reasons as shown in Table 3.1.

Fifty four percent (54%) of the farmers who were ready to buy buffer crops noted that buying and planting buffer crops, established not to be damaged by wild animals, can help farmers to avoid further damage of their crops by wild animals. Agricultural production is boosted by mitigating losses in yields of major food crops grown as analyzed in Chapter Six.

Willingness to buy and plant Buffer Crops to mitigate damage on crops by wild animals.

This book contains by findings from a study on effectiveness of buffer crops as mitigation measure to crop damage by wild animals which further explored whether farmers around Kibale National Park were ready to buy and plant buffer crops established to mitigate loss of yields of the five major crops grown. This aimed at gauging farmers' interest in buying and planting buffer crops basing on gender, distance from the park, and land owned in hectares (Table 3.1). Twenty nine percent (29%) of the respondents grow buffer crops, but ascertaining readiness to buy and adopt buffer crops was done for all the respondents.

Table 3.1: Willingness of farmers to plant buffer crops to deter damage on crops by wild animals (n= 366).

	Readiness to buy and plant buffer crops established	
	Yes (%)	**No (%)**
Gender		
Male	122 (34)	111 (30)
Female	79 (22)	54 (14)
Farms distance from KNP		
<500 metres	166 (45)	141(38)
Within 1000 metres	35 (10)	24 (7)
Farmed land in hectares		
<5 hectares	161 (44)	106 (28)
6-10 hectares	22 (6)	35 (10)
> 10 hectares	18 (5)	24 (7)

Sources of Buffer Crop planting materials around Kibale National Park

Farmers had several sources that supplied them with seeds or planting materials of buffer crops. The main source of seeds and other buffer crop planting materials for those who grew buffer crop was Local Government (77%) as shown in Table 3.2.

Findings reveal that these were supplied with coffee and tea seedlings under National Agricultural and Advisory Service programmes (NAADS) or through Operation Wealth Creation (OWC). Sixteen percent (16%) of the respondents bought coffee and tea seedlings from private nursery owners, KNP supplied less than one percent of the buffer crop planting materials, while

Mpanga Growers Tea Factory supplied 5.75% of tea seedlings to out-growers at no cost (Table 3.2). Tea was mainly planted in Nyabuharwa and Kiko Sub-Counties, coffee in Busoro, Hakibaale and Kitswamba sub-counties, whereas the least grown but most effective buffer crop, khat was only planted in Kahangi Parish, Hakibaale Sub-County in Kabarole District.

Of all the buffer crop planting materials suppliers, the park supplied the least of the planting materials. There is a need for the Uganda Wildlife Authority to invest in buffer crop growing through her park-community livelihood programmes or the revenue shared with communities from gate entry fees. Tea plantations owned by companies such as Rwenzori Commodities contribute significantly to wild animals-crop damage management around Kibale National Park.

Table 3.2: Sources of Buffer Crop planting materials around Kibale National Park (n_1=105).

Sources of buffer crop planting materials	% response
Local Government (NAADS through OWC)	81 (77)
Kibale National Park Management	1 (1)
Private nursery operators/owners	17 (16)
Mpanga Growers Tea Factory	6 (6)

Reasons why some farmers did not grow Buffer Crops

The main reason for farmers not getting involved in buffer crop growing was lack of awareness about what buffer crops were

(43.7%), and 15.3% of the farmers did not own enough land to plant buffer crops (Table 3.3). Lack of awareness about the value of buffer crops was the main factor that influenced buffer crop growing. In Kanamba Parish, Karusandara Sub-County, farmers did not grow buffer crops because the sub-county was prone to floods (4.4%). Other reasons for farmers not growing buffer crops are shown in Table 3.3.

Table 3.3: Why some farmers did not grow Buffer Crops around Kibale National Park (n=366).

Reasons for not growing buffer crops	% response
I am hearing about buffer crops for the first time	**160 (43.7)**
I do not have enough land to plant buffer crops	56 (15.3)
I do not have seeds and seedlings of buffer crops to plant	16 (4.4)
We experience a lot of flooding in my sub-county	16 (4.4)
Commercial buffer crops such as tea have low market prices	9 (2.5)
I do not own the land (hiring)	3 (0.8)
Some buffer crops are damaged by wild animals too	1 (0.3)

Building capacity for farmers to grow Buffer Crops

The most appropriate way to involve farmers in buffer crop growing was to sensitize them on the value of these buffer crops (56.8%) as shown in Table 3.4. Furthermore, the study found out

that helping farmers to find markets for tea would also increase their participation in growing buffer crops (Table 3.4).

Table 3.4: Increasing farmers participation in planting Buffer Crops (n=366)

Farmers participation in planting buffer crops	% response
Sensitize farmers about the value of buffer crops	208 (56.8)
Helping farmers to find market for tea	52(14.2)
Providing farmers with planting materials of buffer crops	49 (13.4)
UWA should provide incentives for growing buffer crops	34(9.3)
Helping farmers to add value to commercial buffer crops	23(6.3)

Narratives on growing of Buffer Crops among farmers bordering Kibale National Park

The Sub-County Production Coordinator for Ruteete S/C noted:

> *Some farmers used to grow tea, but when the price of green tea leaf dropped by half the price, some out-growers cut down tea plantations. Some farmers are now involved in maize growing. Chili was introduced by the park, it is only locally consumed. There is no market at all for tea in our district.*

How best can farmers participate in the growing of buffer crops to deter crop-damage by wild animals?

> *If I am supplied with tea seedlings, taught on sustainable tea growing practices, and supported with a loan for fertilizers. I could adopt tea growing, we have no trenches dug in our village, hippos from Lake Nyabikere graze on our crops at night. I have a relatively large piece of land, if I am supported with seedlings of tea, I could spare part of my land and grow tea.* Interviewee, Rurama Parish.

When farmers were asked whether there were crop farming methods that they used to complement buffer crops, some respondents noted that they used to grow Mauritius thorns, but it was later discovered that the plants would drain fertility from their soil. Mauritius thorns were grown in form of live hedges mainly to deter wild pigs and olive baboons from crossing into gardens and damaging crops.

> *I used to grow Mauritius thorns but I cut them down because the plants quickly colonize new areas reducing on the size of my farmland. I could plant the Mauritius thorns in form of a hedge, but the plant grows very fast covering a large piece of my land. You cannot reclaim that land piece for other crops. The size of my farmland had reduced, the Mauritius thorns had become nonetheless invasive*

species on my farm. Nevertheless, monkeys and olive baboons had learned how to jump over the Mauritius thorn fence. If the park can plant and maintain the Mauritius hedge fences on the parkland, that is okay. Noted a respondent from Kajumiro Village.

If the park can supply us with planting materials of these crops, help us find markets, and continue supporting our on-farm extension services, I could involve my family in Simsim and cotton growing. I don't have seedlings, I continue guarding my maize farm against damage by monkeys. The park is quite big, sometimes elephants do not attack our crops, because they (elephants) could have moved to other areas away from my village. I can sometimes spend a whole month without seeing elephants in my village. Revealed a respondent from Kakooga Parish.

How best can your crops be protected from wild animal damage?

