

Livelihoods, Crops and Coexistence: Understanding Farmers' Agronomical Decisions in High Elephant-Conflict Landscapes

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ABSTRACT

Farmers in rural areas of Botswana depend on subsistence farming for their livelihoods. However, elephant crop-raiding is a challenge in the eastern Okavango area. To devise effective mitigation strategies, it is essential to understand farmers' rationale for crop choices, cropping methods, and perceptions about raiding. To this end, we surveyed 151 randomly selected farmers in 2018. We discovered that farmers relied on arable farming to sustain their livelihoods. The majority use a combination of their own seeds augmented with government seeds. About 95.4% of farmers suffered crop loss to elephants, yet only 35.8% indicated that elephants influence how they arrange crops during plantings. Food preference, crop importance to household and free seeds were leading determinants of the type of crop to grow, rather than vulnerability to elephant raiding. Despite knowing that elephants damage cereal and fruit crops more than legumes, most farmers still preferred to grow these crops since they are a primary component for household consumption. Nonetheless, farmers were willing to grow new crops (87.4%) and adopt new planting methods (84.10%) if it would reduce elephant raiding. However, they strongly believe that planting strategies cannot mitigate the problem. Ultimately, the study highlights that knowledge-sharing platforms to squash negative perceptions, affordability, farmers' preferences, and culture critically influence the farmers' considerations for adopting cropping attributes proposed to improve crop resilience and food security. Therefore, participatory inclusion of stakeholders is key to enhance mitigation acceptance, adoption and long-term sustenance. The resilience measures can improve attitudes towards elephants, minimise crop loss and facilitate coexistence with elephants in communities adjacent to protected areas.

Keywords: Human Elephant conflict, resilience, food-security, vulnerability, crop-raiding

INTRODUCTION

Smallholder farmers in Botswana, particularly those residing in rural areas, depend on agriculture as a source

of income and food. The primary constraints to arable crop production in Botswana include invertebrate pests and



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diseases (Malope *et al.* 2025), rainfall variability (Niles and Brown, 2017), low soil fertility, weeds, and damage by wild animals. In semi-arid areas like Botswana, alternative cropping strategies such as conservation agriculture (Altieri *et al.* 2015) may be coupled with intercropping and crop rotation to benefit subsistence farmers (Baudron *et al.* 2012; Barbieri *et al.* 2017). In some instances, adopting alternative crops or crop diversification (Gaudin *et al.* 2013; McCord *et al.* 2015) are ideal for improving resilience in cropping systems.

In Botswana, communities proximal to protected areas face higher risks of poverty or food insecurity emanating from human-wildlife conflict. This conflict threatens coexistence with elephants but most importantly, agriculture as a whole. Crops damage by wild animals, especially elephants (*Loxodonta africana*), threatens the livelihood of farming communities located near wildlife reserves (Noga *et al.* 2015). For instance, farming areas around the Okavango Delta of Botswana lose over 40% of their annual potential yield to elephant raids (Mosojane, 2004). Similar trends are reported in Asia, where elephants were found to rely significantly on agricultural produce for dietary sustenance rather than natural fodder (Singh and Kumara, 2025). In the eastern Okavango, crop raiding is the most common form of human-elephant conflict (Songhurst, 2017). Unfortunately, recent years have seen a steady growth of elephant herds and numbers in the northern Botswana, Namibia and parts of Zimbabwe, and the increase can only aggravate the already tense human elephant conflict in the areas (Köhler and Bollig, 2025).

In light of the huge elephant numbers in the eastern Okavango, the farming strategies do not seem responsive to the problem, hence, heightened crop loss incidents at farm level within the area. Unfortunately, many traditional and modern deterrents and mitigation methods like electric fences, physical barriers, the use of dogs and flashlights have been widely tried for years (Kiffner *et al.* 2021). However, the methods yielded varying results, though not completely eliminating the elephant crop raiding. Determinations, such as the type of crops grown (Matsika *et al.* 2023), the distance of fields from elephant pathways and water sources (Songhurst and Coulson, 2014), and the history of raiding, have been studied in the eastern Okavango (Songhurst and Coulson, 2014; Nyirenda *et al.* 2018). It is agreeable that just one measure alone cannot effectively predict or reduce elephant crop raiding (Schwarz *et al.* 2025). Other factors such as mitigation acceptance, technical efficacy and sustainability are important (Von Hagen *et al.* 2025). Hence, a need to craft sustainable and socially acceptable approaches for better efficacy and community resilience against elephant raiding (Kei *et al.* 2025).

