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Abstract

Agriculture is critical in the achievement of food security, employment of creation opportunities, steering economic growth, and also a source of raw materials for agricultural industries in many Sub-Saharan countries. However, farmers face various challenges which negatively affect farm productivity and production. Human-wildlife conflict is one of the most pressing challenges that smallholder maize farmers experience in some parts of Kenya. It arises from either people's encroachment on wildlife habitats or the movement of wildlife from their natural habitat into neighboring farmland. Small-scale farmers use various agricultural extension strategies to mitigate the conflict. However, the effectiveness of the agricultural extension mitigation strategies adopted by smallholder maize farmers in Laikipia County had not been investigated and information on the same was inadequate and poorly documented. This study sought to determine the effectiveness of the agricultural extension wildlife conflict mitigation strategies adopted by smallholder maize farmers in Laikipia County. Whereas a document review guide was used to collect secondary data, semi-structured questionnaires were used to collect primary data from maize farmers and extension agents. Descriptive statistics were used to analyze primary data. It was established that crop damage was very severe, even up to 70% per cropping season although farmers used mitigation strategies such growing of unpalatable plants, live fences, hairy crops, and digging trenches. This study concluded that the Agricultural Extension Mitigation Strategies used were not effective. It was recommended concerted efforts between stakeholders in the conflict to realize the benefits of synergies so as to stem crop damage and give small-scale farmers a chance to be food secure.

Keywords

human-wildlife conflict, maize, mitigation strategies, smallholder farmers, Kenya

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Agriculture is critical in the achievement of food security, employment of creation opportunities, steering economic growth, and also a source of raw materials for agricultural industries in many Sub-Saharan countries. However, farmers face various challenges which negatively affect farm productivity and production. Human-wildlife conflict is one of the most pressing challenges that smallholder maize farmers experience in some parts of Kenya. It arises from either people's encroachment on wildlife habitats or the movement of wildlife from their natural habitat into neighboring farmland. Small-scale farmers use various agricultural extension strategies to mitigate the conflict. However, the effectiveness of the agricultural extension mitigation strategies adopted by smallholder maize farmers in Laikipia County had not been investigated and information on the same was inadequate and poorly documented. This study sought to determine the effectiveness of the agricultural extension wildlife conflict mitigation strategies adopted by smallholder maize farmers in Laikipia County. Whereas a document review guide was used to collect secondary data, semi-structured questionnaires were used to collect primary data from maize farmers and extension agents. Descriptive statistics were used to analyze primary data. It was established that crop damage was very severe, even up to 70% per cropping season although farmers used mitigation strategies such growing of unpalatable plants, live fences, hairy crops, and digging trenches. This study concluded that the Agricultural Extension Mitigation Strategies used were not effective. It was recommended concerted efforts between stakeholders in the conflict to realize the benefits of synergies so as to stem crop damage and give small-scale farmers a chance to be food secure.

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Introduction

The agriculture sector is critical for achieving food security (Alliance for a Green Revolution in Africa, 2013). It also employs more than two billion people besides contributing significantly to the world's Gross Domestic Product (GDP) and economic growth (Hanson, 2013). The sector also employs about 65% of the total African workforce (Huho & Kosonei, 2013). In developing countries, growth of the agricultural sector significantly increases income generation in addition to reducing poverty levels (World Bank, 2012). It is therefore considered pivotal in achieving sustainable development goal (SDG) 1, which seeks to reduce the level of poverty in the world (United Nations, 2015). In the developing countries such as Kenya, agriculture provides food, income and also accounting for 65% of the total national export, 18% of formal employment and 70% of informal employment (Biwott & Muriu, 2013).

Although agriculture contributes significantly towards achieving food security, economic development and employment creation, smallholder farmers in different parts of the world experience various challenges. Smallholder farmers in Africa suffer from effects of wildlife problem (Lamarque et al., 2009). Smallholder farmers in Kenya, including Laikipia County also experience the problem of human-wildlife conflict (Government of Kenya, 2010; 2012; Ministry of Forestry & Wildlife, 2012). Human-wildlife conflict is a phenomenon experienced in different parts of the world where wildlife and people compete for limited resources as well as share boundaries (Eniang, Igeomah, Okeyoyin & Uwatt, 2012; Musimbi, 2013). An occurrence of human-wildlife conflict results in injury or death of livestock or even humans, loss of

crops, damage to infrastructure or disease transmission.