Kibale National Park management should support farmers in livestock production and apiculture. Beehives are only used in creating beehive fences, if we can organize ourselves in groups and the park supplies us with beehives, the market for honey is readily available. There are no animals which feed on livestock such as lions in Kibale National Park,

the park can support us in goat and cattle rearing. As communities living near the park, we received goats from the park under the revenue sharing programme, they are not enough. Respondent, Kinyantale Parish, Kyenjojo District.

Sensitising farmers on value of growing buffer crops provides insights on mitigation of crop damage around Kibale National Park. Farmers lacked knowledge of what buffer crops were and continue to grow crops that are damaged by wild animals. Raising awareness about the importance of interaction between wild animals and people is crucial (Gross *et al.*, 2018). Through sensitization, farmers could stop planting crops that entice animals into their farms but adopt effective buffer crops such as tea, coffee and simsim.

Agricultural land uses around Kibale National Park have been expanding towards the forest area, and this still contributes to the destruction of the forest by agricultural communities bringing wild animals closer to crop farms especially in absence of buffer crops. The number of farmers growing bananas (*Musa spp*) and Maize (*Zea mays*) closer to the forest boundary without buffer crops is on the increase hence attracting damage by wild animal species without buffer crops. Involving farmers through sensitization and finding markets for buffer crops could provide insights into adoption and planting of buffer crops as a mitigation measure to crop damage by wild animals around Kibale National Park. Farmers need to be sensitized of the value of buffer crops and efforts should be geared at accessing markets for the 28.7% farmers already growing buffer crops.

Farmers growing buffer crops such as tea, simsim and coffee reported that these crops were not damaged by wild animal species and were effective in deterring crop damage. Awareness should be created about these effective buffer crops. The park authorities provided the least planting materials to farmers. Increasing staple crop production (bananas and maize) around Kibale National Park has implications on crop damage by wild animals. Sensitization of farmers to adopt buffer crops would provide ideal alternatives to mitigate agricultural losses.

Since some farmers that do not grow buffer crops in Rwanda incurred substantial losses of crops, with replacement costs possibly reaching 10 - 20% of the household income. The major crop damaging wild animals in absence of buffer crops were chimpanzees (*Pan troglodytes*) and vervet monkeys, these mainly damaged maize and legume gardens (Shane and David, 2014).

The growing of buffer crops with commercial value such as tea, simsim, cotton, coffee and khat, requires a lot of community sensitization as noted in Table 3.3 and engagement, this can be made possible by increasing the supply of buffer crop planting materials to farmers who are ready to adopt and grow them, while sensitizing those who were not ready to buy and plant them of their value.

According to Nkuringo Buffer Zone General Management Plan (2015-19), the success of Tea and Mauritius thorns as a deterrent to primates, involved the community being employed in its maintenance. Community members were employed to tend to

the tea plantations. Taylor *et al.*, (2016) asserts success of conservation programmes depend on local community support. Therefore, any proposed programme of buffer crop growing needs to specify the roles of farmer's buffer crop growing.

After synthesizing views from 366 farmers bordering Kibale National Park, a qualitative Buffer Crop Farmers Model (BCFAM) whose aim is to guide growing of buffer crops so as to close the gap on loss of yields to wild animals was developed. The model encourages farmers to grow buffer crops that are effective and not destroyed by wild animals and also guides how farmers can grow buffer crops as complementary measure to existing models and interventions that aim to mitigate crop damage by wild animals.

Buffer crops grown against specific wild animals linked to Buffer Crop Farmers Model

A total of 28.7% buffer crops was planted to mitigate damage caused by wild animals on their food crops. Buffer crops grown by farmers around KNP include tea, khat, coffee, simsim, and cotton. Khat is a novel crop documented for the first time. The study found out that these crops are grown against specific wild animals, where, tea was majorly grown to deter crop damage by elephants, buffaloes, chimpanzees, and hippopotamus.

Growing tea as a buffer crop was very effective in deterring crop damage by wild animals and was ranked at 96%. However, tea growing was by farmers who owned relatively big sizes of land. Farmers around Kibale National Park also grow coffee as a

buffer crop. Coffee was predominantly grown to mitigate damage by primates. Growing coffee was ranked as the second most effective buffer crop at 79.5% (Table 2.3). According to farmers, coffee was not wholly damaged by wild animals. Most farmers from Kitswamba and Nyabuharwa Sub-Counties in Kasese and Kyenjojo District grew coffee as a buffer crop. Tea which was also grown by tea growing companies such as Rwenzori Commodities and Mpanga Growers Company Limited was regarded as an effective buffer crops which deterred elephants and buffaloes from crossing into crop farms to damage crops. The buffer crop is non-palatable to wild animals and forms a low conflict barrier zone before crop farms.

Some farmers grew simsim and cotton as traditional cash crops that have always been grown in their localities, but never had any knowledge of whether these were buffer crops. Historically, cotton and simsim have always been grown in Kasese District since the colonial era. The crop was initially grown in Central Uganda and later the rest of the country. Growing of simsim effectively mitigated 16.6% of wild animal damage on crops among farmers bordering Kibale National Park in Rwimi and Kitswamba Sub-Counties. Some (43.7%) of the farmers did not grow buffer crops because they lacked knowledge of the value of planting buffer crops and 15.3% mentioned limited land as one of the reasons as to why they were not growing buffer crops (Table 3.3).

In terms of single wild animal species depredation on major food crops grown, it was elephants (*Loxodonta Africana*) that severely damaged bananas, cassava was mainly damaged by

wild pigs (*Sus scrofa*), maize by olive baboons (*Papio anubis*), sweet potatoes by chimpanzees (*Pan troglodytes*) and beans were mainly grazed on by Uganda kobs (*Kobus kob thomasi*) as shown in Table 3.3. Damage of crops by elephants was prevalent in sub-counties where there were no elephant trenches. Elephant trench network by the time the study on effectiveness of buffer crops as a measure to wild animals-crop damage mitigation was conducted was at 35.1 km^2 (UWA, 2017).

Effect of Wild Animal Damage on yields of major food crops

As noted from the Optimal Foraging Theory (OFT), wild animal damage is triggered by nutritional stress among wild animals and failure by wild animals to access crops of high nutrient value within the protected area (Chiyo *et al.* 2005; Jamam and Huffman, 2008; DieRienzo et *al*, 2012). In the absence of buffer crops, wild animal damage on crops is inevitable as wild animals will easily move long distances in search of high-quality crops. The Buffer Farmers Model (Figure 3.1), in its integrated approach, addresses different categories of farmers depending on land owned with appropriate alternatives to mitigate crop damage by wild animals around Kibale National Park, Uganda.

The Buffer Crop Farmers Model (BCFAM)

Sensitizing farmers about the choice, value and type of buffer crops to grow to mitigate loss of yields to wild animals can improve farmers' livelihoods around Kibale National Park. Farmers should be encouraged to participate in growing of buffer crops such as tea, coffee and simsim which were found to

be effective. Growing of buffer crops should be complementary to already existing park crop protection interventions such as digging and expanding of the trench network and setting up of more beehive fences around the park. This model is mainly informed by quantitative and qualitative findings on effective buffer crops.

Buffer crop growing, and alternative livelihood strategies should be encouraged alongside the park crop protection and animal management interventions such as expanding the trench network around the park, constructing more beehive fences in boggy areas where crops can be grown especially Karusandara S/C which experiences flooding around river points, rocky areas where trenches cannot be dug such as in Kakooga Parish in Rwimi Bunyangabu District. Crop damage management interventions such as digging of new trenches to expand the trench network, maintaining the existing trenches, and constructing more beehive fences is complementary to buffer crop growing.

