Implications of Human-Wildlife Conflict on Food Security among Smallholder Agro-Pastoralists: A Case of Smallholder Maize (*Zea mays*) Farmers in Laikipia County, Kenya

Ronald Orare Nyamwamu[*]

Department of Agricultural Education & Extension, Egerton University, Egerton, Kenya
*Corresponding author: ronnyorare@yahoo.com

Abstract The agricultural sector is important for achieving food security, employment creation and economic growth, besides supplying raw materials for agro-based industries. However, farmers experience challenges which could undermine agricultural productivity and production such as effects of human-wildlife conflict. Wildlife in Laikipia County move out of their habitats into farmland, thus damage crops. This study sought to determine how wildlife attack and damage influence food security among smallholder maize farmers in Laikipia County. A descriptive cross-sectional survey research design was used. Two hundred smallholder maize farmers previously invaded by wildlife were sampled. A questionnaire was administered on the 200 farmers to collect primary data. Secondary data was collected using a document review guide. The questionnaire was piloted in Narok County using 30 agro-pastoralists bordering Maasai Game Reserve. A reliability coefficient of ά=0.85 was adopted because it was more than ά=0.70, which is the acceptable minimum at 0.05 confidence level. Validation of the questionnaire and document review guide was done by 5 agricultural extension experts at Agricultural Education and Extension Department of Egerton University and the pilot testing in Narok County. Data was analysed using the per cent and mode. This study established that human-wildlife conflict is significantly influencing food security among smallholder maize farmers in Laikipia County. This was shown by large maize crop losses of even up to 100% despite the use of various mitigation strategies. It was therefore recommended that a study be undertaken to determine the effectiveness of wildlife mitigation strategies adopted by the farmers in Laikipia County.

Keywords: *food security, human-wildlife conflict, implications, smallholder agro-pastoralists, smallholder maize farmers*

1. Introduction

The Agriculture sector is important sector for achieving food security, employment creation and economic growth in the world (Alliance for a Green Revolution in Africa, AGRA, 2013). The sector is the backbone for economic growth for most African countries, and generates up to 25% of Gross Domestic Product (GDP) in Sub Saharan Africa [40]. Additionally, it is also critical for economic growth and poverty reduction. Since agriculture contributes up-to 40% of the total GDP in African countries [1], an increase in agricultural production raises income for millions of smallholder farmers who make up 75% of the Sub Sahara African population [40]. It is also the main source of food, employment, raw materials for agro-based industries, economic growth and poverty reduction [45]. Up to 80% of the rural population is employed by the agriculture sector. About 80% of all small farms in SSA are small scale and contribute up to 90% of the total production [2]. In Kenya, agriculture is the main source of food and income, besides accounting for about 65% of the total exports [37]. Additionally, agriculture is predominantly small scale, practiced on farm sizes averaging 0.2 to 3 hactares [13]. Furthermore, more than 85% of the total population depends on agriculture [2].

1.1. Challenges Affecting Agriculture

The agriculture sector plays a critical role in achieving food security and economic growth in the world. However, farmers experience challenges which could undermine agricultural productivity and production. Small-scale farmers in the world experience problems such as poor quality land (degraded & less productive), effects of climate change (drought, floods, diseases and reduced water supply) and inadequate extension services [9,12]. In Africa, the small-scale farmers face problems such as provision of inadequate extension services, lack of training and knowledge and effects of wildlife menace

[31]. The small-scale farmers in Sub Saharan Africa experience problems such as insecurity of land tenure, conflicts and effects of climate change [40]. The agriculture sector in Kenya experiences challenges which include low adoption of technology, heavy livestock losses to diseases and pests [13]. Farmers in Laikipia County also experience various challenges such as insecurity, inter-communal tension, poor delivery of extension services and human-wildlife conflict [14,35]. The challenges experienced by the farmers could result in reduced agricultural productivity [5], thus undermine food insecurity. Human-wildlife conflict is one of the challenges affecting smallholder agriculture in Laikipia County and has the potential to reduce household food security.