Consequently, this study believes that proposing or discouraging certain crops to minimise elephant crop raiding should be preceded by understanding the socio-cultural importance of crops to farmers, farmers' willingness to try other crops and reasons underlying

acceptance or rejection of the proposed measures. An understanding of these perceptions in the eastern Okavango panhandle has not been studied to any great extent, especially concerning how elephant crop raiding influences their cropping practices. Moreover, since many measures are boundary enhancers or spatial counter barriers, this study argues that crops and cropping strategies also play a critical role in attracting or deterring elephants to the farms. Hence, understanding farmers' rationale on crop selection and cropping strategies is vital prior to devising any mitigations involving crop manipulation. The objective of the study was to corroborate farmers' perceptions on elephant crop raiding and rationale for crop choices and cropping strategies.

METHODOLOGY

The study covered the six focal villages of Sekondomboro, Mogotho, Mokgacha, Seronga, Gunotsoga and Eretsha, which are located along the eastern Okavango Panhandle (Figure 1). Farmers in this area are rainfed, subsistence farmers. The development status of this area and its poor exposure to commercialised agriculture somehow also dictate the type of arable agriculture (King *et al.* 2016). Farmers in the areas around the Okavango Delta have not relied heavily on technology to improve their production, but rely on livestock-drawn draft power. In addition, human-elephant conflict, particularly elephant crop raiding, is high in this area (Songhurst 2017).

Survey design

A questionnaire was drawn (Appendix 1) and administered by interviewing randomly selected subsistence farmers (Figure 2). A total of 151 randomly selected farmers were interviewed from April 2018 in a survey covering six villages in the eastern Okavango in the Northwest district of Botswana. Respondents were randomly selected from villages along the panhandle and interviews only proceeded after their consent. To avoid bias in approaching respondents, the principal researcher and the Ecoexist community officer alternated in choosing and approaching farmers or households.

The highest number of respondents was from Gunotsoga ($n=38$), followed by Sekondomboro ($n=26$), Eretsha ($n=24$), Mokgacha ($n=23$), Seronga ($n=20$) and Mogotho ($n=20$). The interviews were conducted in English, Setswana and/or the local indigenous language (where an Ecoexist Community Officer assisted with translation). The questions were designed to gain an understanding on: the reasons underlying farmers' choice of crops, planting method, crop layout in the field, seed sources, and perception of susceptibility of crops to elephant raiding. The sample size per village depended on the availability of the farmers who consented to be interviewed.