Planting buffer crops contributes 68.5% (Table 2.4) towards mitigation of crop damage by wild animals around Kibale National. The trench network around KNP has increased from 35.1km^2 to 82km^2 from 2019 to 2021 out of 795km^2. This is a mere 10% of the protected area boundary where trenches are dug to mitigate damage by wild animals. By 2019, interventions such as beehive fence lines contributed about 27.1% of crop damage mitigation and buffer crops about 28%. A pilot study of 366 farmers around Kibale National Park suggested increasing planting of buffer crops requires through sensitization at 56.8%

and providing farmers with buffer crop planting materials at 13.4% (Rusoke, 2020). Based on findings, a qualitative Buffer Crop Farmers Model as illustrated in Figure 3.1 was conceptualized.

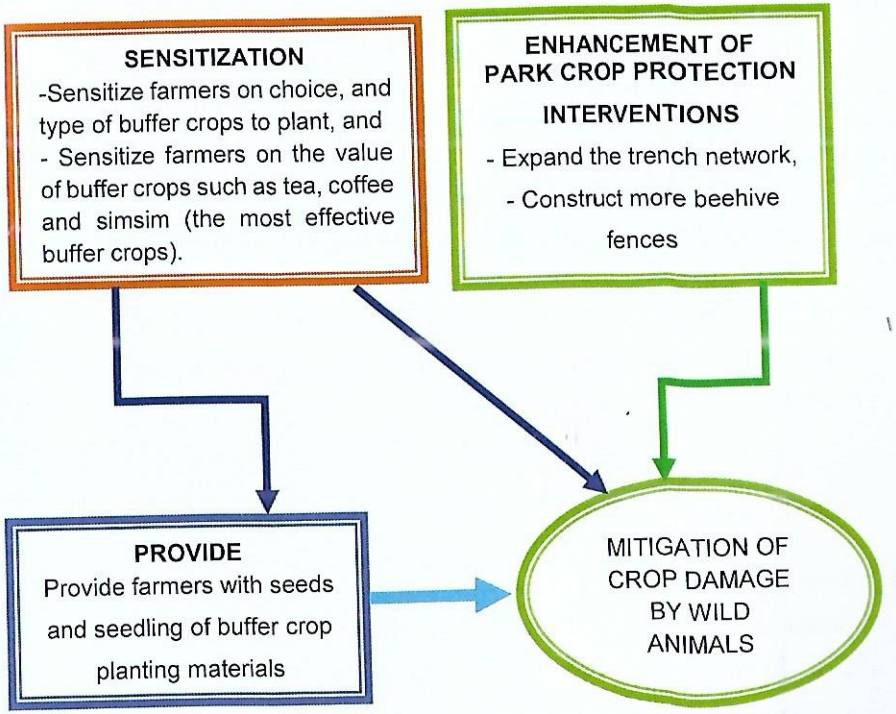

Figure 3.1: The Buffer Crop Farmers Model (BCFAM), developed from the Research and Literature Review.

A farmer to grow buffer crops should be owning sizeable piece of land since most buffer crops such as tea are perennial cash crops. Such farmers would realise enormous benefits of large-scale buffer crop growing. It is further assumed that for the

BCFAM to be effective, Kibale National Park must get involved in sensitizing farmers about the value of buffer crops, find market for farmers growing buffer crops and supply buffer crop planting materials freely to the farmers.

Reports from farmers already growing the novel buffer crops such as khat did not experience any form of damage on their crops from wild animals. These farmers ranked khat as very effective (100%) buffer crop as shown in Table 2.1. Khat as a buffer crop is of commercial value and with readily available market. Ideally, since the novel buffer crop was only grown by a few farmers in one sub-county of Hakibaale, and these farmers had no complaints about their crops being damaged by wildlife, these farmers' reports can be relied upon to scale up buffer crop growing.

Conclusion

Participation of farmers in buffer crop planting requires sensitizing farmers about the economic value of buffer crops. For farmers to actively participate in buffer crop growing, markets for buffer crops such as tea needs to be assured. In sub-counties such as Karusandara there was no buffer crop growing. Increasing farmers' awareness about the value of buffer crops against mitigation of crop damage by wild animal results in adoption and planting of buffer crops.

If the Buffer Crop Farmers Model (BCFAM) is adopted by conservation managers and implemented among farmers, it can

significantly contribute to mitigation of damage on crops by wildlife among farmers' bordering Kibale National Park (KNP). BCFAM identifies measures on farmers' participation in planting buffer crops and suggests reinforcement of already existing crop protection interventions around Kibale National Park as means to mitigate wild animal damage on crops. Implementation of the BCFAM will not only serve as a measure to mitigate wild animals' damage on crops, but can also directly promote farmers livelihoods around Kibale National Park.

CHAPTER FOUR

HISTORICAL, PHILOSOPHICAL AND THEORETICAL PERSPECTIVES ON CROP DAMAGE BY WILDLIFE AND MANAGEMENT

Historical ideas and perspectives on management of crop damage by wild animals

Historical, philosophical and theoretical perspectives highlight important epochs on management of crop damage by wild animals, the philosophy that guided wildlife management in advent of agriculture, and the theories that underpin change in management of crop damage by wildlife species.

During the era of Pre-3500 B.C, humans looked at management of wildlife that damaged their crops from a utilitarian view of nature by practicing hunting and gathering (Descartes, 2010). Crop loss to wild animals was not common as this period was marking the birth of agriculture. Humans were an integral part of the food chain, and the killing of wild animals was majorly done to ensure human safety but not for crop protection. Crop damage by wild animals started to intensify during the ancient-medieval times the period from 3500 B.C - A.D 1607 (Ancient–Medieval) marked the spread of agriculture, humans began to treasure farming, and keenly cherished their crops and not as food for wild animals. Agriculture was viewed as a major form

of food as opposed to hunting and gathering. Herbivorous wild animals found crops as a convenient source of food readily available in nearby locations. Damage of fruit crops by primates started becoming a problem and farmers started improvising crop damage management measures. Agriculture began benefiting society, humans started building permanent shelter for safety and protection. Agriculture was then viewed as a source of income and any natural disaster that affected agricultural production subsequently increased resentment to wild animals (Lichtenfeld *et al.*, 2014). This period and paradigm had been referred to *as "Detached Utilitarianism"* (Conover, 2009).

Civil strife also increased intolerance to wild animals as protection of lives, property, and resources topped priorities. Wild animals were still viewed as good or bad, though animals and their food were viewed separately from people and their food. This period and paradigm had also been referred to as "*Detached Utilitarian*" During this time humans used themselves as tools to mitigate crop damage by wild animals with help from domestic animals such as cats; children would be sent to crop fields to chase away birds and monkeys (Conover, 2009). Scarecrows could also be planted in gardens, and cats were used to scare away rodents from destroying harvested and stored grains. During this medieval time crop damage management methods expanded to include the use of toxic plants such as hemlock, oleander, and wolfsbane which were ground and mixed with honey to repel storage pests especially rodents (Conover, 2009). Nets and traps were also used to trap birds in

crop fields to mitigate crop damage and loss. '*Rat letters'* though the most ineffective method of crop damage management were written to persuade rats from destroying stored grains, the rat letters were placed in areas frequented by rats (Frank and Conover, 2015). This period was followed by the Colonial and Frontier America 1607-1890.