To mitigate human-wildlife conflict, farmers adopt various Agricultural Extension Wildlife Mitigation Strategies (AEWMS) after being trained by agricultural extension service providers. Extension workers in the Ministry of Agriculture, Livestock and Fisheries (MoALF) promote growing of crops that are unpalatable to wildlife such as chili, pyrethrum and tobacco and growing of hairy or spiked crop varieties. Other strategies include growing of tightly covered maize cobs/husks, construction of trenches around the farm to form a barrier against wildlife and also growing of live fences around the farm using mauritius thorn, kai apple or sisal. Although the Kenya Wildlife Service (KWS) is mandated to conserve wildlife, it also promotes extension wildlife conflict mitigation strategies such as construction of trenches round the farm to serve as barriers against wildlife entry (Kenya Wildlife Service, 2016). However, the effectiveness of the agricultural extension wildlife mitigation strategies being used by smallholder maize farmers in Laikipia County had not been studied and the information about the same was inadequate and poorly documented.

Theoretical Framework

The study was informed by the conflict theory and the functionalist theory. The conflict theory was propounded by Karl Marx and Herbert Spencer while Robert Merton proposed the functionalist theory. A conflict is a disagreement between individuals over differences in goals and values (Hammer, 2007). Competition for resources results in conflicts by ensuring that only the individuals of a species that are fit in the niche survive. Unequal distribution of scarce resources in a community increases chances for a conflict (Adu-Febri,

2012). This means that conflicts will arise from a clash in interests held by individuals due to their differences or incompatibility. Further, a conflict can arise when individuals are motivated to pursue their interests, needs and resources that they consider important and desirable. Therefore, a society is in perpetual conflict due to competition for limited resources since it holds groups who are competing for power and resources. Thus, based on the conflict theory, people and wildlife in Laikipia County continually compete for scarce resources resulting in human-wildlife conflict.

In contrast to the conflict theory, the functionalist theory views a society as a complex unit having different parts working together harmoniously with the aim of promoting solidarity and stability. A society is a unitary system comprising different parts that are interconnected but working harmoniously to maintain a state of balance and social equilibrium (Mooney, Knox & Schacht, 2007). The different parts of a social system are interdependent. A society is functional only if its constituent parts are functional, thus contributing to social stability, and if they are dysfunctional then the society also becomes dysfunctional (Ritzer, 2007).

Conflict theory provides insight into the possible causes of a conflict in a society by showing that a conflict results from competition for limited natural resources to satisfy needs, goals and interests which could be different and incompatible. This could mean that always there shall be a conflict due to competition for the limited resources among members of a society, as they seek to satisfy their incompatible needs, interests and goals. On the other hand, a functionalist theory informs this study by showing that a society resembles a social system which is composed of different parts that are interconnected and interdependent.

Further, for a social system to function well and benefit its members, each part of the system must perform its functions well, resulting in social stability and equilibrium.

In Laikipia County, wildlife and people compete for scarce natural resources resulting in human-wildlife conflict. This leads to ecosystem change, injury or even death of humans and displacement of wildlife. The Laikipia County ecosystem includes farmers, forests, and rivers, organizations like the Kenya Wildlife Service, Ministry of Agriculture & Fisheries, community-based organizations and Non-Governmental Organizations (NGOs). These elements of the ecosystem play a role in the maintenance of balance and social equilibrium. If any of these elements of the ecosystem is dysfunctional, then eco-social balance and stability will be disrupted. For instance, if forests are dysfunctional, or depleted and do not meet the requirements of wildlife's survival, then wildlife will move out of the forest in search of pasture and water. Similarly, if land is scarce due to rapid human population increase, people will encroach forests in search of agricultural land. This will destabilize the forest ecosystem resulting in human-wildlife conflict.