1.2. Human-wildlife Conflict Manifestation and Mitigation

The human-wildlife conflict phenomenon is experienced throughout the globe in areas where people and wildlife share limited resources [36], and also share boundaries [7]. In America, bears attack dustbins in towns in Northern USA, and about 29, 000 deers are killed annually after colliding with automobiles, wolves killed 2, 806 livestock in Canada between 1992 and 1996, wolves killed 718 livestock in USA between 1987 and 2001 [36]. Human-wildlife conflict manifests itself as crop damage, livestock injury or death, human injury or even death, competition for pasture or infection of livestock with zoonotic diseases [36,43]. Among farmers in Nigeria, crop damage is sometimes up to 98% [7], in Botswana farmers sometimes stop farming due to wildlife menace [18]. It was estimated that in Cameroon, up to 28.4 ha of crop was destroyed by wildlife around Campo-maan area and two people were killed in 2004 [8]. Crop damage by wildlife reduces yield by up to 50% in Uganda [44]. Although on a national scale the loss of 2ha of maize to wildlife on a single day may be considered insignificant, to the family concerned it may mean a loss of food supply for a year [16]. It may mean the difference between self-sufficiency and starvation. Crop damage affects a farmer's capacity to feed her family and reduces her household income. This ultimately affects their health, nutrition, education and general community development [11]. After crop damage, the available finances are diverted from meeting other household needs to meet the cost of food. However, limited information is documented on the influence of human-wildlife conflict on food security among small-scale agro-pastoralists in Laikipia County. This study therefore sought to determine the influence of wildlife attack and damage on food security among small-scale maize farmers in Laikipia County.

In response to human-wildlife conflict, farmers use different mitigation strategies such as guarding (human and animal), use barriers (fence, trench, walls or buffer zone), use repellents (chemicals, auditory, visual aversiveness or stimuli) or removal of wildlife (Treves, 2007). Some farmers plant crops that are unpalatable to wildlife, plant heavily attacked crops beyond a buffer of unappealing crops [19]. Farmers in Africa chase away wildlife, fence the farm, use olfactory deterrents or African honey bees [24,27]. For instance in Uganda, small-scale farmers use barriers like fences, buffers, guard

against wildlife, use deterrents or repellents [44] while others clear forests or trap wildlife [25]. Farmers in Mozambique make loud noises, light fire and use chilli barriers [3]. The farmers in the Tsavo Conservation Area of Kenya make loud noises, erect scare crows, burn hot pepper and light fire [33]. They also burn animal manure to produce offensive smell (smoke), guard using dogs and also chase away the wild animals. Some research trials have been done in Laikipia County on various human-wildlife conflict mitigation strategies such as the use of fire, digging trenches, making loud noise, chilli-grease fence, powerful electric light and electric fence. However, limited information has been documented on the extent to which human-wildlife conflict influences household food security among small-scale maize farmers in Laikipia County. Furthermore, maize is a major staple crop in Kenya and therefore its deficit is considered synonymous with food insecurity [42]. A total of 3, 750,700 and 2, 157,800 people needed food aid in the pastoral and marginal areas in Kenya in 2011 and 2012 respectively [14]. During the same period, about 61,900 and 56,600 people needed food aid in Laikipia County. In 2011, the quantity of maize, beans and potato had declined due to low food stocks in Laikipia County [15].

2. Research Methodology

2.1. Description of the Study Area

The study was done in Laikipia County among smallholder agro-pastoralists who border Rumuruti Forest. Rumuruti Forest is 6,217km^2 in size and hosts various wildlife such as monkeys,buffalo, elephant, birds and bush buck although not a gazetted wildlife habitat [35]. Other wildlife found in Laikipia County is the lion, leopard, rhinocerous, zebra and the African dog [15]. Laikipia County is about 9.700km^2 in size [30,34]. The County is semi-arid and receives bimodal rainfall [15]. Major sources of livelihood for most households in the County include farming of maize, beans, rearing of dairy and beef cattle, camels and sheep [15]. Laikipia County is an arid and semi arid area with the second highest wildlife population in Kenya. Additionally, it has forest areas which are not gazette as wildlife habitats although they host large wildlife populations. The study targeted the small-scale agro-pastoralists in Laikipia County whose average farm size is 0.8ha with crop or livestock production being their main source of livelihood [15]. Laikipia has a total human population of 399,227 with 198,625 males and 200,602 females and an average population density of 42 persons/km^2 [26]. In addition, majority (75%) of the population is below 35 years of age, while the proportion aged at least 15years is literate and comprises 86%.