This period (Colonial and Frontier America 1607 – 1890), was the period of the first permanent English settlers in America, as the cities and economies grew in Europe; migrants to America lacked stability and faced imminent starvation. To protect their crops, many colonists adopted Native American techniques to manage crop damage by wild animals such as erecting platforms in crop fields so that children can throw stones at birds (Conover, 2009). Frontiersmen viewed wild animals as good. This paradigm was described as *"Manifest Destiny"*. Colonists believed that taming the wilderness was much more important than living with wild animals. The use of firearms to decimate wild animals started and bounties were offered for nuisance crops-damaging wild animals especially birds such as passenger pigeons [*Ectopistes migratorius*] (Conover, 2009); also, market hunting began as a way of boosting economic growth in the found country.

However, in Europe Colonial and Frontier America: 1607- 1890 marked the enactment of the Game Act of 1831 for the protection of birds in England and Wales. This was an Act that also controlled hunting seasons. The purpose of the law was to balance preservation needs while ensuring economic growth

(Fynn *et al.,* 2015). During this era, the killing of wild animals in Britain without a license was almost equivalent to killing a king's subject (Potter *et al.*, 1973). Furthermore, during this Era, Rhode Island in America closed hunting and introduced seasons for the deer from May to November in 1832 (Potter *et al.*, 1973). In Britain, The Sea Birds Preservation Act of 1869 was enacted as the first nature protection law in the world (Leopold, 1963). The transition to the industrial era marked the founding of The Royal Society for the Protection of Birds in 1889. The society was founded by Emily Williamson at her house in Manchester as a protest group campaigning against the use of great crested grebe and kittiwake skins and feathers in fur clothing (Leopold, 1963). Such laws boosted populations of wild animals, increasing threats of crop damage by wild animals. This period marked the transition to the industrial era.

The industrial revolution (1780 – 1914) allowed human needs to be met on a larger scale than ever before. Increased and efficient production of food to nourish populations begun. People began living in cities, the economy boomed and jobs were created. The American Frontier closed, environmental problems such as pollution begun to emerge and people started reconsidering their new progress (Conover, 2009). People started to rethink the loss of wilderness and resources. New awareness about the importance of wild resources and wilderness started to characterize the industrial era. Two paradigms emerged during this era: the *conservation* and *preservation* paradigms. Conservationists such as Theodore Roosevelt and Gifford Pinchot (1900) started advocating for the promotion and

sustainable use of natural resources (Callicott, 2000), whereas preservationists such as John Muir argued that nature and wild animals should be protected for spiritual and intrinsic values (Callicott, 2000).

Due to a stable economic basis, wild animal damage management begun to emerge as a profession. C. Hartter Merriam conducted the first survey on birds on agricultural fields in 1885 (Miller 2007). This marked the birth of Wildlife Damage Management (WDM) as a science. In 1899 after the formation of The British National Trust (1895) which was aimed at permanent preservation, a British amateur naturalist at 22 years Charles Rothschild was funded by the National Trust to purchase two acres of Wicken Fen to establish the first nature reserve in Britain. Rothschild went further to establish many other nature reserves and conducting a series of research up to 1923 when he died (Leopold, 1963). Rothschild researched both Eras of the Industrial Revolution (1780-1914) and the Great Depression and World Wars (1914-1945).

Though Wildlife Damage Management (WDM) as science had begun in the preceding era of the industrial revolution, during this period of Great Depression and World Wars (1914-1945), increasing foreign tensions and concerns about the war substantially decreased tolerance for crop damage by wild animals. Enormous funds were made available for wildlife damage control during 1915, though World War I ended three years later (Miller, 2007). The basic needs of people were not being met world over, food shortages and there were increasing

food prices; people began to view and watch wild animals from a '*Utilitarian Perspective*'. Removal of non-injurious and non-predatory wild animals massively took place.

Scheffer (2019) referred to the *Modern Era* period (1945 to-date) as the Age of Environmental Awareness. The age of environmental awareness dawned in the 1960's and marked the benign – 'sympathetic' use of wildlife resources in ways that were less harmless and exploitative to wild animals and human populations. This era marked the growth of the economic sector through activities such as wild animals watching, growth of interest in recognition of animal rights, legislating in favour of fauna protection, and decrease in sport hunting.

The human population is increasing globally during the Modern Era, with over 800 million people living under extreme poverty spending < $1.25 a day (UNDP-SDG report, 2015). In Uganda over 80% of the population are agriculturalists farming in the countryside where protected areas such as Kibale National Park are found (Jason and Eric, 2009). Agriculture has accelerated encroachment on natural resources which are habitats for wild animals (Lynagh and Urich, 2011). The increasing destruction of wildlife habitats is pre-disposing farmers to crop damage by wild animals through human-wildlife interactions. This results in farm damage, and loss of crop yields, especially for farmers close to Kibale forest boundary, can result in hunger and poverty as livelihoods are lost to wild animals. Overall, crop damage by wild animals has increased as a result of wildlife habitat encroachment, and intolerance to wild animal damage has

increased due to crop loss and damage which is subduing economic needs.

"Whenever the needs of humans and wild animals overlap, there is a potential for wild animals' damage to occur," (Frank and Conover, 2015). In the 19th Century, elephant crop damage became widespread in Africa resulting in a shortage of food (Hoare, 2012). It can now clearly be noted that the principal dependent causes associated with crop damage by wild animals are increasing human population, demand for natural resources which has transformed ecosystems into agricultural land and degradation of wildlife habitats which make wild animals wander into human settlements damaging their crops (Gubbi, 2012).

According to Naughton-Treves *et al.,* (2011), Africa's wildlife resources have fared poorly in the 20th century, colonial approaches to wildlife population ownership emphasized the creation of parks and restrictions on hunting technology, though Toro royals enjoyed privileged access to the big game. Wild animals kept in National Parks, where it was later decimated by war and poaching; however, today recovering wild animal populations destroy crops whenever they stray into densely settled agricultural farms. Growing tea as a physical buffer crop (Brad and Jon, 2004) unintentionally promotes conservation of Kibale National Park; crop damage by wild animals still causes agricultural livelihoods loss (Woodroffe *et al.*, 2005). Buffer crops such as the growing of tea as buffer crops around Bwindi Impenetrable National Park (Sean, 2016), could provide insights

on the identification of effective buffer crops farmers can grow to mitigate the agricultural loss to crop damage by wild animals. Proximity to a protected area is the strongest predictor to crop damage, there is a need for farmers to adopt buffer crops such as tea (Akampulira *et al.*, 2015) and other buffer crops such as khat, cotton, simsim and coffee which were grown by farmers bordering Kibale National Park.

In Tooro Kingdom, where Kibale National Park (KNP) is located (Businge *et al.*, 2019), wild animals management centered on spiritual appeasement and hunting rights, this had decimated wild animal populations (Hill, 2017). Crop damage by wild animals is a major problem around protected areas which creates resentment and sometimes wild animals are killed in large numbers when they damage crops. During the mid-19th Century when the Government of Uganda started the creation of National Parks, the increasing wild animal populations started to stray into densely cultivated agricultural lands causing crop damage (Naughton-Treves *et al.*, 2011). Recovering animal populations around KNP, translate to increased crop damage by wild animals (Mackenzie *et al*, 2015) since most species in a class of primate genera include crops in their diet (Hill, 2017).