Statement of the Problem

Agriculture is important in Kenya's economic development, generation of income and employment and provision of raw materials for agricultural industries. However, the agriculture sector faces various challenges, one of them being human-wildlife conflict. It results from human encroachment on wildlife habitats and or movement of wildlife out of their unprotected habitats such as Rumuruti Forest or protected areas into areas surrounding farmland. When wildlife move into the neighboring farming areas, they cause damage to crops, injure or kill

livestock or even people. Although farmers experience significant human-wildlife conflict, the government of Kenya considers the tourism industry as one of the key engines for economic development, with wildlife being the base for the industry. Available information on how much effective Agricultural Extension Wildlife Mitigation Strategies used by smallholder maize farmers were was inadequate and poorly documented. This could mean that farmers will continue using the strategies that are not effective, thus, remain susceptible to the conflict. This study sought to avail the information to policy makers and agricultural extension service providers to enable them plan better on how to reduce human-wildlife conflict among smallholder farmers.

Purpose and Objectives of the Study

This study sought to establish the effectiveness of Agricultural Extension Wildlife Mitigation Strategies used by smallholder farmers in Laikipia County, and then make it available to extension service providers and policy makers who will use it to plan better on how to mitigate the conflict. The following objectives guided this study:

1. Determine the Agricultural Extension Wildlife Mitigation Strategies used by smallholder maize farmers;
2. Establish the severity of crop damage among smallholder maize farmers in Laikipia County; and
3. Investigate the effectiveness of the Agricultural Extension Wildlife Mitigation Strategies used by smallholder maize farmers.

Methodology

During this study, a cross-sectional survey research design which was descriptive in nature was used among

smallholder maize farmers bordering Rumuruti Forest in Laikipia County. The smallholder farmers comprise majority of farmers in Laikipia County. Public extension agents were also involved because they promote various wildlife mitigation strategies. Simple Random Sampling (SRS) was used to select 203 smallholder farmers for administering a farmer's questionnaire while purposive sampling was used in selecting 10 extension agents for administering extension agent's questionnaire. Semi-structured questionnaires were used for primary data collection from both farmers and extension agents. The questionnaires collected both qualitative and quantitative data on the severity of crop damage, extension mitigation strategies used and their effectiveness so as to address study objectives. A document review guide was used for secondary data collection. The questionnaires and document review guide were developed by the researcher and validated by five Agricultural Education and Extension experts of Egerton University. Primary data were collected for years 2012 to 2015, with 2012 serving as the baseline. Data were analyzed using mean, mode and frequencies using Statistical Package for Social Sciences (SPSS).

Results and Discussion **Agricultural Extension Wildlife Mitigation Strategies (AEWMS) Adopted by Farmers**

In Laikipia County, the major wildlife which attack maize includes monkeys, elephants, buffalo, squirrel, porcupine, hippopotamus and birds. Smallholder maize farmers use a combination of various AEWMS strategies against wildlife attack, with the growing of a live fence, growing of unpalatable crops and digging of trenches being the commonly used strategies, as shown in Table 1.

Table 1

Extension Mitigation Strategies Adopted

Strategy	Targeted Wildlife	Farmers Adopting (%)
Growing unpalatable crops	Monkey, elephant, zebra	38.7 (n=79)
Growing a live fence	Monkey, elephant, buffalo, zebra	45.3 (n=92)
Digging a trench as a barrier	Elephant, hippopotamus	21.7 (n=44)
Dressing seeds with pesticides	Squirrel	0.5 (n=1)
Achieving optimal plant population	Porcupine	0.5 (n=1)
Growing hairy or spiked crops	Weaver & quelea quelea birds	8.4 (n=17)
Growing resistant crop varieties	Birds	9.5 (n=19)

Crops that are unpalatable to monkeys such as sunflower, beans and pyrethrum can be integrated in a crop rotation cycle. About 2-3 lines of chili can also be grown around the main crop to act as a repellent. Crops such as chili, tobacco, pyrethrum and sunflower that are unpalatable to elephants can be grown around a main crop to serve as repellents. Unpalatable crops such as sunflower and pyrethrum can also be grown as main crops or around the main crop to repel zebra. Mauritius thorn can be grown as a barrier against monkeys, elephants, buffalo and zebra. Trenches measuring 6 feet wide and 6 feet deep can be dug around the farm to form a barrier against elephant and hippopotamus. Dressing of seeds with pesticides before planting makes them unpalatable and poisonous to squirrels. Achieving optimal plant population through using correct spacing for a maize crop ensures that stems are strong enough to resist bending and lodging. This reduces attack by porcupines.