2.2. Research Methodology

This study used a descriptive cross-sectional survey research design. A sample was selected from the population of agro-pastoralists and contacted at a single point in time to determine the prevalence of the outcome of interest in the population [6]. A semi-structured questionnaire developed by the researcher. The questionnaire was used to collect both qualitative and

quantitative data from the smallholder agro-pastoralists who are heads of households bordering Rumuruti Forest, in Laikipia County. During this study, reliability of the questionnaire was estimated through pilot-testing using 30 agro-pastoralists bordering Maasai Mara Game Reserve in Narok County. The findings of the pilot-testing exercise was used to revise the questionnaire items until the reliability coefficient of α=0.85 was achieved, which was above the recommended minimum reliability coefficient of α=0.7, at a confidence level of 0.05. The results of the pilot-test were used to improve the questionnaire which was later used in the actual study. Data collection involved administration of the semi-structured questionnaire on a sample of 200 agro-pastoralists bordering Rumuruti Forest in Laikipia County who had previously been affected by wildlife invasion on their farms. The farmers were assembled to designated central places on different days. A document review guide was also used to collect secondary data. Secondary data collection involved review of annual reports and crop damage assessment reports as from 2012 to 2015 at the County and Sub County agriculture and Kenya Wildlife Service offices. Secondary data collection involved a critical examination of recorded information related to human-wildlife conflict, recording the source and the information collected. Data was analysed using the mode and per centages to determine the frequency counts of the mitigation strategies adopted by farmers, amount of crop damage and challenges faced in adopting various mitigation strategies.

3. Results and Discussion

3.1. Gender of the Farmers

A total of 200 small-scale maize farmers previously affected by human-wildlife conflict were involved in the study through administration of questionnaire. This study established that more than half (61.1%) males participate in farming activities than females (38.9%) as shown in Figure 1. This means that agriculture in Laikipia County is dominated by men. This disagrees with Kiura [29] who found that more women (75%) than men participate in farming through the provision of farm labor. Furthermore, women play a significant role within the smallholder system where they produce food crops [21]. The World Bank [45] also found that addressing gender inequalities and empowering women is vital in improving food and nutrition security. Women play a significant contribution in the agricultural labor-force and agricultural activities, which are estimated to produce up to 80% of the food [11].
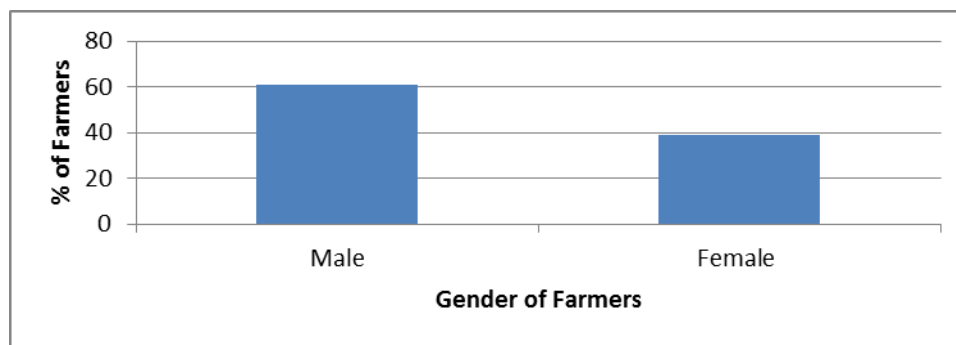

Figure 1. Gender of farmers

3.2. Age of Farmers

This study established that of the 200 respondents, 19.1% were aged 40 and below while 80.9% were aged 41 and above (Figure 2). This implied that over two thirds of the maize farmers were aging, while the youth were few in maize production. This means that agricultural activities in Laikipia County are undertaken by an aging population and the youth have shunned agriculture. This may lead to reduced agricultural production since humans become less active with increase in age especially the small-scale farmers who mostly rely on manual labor.
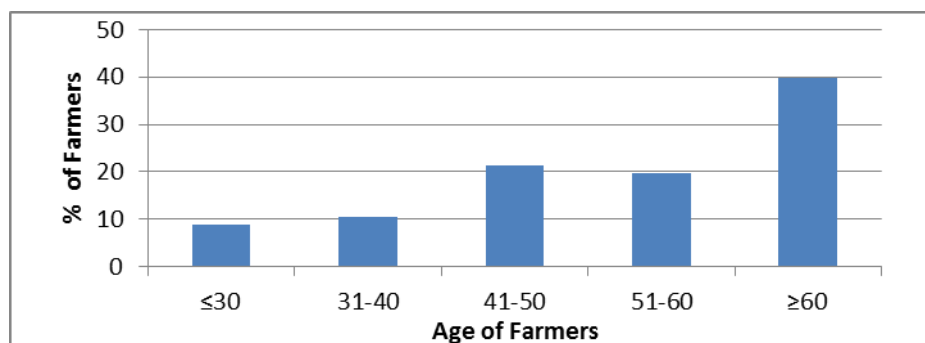