During the British colonial rule, Naughton-Treves *et al.*, (2011) noted that hunters were hired to kill problem animals that caused crop damage. Crop damage by wild animals implies school-going children sometimes miss school guarding crops (Hill, 2017). In absence of effective buffer crops, farmers continue to suffer agricultural losses globally.

Crop damage by wild animals is a prevalent form of human-wild animals-conflict (Lee and Priston, 2005) along protected area boundaries. In Indonesia, the Sumatran elephant (*Elephas maximus sumutranus*) damage farmers' crops on the mountain ranges due to continuous forest conversion into agriculture (Hockings, 2009). Apart from crop damage, wild animal raids can have other significant effects such as loss of lives during elephant raids as noted by Krain *et al.*, 2003, Inskip *et al.*, 2016.

Most of the farmers' complaints recorded around protected areas are about crop damage by wild animals which leads to agricultural losses (Pywell *et al.*, 2015). A study by Shane and David (2014) found substantial losses of crops to wild animals with replacement costs possibly reaching 10-20% of total household income. Chimpanzees (*Pan Troglodytes schweinfurthii*) and Vervet monkeys were reported to affect maize and legumes. The adaptability intelligence and opportunistic nature of some primate species have led to them being considered a menace to agriculture (Else 2009). Crop damage mitigation by wild animals was restricted by guarding of crop farms and modification of farming practices such as adopting livestock production around National Parks that do not contain major livestock predators such as lions, leopards and hyenas (Hill 2012, Shane and David, 2014).

Farmers around Virunga and Volcanoes National Parks in Congo tend to grow palatable crops around the park boundaries (Shane and David, 2014). These farmers have continuously suffered crop damage by elephants. Studies by Hill (2012) and

Fungo (2011) provide measures to deter crop damage by wild animals such as guarding and digging elephant trenches to stop wild animals from destroying community gardens. Such measures of dealing with wild animals-crop feeders have yielded limited success as Hill (2012) who noted that some wild animals-crop feeders resorted to damaging and destroying crop gardens at night when crop guarders retired to sleep. Crop guarding in some areas resulted in pupils and students missing school during the crop fruiting season (Fungo, 2011). It is expected that children spend time guarding crop farms and miss school during crop fruiting-harvesting season will be able to attend school since farmers would have adopted planting of buffer crops around Kibale National Park.

Philosophical views on Crop Damage by Wild Animals and its Management

Though damage to crops by wild animals is a natural phenomenon presumed to have existed since the birth of agriculture (Ogra and Badoola, 2008) and it has been noted to deprive communities of agricultural livelihoods, eco-philosophers and ecologists continued to value the importance of wilderness especially during the Industrial Revolution (Roleston, 1992). In the mid-19th Century Eco-philosopher Thoreau emphasized wildlife freedom irrespective of the damage wild animals imposed on agriculturalists. Ecologist Foreman (1992) maintained that it was necessary to let nature go unaffected, without any human use of it (Boreiko, 2004 and 2010). Such philosophical thinking boosted wild animal

populations in the 19th Century, facilitating increased crop damage by wild animals (Boreiko *et al.*, 2013).

Eco-philosopher Rolston III (1992) emphasized that there should be a distinction between natural and artificial interference by people with dealings regarding wild animals, Rolston (1992) suggested passing a declaration of freedom for the remaining wild animals. He noted that freedom and autonomy should be guaranteed for people managing wild animals in nature reserves and sanctuaries. Eco-philosopher Turner (2003) criticized Rolston's idea on the administration of nature reserves which principally controlled and managed wild animals for tourist recreation. Turner (2003) was of opinion that people cannot conserve wild animals the same way as they do to strawberries – pick, cook, and preserved in jars. Non-use of wild animals such as ecotourism and tourism provide significant benefits to wildlife resources conservation, if revenue generated from such activities is re-invested sustainably in wild animals' management.

Turner (2003) emphasized some form of sustainable utilitarianism of wild animals though considering conservation autonomy and freedom. The founding father of utilitarianism Bentham (1823) also noted that *"pleasure is good and pain is evil; and an ethical person should attempt, in choosing courses of action, to maximize one and minimize the other, no matter whose pain or pleasure may be involved"*. Jeremy's grounding paved way for utilitarianism of wild animals, though Singer (2009), a resolute philosophical opponent of utilitarianism and

supporter of animal liberation did not support the utilitarianism of wild animals.

Singer (2009) further argues that the interests of animals should be considered because of the ability to experience suffering. Accordingly, it can be noted that philosophical viewpoints have influenced how wild animal populations could be managed, and this had an implication on crop damage by wild animals alongside agricultural developments. Crops provide wild animals with an alternative and accessible food source (Wallace and Hill, 2012).

Further, this chapter is underpinned by the philosophies of Theodore Roosevelt 1924, and Gifford Pinchot (1900) who advocate for sustainable use of wild animal resources and Singer also supports the moral use of natural resources. There should be a balance between uses of wild animal resources ethically, morally, and sustainably. The returns from wildlife resources conservation should sustainably be used to mitigate crop damage by wild animals.

> *"We have fallen heirs to the most glorious heritage a people ever received, and each one must do his part if we wish to show that the nation is worthy of its good fortune"* Theodore Roosevelt, 1924.

This statement implores humanity to take charge of natural resource use in a sustainable manner for posterity. In a personal view on mitigating crop damage by wild animals, there is a need to use the returns from conservation to promote conservation, by

enabling communities to adopt and grow buffer crops as a mitigation strategy to crop damage by wild animals.

Vulnerability to Crop Damage by Wild Animals in Africa

In most tropical regions across Africa, abundant biological resources are being used by humans, and crop damage is inevitable and is the most significant source of human-wildlife conflicts (Walpole and Thouless, 2005; Barirega *et al.,* 2010; Howlett and Hill, 2016). Since protected areas in the world are often implemented as top-down conservation strategies (Adam, 2004a), this makes it difficult for farmers to protect themselves from crop-raiding and damage by wild animals (Woodroffe *et al.*, 2005). This has made wild animals flourish and become common pests to farmers near protected areas in Africa (Drazo *et al.*, 2008). Several species of wild animals have been implicated to cause crop damage, especially in Africa.

Species such as the African elephants [*Loxodonta africana*] (Barnes, 1996) and primates (Madden, 2006) are recorded to cause severe damage to subsistence farmers in Africa. Several factors are known to increase crop damage. Factors such as growing crops between forest patches and farming close to the protected area boundary are known to increase crop damage by wild animals. Farmers living close to permanent water sources and well-distributed rainfall are associated with increased crop damage (Barnes *et al.*, 2006).

Increasing natural forest cover near crop gardens (Tweheyo *et al.*, 2005), types of crops grown and their maturation period can

also exacerbate crop damage. Understanding the natural environment where farmers practiced agriculture, the nature of crop damage by wild animals, the social, and political circumstances are important parameters in understanding wild animal damage on crops (Hoare, 2012). Thus, farmer's vulnerability to crop damage by wild animals can be categorized into three dimensions, biophysical, social, and institutional vulnerability (Fairet, 2012).