On the other hand, growing maize varieties which have tightly covered husks and cobs reduces attack by birds. Growing hairy or crops which have spikes such as some varieties of sorghum reduces attack by birds. These findings concur with those of other studies which showed that small-scale farmers in African countries grow

unpalatable crops such as chili to mitigate elephants (Hockings & Humle, 2009; King, Douglas-Hamilton, & Fritz-Vollrath, 2011). Chili is also used in Queen Elizabeth Park Area (QEPA) in Uganda (Babaasa, Akampulira, & Bitaribo, 2013). Live fences are used in Kibale and Bwindi areas of Uganda against elephants, baboons and gorillas while trenches are used against elephants and buffaloes in Kibale and QEPA regions.

Severity of Crop Damage

Through primary data collected, this study established that maize crop damage among smallholder farmers in Laikipia County is severe. It occurs even up to 70% per acre per cropping season, as shown in Table 2.

Table 2

Degree of Crop Damage per Acre (n=203)

Year	Degree of damage (%)
2012	68 (n=167)
2013	69 (n=174)
2014	70 (n=187)
2015	69 (n=182)

These findings match with those of a study in Nigeria which showed that crop

damage by wildlife in some cases is as high as 98% per acre per year (Eniang et al., 2011) and 65% of maize crop per year in Tomboro area of Cameroon (Eyebe, Dkamela, & Endomana, 2012). These high crop damage values mean that the agricultural extension mitigation strategies adopted by smallholder farmers are not effective.

Effectiveness of Agricultural Extension Wildlife Mitigation Strategies Used by Farmers

In this study, the term effectiveness was used to mean the degree to which the AEWMS could reduce crop damage by at least 10%. The AEWMS were rated on a

five-point Likert-type scale by both sampled farmers and extension agents. Farmers rated the degree of effectiveness of each strategy they had used on their farms on a scale. Further, extension agents who had trained the farmers on extension mitigation strategies and also observed the strategies as they were being adopted by farmers rated the mitigation strategies on the degree of effectiveness. The sum of the values of the rates by farmers and extension agents were used to estimate the rate of the effectiveness of the mitigation strategies. This study established that the AEWMS used by maize farmers in Laikipia County have low rate of effectiveness as summarized in Table 3.

Table 3

Rate of Effectiveness of Extension Mitigation Strategies

Strategy	Target Wildlife	Rate of Effectiveness (%)
Growing unpalatable crops	Elephant	25.0 (n=53)
	Monkey	30.0 (n=64)
	Zebra	31.6 (n=68)
Growing a live fence barrier	Elephant & buffalo	25.0 (n=53)
	Zebra	27.3 (n=58)
	Antelope/Gazelle/Impala	26.1 (n=55)
Digging trenches as a barrier	Elephant/Impala/Gazelle	33.3 (n=70)
	Hippopotamus	28.6 (n=62)
Dressing seeds with pesticides	Squirrel	45.0 (n=96)
Growing hairy or spiked crops	Weaver/ quelea bird	11.8 (n=26)
Growing resistant crop varieties	Weaver bird	33.3 (n=70)

For instance growing a live fence against elephants is 25% effective, growing unpalatable crops such as sunflower, chili, pyrethrum or tobacco against elephants is 25% effective while digging trenches to serve as a barrier against elephants is 33.3% effective. Results of this study showed that the agricultural extension mitigation strategies used by smallholder farmers in Laikipia County have low rate of effectiveness, as low as 25%. The average

effectiveness of all the extension mitigation strategies is just about 33%. The low rate of effectiveness means that the extension mitigation strategies used by smallholder farmers in Laikipia County are not effective. This is because farmers are not using the strategies as recommended by extension agents. This was evidenced by a large proportion (87.5%) of farmers who were found to have a negative attitude towards the mitigation strategies promoted. This results

from their failure to accept the agricultural extension mitigation strategies for instance, chili, sunflower, sorghum and pyrethrum. Further, the system of land tenure especially, leasehold which is common among a significant proportion (50%) of smallholder farmers hinders adoption of some mitigation strategies such as trenches, planting of sisal and Mauritius thorns. These plants take long to grow and fully establish to serve as mitigation strategies. In addition, most farmers (75%) indicated that they had inadequate knowledge and skill on the available extension mitigation strategies and their usage.