Figure 2. Age of farmers

3.3. Education Status of Farmers

This study found that about 26.9% of the respondents had no formal education, more than half (57.3%) had at least primary education, 11.9% had up to secondary education while only 3.9% had up to tertiary education (Figure 3). This could mean that the farmers in Laikipia

County are literate and averagely educated. Involvement of a literate and educated population in training could increase their understanding of the subject matter thus increase their adoption of innovations and technologies. This is consistent with KIPPRA [28] and Nyagaka et al. [39] who found that an educated labor-force easily understands, interprets new information and adopts new technologies. Technology adoption by farmers is positively correlated to the education level of a household head. Training facilitates good performance and sharpens skills of farmers, which in turn enhances adoption of technologies. Education improves a farmers' ability to access and process agricultural information in improving on-farm activities [4].

Education is productivity-enhancing [20]. Additionally, an educated labor-force is better at creating, implementing and adapting new technology, thereby generating growth.

A one year increase in average education raises the level of output per capita by between 3-6% or raises the rate of potential growth by just over 1% per annum. The number of years of schooling by the farmer positively influences the probability of farmer adoption of a technology [17]. Education is important for economic growth since higher levels of education attainment lead to a more skilled and productive workforce, producing more effectively and a higher quality of services hence economic growth and rising standard of living [22]. This could mean that the low educational status of the farmers in Laikipia County could be affecting their technology adoption and productivity. All (100%) the respondents reported that they grow maize annually. This is consistent with Lung'aho et al. [32] who found that in Kenya maize is grown mostly by farmers for food.
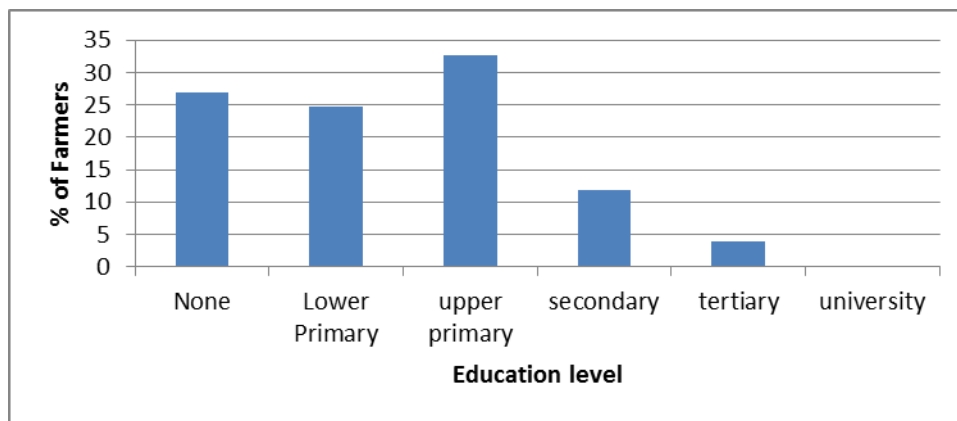

Figure 3. Education level of farmers

3.4. Economic Status of Farmers

Most (61.9%) of the small-scale farmers in Laikipia County are poor, earning less than kshs. 60,000 as income annually and only 38.1% earning at least kshs. 60,000 or more (Figure 4). This means that most farmers in Laikipia County are of low income status. This agrees with an observation by Seguino and Were [41] that low levels of income limits access to technology. Kabanyoro et al. [23]

adds that a farmer's financial resources, credit and marketing services affect her adoption of agricultural technologies. Limited access to credit and information on marketing systems limits farmers from achieving optimal production and agricultural development [38]. This condition could be hindering maize farmers' adoption of agricultural wildlife mitigation technologies in Laikipia County and therefore be susceptible to wildlife invasion.
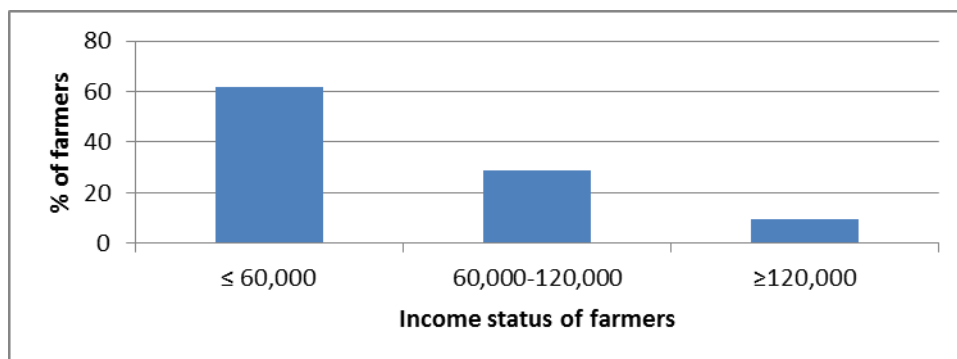