Vulnerability to crop damage by wild animals increases food and economic insecurity among subsistence farmers in Tanzania (Kaswamila *et al.*, 2007) and Uganda (Barirega *et al.*, 2010). Food insecurity can be defined as inadequate food in terms of quality, quantity, and safety of food reserves and economic security as subsistence income for daily needs (Gross, 2002). Farmers bordering Kibale National Park in Uganda are prone to food insecurity since they are liable to deprivation of adequate food reserves through crop damage (Hill, 2017).

Crop farms' proximity to the protected areas, and the nature of agricultural activities practiced by farmers make them vulnerable to crop damage by wild animals. Some farmers are known to plant crops that attract wild animals into their farms. This makes institutions mandated with managing crop damage also vulnerable to compensate communities for crop loss or damage and mitigation (Figure 4.1). Therefore, establishing buffer crops which farmers can plant to mitigate wild animal damage on crops reduces vulnerability to crop damage by wild animals around protected areas as illustrated in the three-

dimensional approach of vulnerability to crop damage by wild animals.

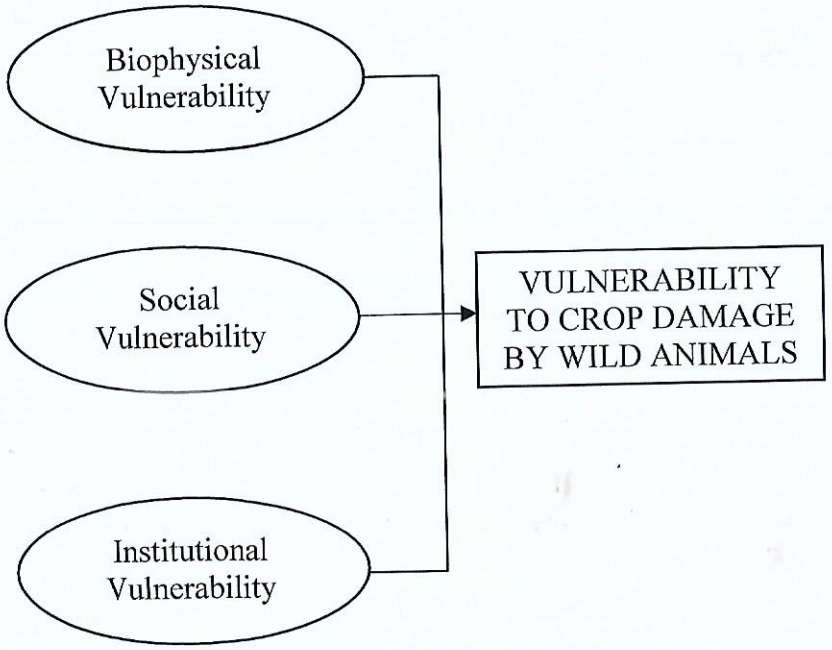

Figure 4.1: Three-dimensional approach of vulnerability to crop damage by wild animals (Modified from Fairet, 2012).

Theories and practices regarding management of crop damage by wildlife

Regarding the theoretical perspective, the Optimal Foraging Theory (OFT), as illustrated by the behavioral ecology model, helps to predict how an animal behaves when searching for food. Crop damage by wild animals is facilitated by growing of food crops which are higher in nutrient value compared to plants

found within protected areas; therefore, mitigating crop damage by wild animals requires participation of farmers in growing of buffer crops that are not devoured by wild animals. Although obtaining food provides the animal with energy, searching for and capturing the food requires both energy and time (Di Rienzo *et al.*, 2012).

In feeding ecology, OFT further stipulates that an animal's decision to feed is made to maximize net energy gain according to diet choice, location, and time (Stephens and Krebs 1986). These tenets influence crop damage by wild animals around protected areas, making OFT an appropriate theory to underpin the study on effectiveness of buffer crops as a mitigation measure to crop damage, a case of farmers around Kibale National Park. Foraging species encounter several food types randomly, which are ranked according to their energy content relative to time spent foraging (Shipley *et al.*, 2009). Crop damage by wild animals follows consumption patterns that relate to seasonality, habitat quality, food abundance, and distribution (Chiyo *et al.*, 2005; Jamam and Huffman, 2008). As noted by Chiyo *et al* (2005), high nutritive value is found in planted crops than wild plants. Optimal Foraging Theory explains crop damage by wild animals.

Crop damage by wild animals is sometimes a single most important determinant of crop yields (Hill, 2017). According to the Optimal Foraging Theory (OFT) crop damage by wild animals is facilitated by forage availability within a protected area (Chiyo *et al.*, 2005). The more, the forage is within a

protected area, the lesser the chances of crop damage by wild animals. The tenets of OFT such as influence of seasonal changes which result in reduced forage for wild animal's hence animal movements to search for quality forage outside protected areas gives insights that inform farmers to grow non-palatable plants to wild animals to mitigate crop damage by wild animals. In absence of buffer crops and increasing forage unavailability triggers nutritional stress among wild animals. The availability of palatable crops on farmlands escalates crop damage by wild animals beyond protected area boundaries throughout the year.

Osborn and Parker (2003) note that the timing to crop damage is triggered by nutritional stress caused by the decline in quality and nutritive value of natural forage inside the protected area. Crop damage occurs throughout the year and it is triggered by nutritional stress (Mackenzie *et al.*, 2018). Whereas crop damage occurs throughout the year with peak seasons experienced during the dry season (Mackenzie *et al.*, 2018). It is, therefore, important for farmers to adopt buffer crops that are less nutritive to wild animals. Buffer crops such as tea grown around Bwindi Impenetrable National Park (Akampulira *et al.*, 2015) were found to be somewhat effective against gorillas.

Chiyo *et al.*, (2005) attributed temporal crop raiding behaviour of wild animals to crop availability at certain phenological stages which in turn are driven by seasonal patterns in rainfall. Decisions on farmer's participation in mitigation of crop damage by wild animals through planting of buffer crops can be guided

by how seasons of the year influence the types of crops grown as attractants to crop damage by wild animals (Hill, 2017).

The Optimal Foraging Theory (OFT) is supported by the availability of forage within the protected area, the nutritive value of forage, the season of the year, and crops grown by farmers. These aspects elucidate the feeding strategies of wild animal species. Nishant *et. al.* (2019) observed that crop-raiding which results in crop damage maximizes nutrients for wild animals. This is so during periods of natural forage availability. If farmers adopt buffer crops that are less palatable to wild animals, crop damage by wild animals can be mitigated.

Barry (2006) notes that on average when observing animals in the wild, you are most likely to see them foraging for food. If successful, their foraging efforts culminate in feeding. Wild animals search, sense, detect, and feed. Therefore, wild animals do not intentionally feed to destroy crop farmlands, but because farmers grow crops that are of more nutritive value, this compounded by insufficient forage in the protected area due to carrying patterns of rainfall distribution (Fynn *et al.,* 2015), wild animals are attracted to invade farmlands and damage crops grown by farmers.