For instance, they had inadequate knowledge on available crops that are unpalatable to wildlife found in the County. They also had inadequate knowledge on the propagation and maintenance of some plants especially Mauritius thorn. This study further established that inputs such as seeds for AEWMS, for example, Mauritius thorn, are expensive. This affects a significant (50%) proportion of farmers who cannot afford them. This fact was supported by the fact that most (81%) farmers earn kshs. 60,000 or less annually. This affects the effectiveness and sustainability of AEWMS used. Farmers were therefore likely to experience significant crop losses resulting from wildlife attacks hence the high crop damage as shown in Table 2. However, a study in the Greater Virunga Landscape (GVL) showed that live fences such as growing Mauritius thorn are effective against baboons, gorillas and bush-pigs (Andama, 2009; Babaasa et al., 2013). This is possible only when it is planted and maintained as recommended, particularly, planted and placed in 3 rows, 30cm apart, when branches are layered and intertwined to form an animal-proof barrier.

If the AEWMS were effective, wildlife would be restricted from accessing farmland and people prevented from

encroaching wildlife habitats, chances of an outbreak of human-wildlife conflict would be reduced and the rate of severity of crop damage will be low. This agrees with the conflict theory which indicates that as members of a society pursue their interests and seek to meet their needs, they are bound to be in conflict, and in this case it is the human-wildlife conflict. On the other hand, if the AEWMS are effective, elements of a society which is in the form of an ecosystem will be restricted to their niches. The different species of organisms will therefore not compete for limited natural resources, thus help to alleviate a conflict situation. This means that all parts of a society will remain interconnected as functional, as postulated by the functional theory.

Conclusions, Recommendations and Implications

In Laikipia County, wildlife is conserved in Rumuruti Forest which is not a protected area or gazetted wildlife habitat. Furthermore, humans are settled and are also allowed to undertake farming in areas bordering unprotected wildlife habitats. Wildlife therefore moves out of their habitats into farmland neighboring their habitats thereby damaging crops. This study established that small-scale maize farmers use various agricultural extension wildlife mitigation strategies promoted by agricultural extension agents concurrently. About 38.7% of farmers grow crops that are unpalatable to wildlife such as chili, pyrethrum, sunflower and tobacco as main crop and growing of unpalatable crops as barrier to the main crop. At least 45.3% of farmers construct trenches around the farm to form a barrier against wildlife entry, 1.8% grow maize crop varieties which have tightly covered cob or husk.

The low percentage of farmers using the extension mitigation strategies was attributed to the fact that farmers did not

have adequate knowledge about the strategies or they were not willing to adopt the strategies. Farmers can also not afford using the strategy or the strategies were not sustainable. Further, farmers might have realized that the strategies are not effective and therefore abandoned them. Thus, only a few farmers were using them. This could mean that smallholder farmers will continue experiencing significant crop losses, thus affecting crop production, productivity and household food security. This study also found that smallholder farmers experience severe crop losses of up to 70% per acre per cropping season due to wildlife attack even with the use of AEWMS. Additionally, this study established that AEWMS used by small-scale farmers have a low rate of effectiveness. For instance, unpalatable crops are 30% effective, live fences are 27%, digging trenches 33%, seed dressing with pesticide 45%, growing spiked crops 11.8% while growing resistant crop varieties are 33% effective. The low rate of effectiveness for the mitigation strategies implies that the mitigation strategies promoted by extension service are not effective. Consequently, smallholder farmers will continue experiencing high crop losses. It was therefore concluded that smallholder maize farmers in Laikipia County are using agricultural extension mitigation strategies that are not effective, hence the high crop losses experienced. Farmers therefore continue suffering from the effects of human-wildlife conflict. An investigation should be conducted to find out the causes of the low effectiveness of AEWMS among smallholder farmers.

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