Figure 4. Farmers' income level

3.5. Magnitude of Crop Damage by Wildlife

Farmers in Laikipia County experience wildlife attack on their crops at varying degree. Results of this study show that up to 73% of the farmers experience crop damage of between 55% and 100% annually as shown in

Table 1. This match with findings in Nigeria which showed that sometimes crop damage of up to 98% is experienced [7]. It also agrees with findings in Uganda which showed that crop damage by wildlife reduces yield by up to 50% [44]. About 10% of the farmers stopped farming after experiencing crop damage of at least 85% for two consecutive years. This also agrees with findings

by Gupta [18] that in Botswana, sometimes farmers stop farming due to losses caused by wildlife attacks. This implies that crop damage by wildlife could be significantly contributing to food insecurity among small-scale farmers in Laikipia County.

Table 1. Annual Crop Damage

Proportion of Farmers (%)	Crop damage (%)
8.7% (n=17)	40
18.3 (n=36)	45
14.3% (n=29)	56
14.3 % (n=29)	66
12.7% (n=25)	76
14.3% (n=29)	86
17.4% (n=35)	96
Total	n=200

3.6. Wildlife Mitigation Strategies Used by Farmers in Laikipia County

Table 2. Mitigation Strategies Used by Farmers

Strategy	Farmers using the Strategy (%)
Establishing apiary (Bee keeping) (n=5)	2.4
Barbed wire fence (n=36)	28.6
Noise making-beating objects/shouting (n=57)	28.6
Bonfire (n=5)	2.4
Burning materials to produce offensive smell (n=27)	13.5
Chasing away (n=14)	7.1
Tie string soaked in pepper (n=3)	1.6
Establishing woodlot (n=52)	26.2
Planting unpalatable crops (n=37	18.3
Digging trenches round the farm (n=35)	17.5
establish early maturing crop (n=40)	19.8
Lighting fire to scare away wildlife (n=71)	35.7
Establish fodder crop (n=27)	13.5
Establish thorned plants/crops like kai apple (n=32)	15.9
Establish fruit trees (Orchard) (n=22)	11.1
Guarding using watchman & dog (n=38)	19.0
Using flashlight/torch (n=52)	26.2
Scaring away (n=14)	7.1
Solar fence (n=3)	1.6

This study established that small-scale maize farmers in Laikipia County use various wildlife mitigation strategies as shown in Table 2. However, there has been no previous research documented on the mitigation strategies used in Laikipia County. A significant proportion of farmers (35.7%) scare away wildlife while some farmers (28.6%) used barbed wire fence and an equal proportion make noise by beating objects or by shouting. On the other hand, about 26.2% establish woodlot to mitigate wildlife invasion. These findings agree with other studies which show that in African countries small-scale farmers chase way wildlife or erect fences to mitigate wildlife [19,27]. The findings also agree with a study in Mozambique which established that farmers use loud noise and fire [3]. The findings of this study also concur with those of a study done in the Tsavo Conservation Area (TCA) in Kenya which established that farmers use loud noise, light fire, burn offensive materials such as cow dung [33]. The farmers also chase away wildlife. Despite the use of various mitigation strategies by the small-scale maize farmers in Laikipia County, they continue to experience significant crop losses. This may imply that some of the mitigation strategies adopted by the farmers are not effective. It is therefore necessary to undertake a study to determine the effectiveness of the wildlife mitigation strategies adopted by farmers. This will help to reduce the crop losses caused by wildlife attack and probably reduce its effect on household food security.

3.7. Conclusion and Recommendation

This study concluded that human-wildlife conflict significantly affects household food security among small-scale maize farmers in Laikipia County. This is shown by the large crop damage and losses caused by wildlife despite the use of various mitigation strategies. It was therefore recommended that a study be done to establish the effectiveness of the human-wildlife conflict mitigation strategies used by the farmers.

Acknowledgement

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