"In most habitats, food quality and abundance vary seasonally because plant growth and phenology induced by rainfall distribution patterns" DieRienzo *et al* (2012). Nishant *et. al.* (2019) demonstrates that cultivated plants are richer in macronutrients and mineral salts than wild plants of the same

taxa. This can imply that as long as farmers do not adopt buffer crops, crop damage by wild animals might continue. The optimal foraging theory has been found to the most appropriate theory to underpin this study, whereas the value belief norm theory provides insights on how farmers can be involved in adopting of buffer crops to mitigate crop damage by wild animals. The means on how farmers can participate in planting of buffer crops were guided by the Value-Belief-Norm Theory.

Value-Belief-Norm Theory (VBN): Whether farmers are to adopt the growing of buffer crops as mitigation to crop damage by wild animals, their decisions and choices are informed by the values, and beliefs they might attach to the selected crops. Value-Belief Norm theory is suitable to guide farmer's choices and decisions on buffer crop planting based on its tenets of perception influence. Some farmers considered some buffer crops were not attracting good prices on the market, especially tea. The Value-Belief-Norm Theory (VBN) describes how environmentally-friendly behaviour can be adopted based on personal norms, values, and attitudes. For people to act in an environmentally-friendly way, the need to be informed of the problem and understand the threats (to humans, other species, and or the biosphere) is needed. Restrictions such as laws, regulations can limit or hinder action. Therefore, if farmers are involved in decision-making concerning wild animals crop feeding and appropriate policies to follow, their actions are likely to change.

Contrary to traditional wild animals' management techniques such as guarding of crop farms, planting of scarecrows in gardens and use of firecrackers (Rebekah, 2009), construction of crop field watch-over towers (Sudip and Siddhartha, 2006), shooting to death crop damaging wild animals trapped using remotely sensed cameras as a way of minimizing crop loss are common trends in Europe and America (Rod and William, 2016).

The Optimal Foraging Theory (OFT) asserts that crop damage by wild animals can be triggered by nutritional stress caused by a decline in the quality and nutritive value of natural forage (Osborn and Parker, 2003). Vulnerability to crop damage can also be exacerbated by crop farms proximity to the national park (Shaurabh and Sindhu, 2017). Since proximity to a protected area is the strongest predictor to crop damage, there is a need for farmers to adopt buffer crops such as tea (Akampulira *et al.*, 2015) and other buffer crops such as khat, cotton, simsim and coffee which are grown by farmers bordering Kibale National Park in Uganda.

Conclusion

Crop damage by wildlife has been documented as earlier as pre-3500 B.C. Crop damage by wildlife management was shaped by preservation and conservation paradigms. Crop damage by wildlife is not a new concept. Most measures of crop damage mitigation require constant human presence. The conservation philosophy re-emphasizes that returns from conservation should

be re-invested in conservation. Following the conservation philosophy, proceeds from conservation activities such as tourism can be re-invested in improving livelihoods through supplying farmers with buffer crops to grow through appropriate policies.

CHAPTER FIVE

POLICIES AND PRACTICES ON MANAGEMENT OF CROP DAMAGE BY WILD ANIMALS IN UGANDA

Conservation policies on management of crop damage by wild Animals

Conservation policy in Uganda has evolved from pure-protectionism to a protected-neighbour strategy (Mackenzie *et al.,* 2017). Most of the legal framework about wild animals is geared towards wild animals' protection and conservation, with less effort geared towards the management of crop damaging wild animal species and compensation. Only the Uganda Wildlife Bill 2017 provides for compensation of crop damage by wild animals. Though the Uganda Wildlife Bill 2017 provides for monetary compensation, compensation is slow, cumbersome, may involve corruption, there may be no significant funds to cover compensation, and may not decrease the problem of crop damage by wild animals (Naughton-Treves *et al.,* 2011). Thus, examining the effectiveness of buffer crops and determining how farmers can adopt and plant them to mitigate crop damage by wild animals is imperative.

The Constitution of the Republic of Uganda (1995) states that natural resources should be conserved and managed sustainably to grant development and environmental needs for the present

and future generations. The National Environment Act (1995) under section 73 (2) also provides for the protection and sustainable use of wild animals. The Land Act (1998) under articles 43 and 44 provides for the right of the Local Government to acquire land for wild animal's protection. The Uganda Wildlife Act of (1996) as the main legislation about wild animal's conservation, management, and prosecution of wild animal's crime establishes Uganda Wildlife Authority (UWA) and mandates it to manage wild animals and license any activity regarding wild animals use in Uganda. The Uganda Forestry Policy (2001) supports the idea of inclusive and sector-wide policy, supporting the sustainable use of forest resources for economic development, poverty alleviation, and environmental sustainability.

The Uganda Wildlife Policy (2014) is focused on sustainably managing wild animals' resources and healthy ecosystems through sustainable utilization of wild animal resources for economic development through curbing wildlife crime. The National Policy for the Conservation and Management of Wetlands (1995) supports the utilization of wetlands in a way that they do not lose traditional benefits while providing basic livelihoods to communities. The National Forestry and Tree Planting Act 2003 regulates the use and accession of forestry resources and their derivatives. The Local Government Act, Cap 24, mandates its committees to initiate and formulate policies regarding the use of natural resources. The Uganda Wildlife Conservation Education Centre (UWEC) Act (2015) mandates UWEC to manage and promote conservation education in

Uganda. The Uganda Wildlife Act Cap 200 does not provide compensation for loss of property and lives from wild animals escaping from the protected area.

Furthermore, under Uganda Wildlife Act Cap 200, Uganda Wildlife Authority (UWA) is not fully liable to wild animals induced damage occasioned on communities by crop damaging wild animal species (Uganda Wildlife Bill, 2017), though some revenue is shared as per revenue sharing guidelines to cater for crop damage. The money is sent by Uganda Wildlife Authority (UWA) to the Local Government (districts) which share boundaries with protected areas, who remove only 5% as administrative costs and 95% are sent to sub-counties for the agreed-upon projects between communities and UWA (UWA, 2014). The focus of this revenue sharing scheme could consider increasing funding for livestock production around Kibale National Park, since there are no major predators such as hyenas and lions that could attack livestock. Such an intervention could target farmers at the periphery of Kibale forest.

Through revenue sharing scheme, the revenue shared around Bwindi Impenetrable National Park increased from 3,000,000/= per parish in 1995 to 15,000,000/= per parish in 2014 (UWA, 2014). These are important milestones by UWA to promote harmonious co-existence between wild animals and communities where these protected areas are located. However, UWA not fully being liable to crop damage by wild animals could keep farmers more vulnerable to individual agro-economic losses, threatening food insecurity, and increasing

resentment to wild animals. Section 58(1) of the Uganda Wildlife Bill (2017) provides for farmers to report any form of crop damage to a wildlife officer. Clause 2(1) provides for the assessment of damage and clause 3 provides for decision making on compensation in line with the conservation status of crop-damaging wild animals. Section 82(1) provides for the formation of the wild animals compensation verification committee, with section 82(2) defining the roles of the committee. Section 83 creates compensation scheme, Section 83(1) clauses a, b and c provides for monies to be used in compensating crop damage, and other damage occasioned by wild animals to communities living outside protected areas.

The Fourth Schedule of the Uganda Wildlife Act 2019 (*compensable wild animals species whose damage creates a liability to compensation*) Section 84(1) clause b on damage to property which also involves crops, only buffalo, hippopotamus, baboons, gorillas, chimpanzee, and bush pigs are listed for compensation, this leaves out other primates which are known to raid crops around Kibale National Park. Apart from baboons and chimpanzees which are listed on the list of compensable wild animals on the Fourth Schedule of The Uganda Wildlife Bill (2017), the other four crop damaging wild animals species such as red-tailed monkey (*Cercopithecus ascanius*), vervet monkey (*Cercopithecus aethiops*), black and white colobus (*Colobus guereza*), L'Hoest's monkey (*Cercopithecus lhoesti*), are not listed. These species not listed were recorded in 1998 as wild animals that damage crops (Naughton-Treves *et al.*, 2011).

The Uganda Wildlife Act 2019 provides for compensation schemes that could help farmers to replace agricultural livelihoods lost. However, there is no policy to promote growing of buffer crops that can mitigate crop damage by wild animals however Akampulira *et al.,* (2015) noted that tea was effective in buffering for crop damage at 93% around Bwindi Impenetrable National Park. Policies on promoting buffer crop growing are feasible.

It is important to understand ways that promote conservation of wild animals by understanding wildlife conservation philosophy. Philosophical views of Theodore Roosevelt, Gifford Pinchot on wild animals' conservation, and those of Turner that emphasize sustainable utilitarianism through tourism as opposed to total preservation using wild animals for spiritual and intrinsic values by John Muir have been understood to underpin policy change on management of crop damage by wild animals. Promoting sustainable utilitarianism practices such as tourism and re-investment of tourism proceeds in crop damage mitigation gives insights on avoiding crop damage by wild animals.

Funds generated from tourism activities can be invested in projects that support crop damage management such as buying farmers seeds, seedlings, and plantlets of buffer crops to grow. Involve small holder subsistence farmers digging near the protected areas in alternative livelihood projects such as apiary and livestock production and make more direct investments in enhancing protected area problem management interventions

such as expanding trench networks and setting up more beehive fences to deter wild animals from crossing and damaging crops in farms.

Khat was an effective buffer crop against most wild animals that damaged crops, since it was not eaten by any wild animals. Crops such as coffee was not wholly damaged by monkeys. Some farmers never knew what buffer crops were, and based on the study gaps such as having species of wild animals not being listed among those to be compensated for as per the Uganda, Wildlife Act 2019, lack of information on what buffer crops were, inability to grow buffer crops in study sites such as Karusandara Sub-County which experiences flooding and in Kakooga Parish where buffer crops cannot be grown due to the nature of soils.

Novel Buffer Crops grown by farmers bordering Kibale National Park in Uganda

Farmers grow several types of buffer crops to deter crop damaging wild animals. A novel buffer crop called khat is grown by farmers in Hakibaale Sub-County in Kabarole District. Khat as a buffer crop is being documented for the first time. There is need to encourage farmers to grow such buffer crops to mitigate against loss of yields to wild animals that damage crops as guided by the Buffer Farmers Model (BCFAM) amongst farmers around Kibale National Park.

It is significant to plant buffer crops as mitigation measure to crop damage by wild animals through providing information on

some buffer crops such as coffee and simsim which are not wholly damaged by some primates especially red-tailed monkeys, chimpanzees and olive baboons.

Five major food crops grown namely, Bananas, Maize, Beans, Sweet Potatoes and Cassava are independently affected by wildlife damage in terms of reported and observed damage by wild animals among farmers bordering Kibale National Park. Such information is useful in making decisions by protected area managers and farmers around KNP on diversification of livelihoods through participation in other income generating activities other than crop farming. Such activities that can improve household income include livestock production, ecotourism and planting of commercial buffer crops such as tea and simsim.

Securing farmers' livelihoods through wild animals-crop damage mitigation improves income at household level, improves nutrition and food security among farmers living adjacent to protected areas, these improvements in lives of rural farmers around protected areas such as Kibale National Park relate to United Nations Sustainable Development Goals (SDGs) SDG1 on "no poverty", and SDG2 on "zero hunger". Encouraging farmers to plant buffer crops as mitigation measure to crop damage by wild animals is in line with Uganda's National Development Plan phase three (NDP-III) objective one on Increasing Sustainable Production and Value Addition in sectors such as agriculture since growing buffer crops reduces on loss of yields among farmers. Growing of tea, coffee and

cotton does not only act as a buffer crop, but also increases household income among farmers.

The Application of Buffer Crop Farmers Model (BCFAM)

At policy level, the Uganda Wildlife Act 2019, provides for a list of species where a farmer can be compensated when the wild animals damage their crops. Some wild animal species that damage crops are not listed for compensation under the Uganda Wildlife Act 2019. This is a major policy gap that leaves farmers crops prone to damage by wild animals. This chapter addresses the policy gap by developing a Buffer Crop Farmers Model (BCFAM) in Figure 8.1 where farmers are supported with buffer crop planting materials such as seeds and seedlings, this can increase participation in planting buffer crops to mitigate wild animal damage on crops.

Buffer Crops not wholly damaged by wild Animals

Some 43.7% of farmers never knew what buffer crops were (Table 2.3), some farmers grew cash crops such as coffee and this was not wholly damaged by primates. The contribution highlights the importance of enhancing continuous environmental education in creating awareness about the value of buffer crops to farmers.

When farmers are now fully aware of the economic values of buffer crop growing, then crop loss can be mitigated when the buffer crops have been fully adopted and grown around Kibale National Park (KNP). The contributions made in this book can

be replicated in other parks in Uganda and globally where crop damage by wild animals remains a challenge.

Conclusion

Planting effective buffer crops mitigates crop damage by wild animals around Kibale National Park. Farmers had limited knowledge on the value of planting buffer crops and supporting farmers with buffer crop planting materials is limited. Crop damage by wild animals around Kibale National Park can be mitigated through encouraging farmers to grow effective buffer crops such as tea, coffee and Simsim as guided by the Buffer Crop Farmers Model (BCFAM). Mitigating crop damage by wild animals around KNP is not only a means to enable farmers improve on yields but also a new strategic approach to protecting the wild animals against human resentment.

CHAPTER SIX

RETHINKING CROP FARMING BY PROTECTED AREA BOUNDARIES

Sensitize farmers about the value of Buffer Crops

Farmers especially those with large pieces of land need to be enlightened on the values of commercial buffer crops and associated benefits in terms of crop damage management. This can be done by Kibale National Park Authorities to promote commercial agriculture while mitigating crop damage by wild animals.

Encourage farmers bordering Kibale National Park to grow Buffer Crops

Farmers around Kibale National Park should be encouraged to grow buffer crops. This can be done by the Ministry of Agriculture, Animal Industries and Fisheries (MAAIF) in cooperation with Ministry of Wild animals Tourism and Antiquities (MWTA), working together with Uganda Wildlife Authority can develop appropriate agricultural policies that incorporate growing of buffer crops.

Reinforcement of KNP crop damage management interventions

KNP management should expand the trench network around the park and set up more beehives fence lines where trenches cannot be dug. Reinforcing these interventions can reduce crop damage by wild animals such as buffaloes, wild pigs and elephants.

Helping farmers growing Buffer Crops to access markets

In collaboration with Local and Central Government, Kibale National Park Authorities should help farmers growing buffer crops such as tea and simsim to gain access to markets for these buffer crops grown.

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