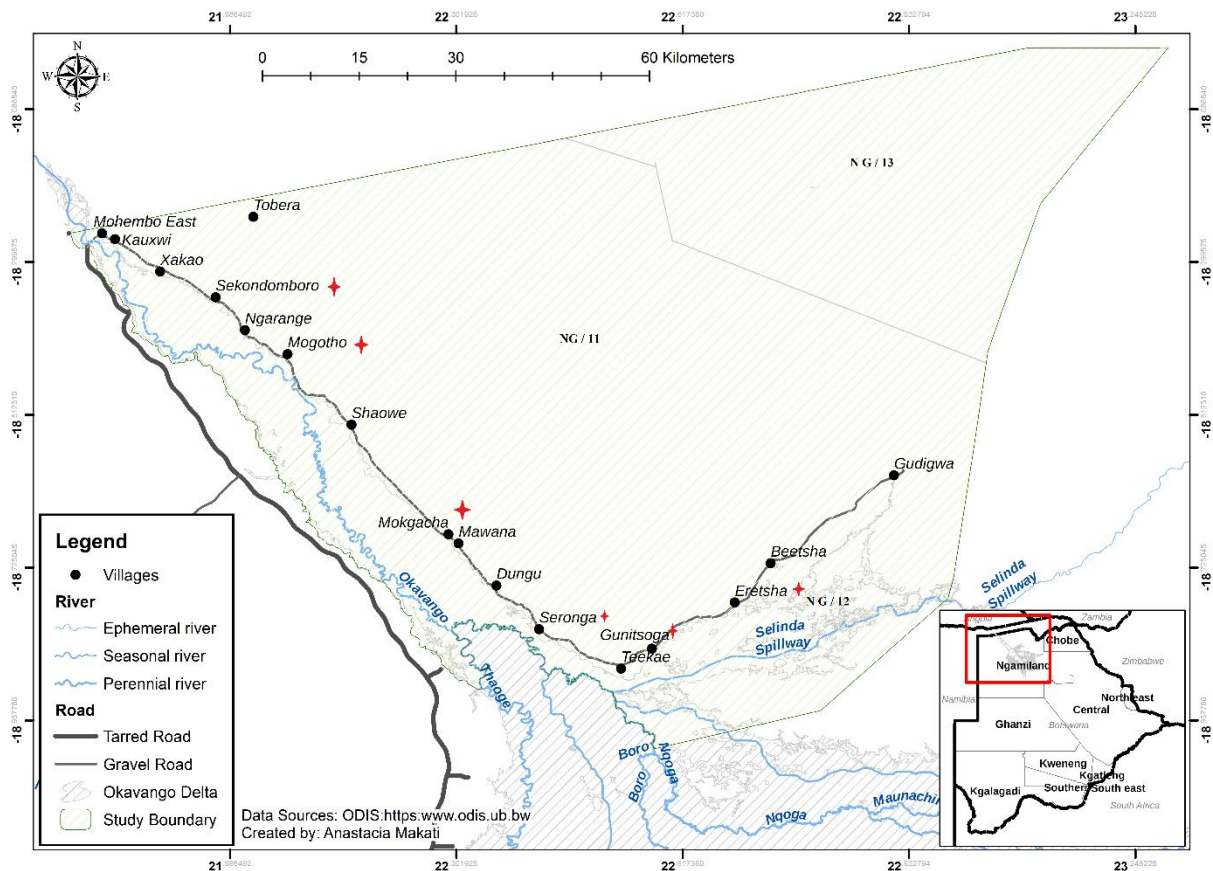


Figure 1: The six villages surveyed along the eastern Okavango are indicated in red.



Figure 2: Interviews with farmers in villages along the eastern Okavango Delta with the help of local Ecoexist officers (photo credit: Ogaufi Maripe).

Statistical analysis

Data were encoded, entered into Microsoft Excel 2013, and analysed using the SPSS statistical software Version 23.0.0. Frequencies and percentage variable occurrences were calculated using basic descriptive statistics such as percentages and correlation at 95% confidence level.

The correlation coefficient was computed as:

$$r = 1 - \frac{6\sum d^2}{n(n^2 - 1)}$$

Table 1: Demographics of farmers interviewed in the eastern Okavango.

Category	Summary of responses (%)
Gender	
Males	28.5
Females	71.5
Age (years)	
≤ 30	6.62
31-40	24.5
41-50	32.4
51-60	15.2
60 ≤	17.2
Unknown	4.08
Household	
Married	30.5
Not married	69.5
Arable agriculture is a primary source of income	86.1
Arable agriculture not a primary source of income	13.9
Farm perceived far from the homestead	53.0
Farm perceived close to homestead	47.0
Labour	
With labour assistance	72.8
Without labour assistance	24.5
Mechanised farming	0.00
Oxen draft power	100.0

**Figure 3:** Manual hand sowing (left) and row planting using oxen draft power (right) in the eastern Okavango.

RESULTS

Demographics of the farmers surveyed in the Eastern Okavango

All the 151 randomly selected farmers' demographics significantly varied along the study site ($P=0.02$). The results suggest that more females (71.5%) than males (28.5%) practise crop production in this region. The mean age of respondents was 47 years, ranging between 21 and 88 years, but six respondents did not know their age (Table 1). Respondents' age did not have any significant association with other variables, such as the adoption of alternative crops, attitude towards elephants, method of planting or choice of crops (Appendix 2). Most farmers (86.1%) considered the products of arable agriculture as their primary source of income. None of the farmers

interviewed practised tractor-powered mechanised farming, but instead used the traditional method of ploughing with oxen draft power (Figure 3). Most respondents (72.8%) said they have assistance with labour, and many (53%) reported that their farms were far away from their homes. Farmers who had assistance with labour were significantly less likely to consider their farm far from home ($P<0.0001$) and similarly less likely to consider elephants a problem ($P=0.02$) (Appendix 2).

Most farmers in the Eastern Okavango use seeds from multiple sources

Overall, almost 72% of farmers in the eastern Okavango region of Botswana used seeds from the government. Most farmers (77.5%) used seeds from a combination of sources in any single season (Table 2), including their own

Table 2: Source of seeds for farmers in the eastern Okavango.

Single source	34	22.5%
Government	6	4.0
Own seed	20	13.2
From families and other farmers	7	4.6
Non-Governmental Organisations (NGOs)	1	0.7
Combined Source	117	77.5%
Own seed and Government	72	47.7
Own seed and NGOs	3	2.0
Own seed and bought from retailers	6	4.0
Government and retailers	8	5.3
Government, own seeds and family	23	15.2
Own seed and families	5	3.3
Total	151	100.0

Table 3: Farmers have different reasons for their seed source preference.

Reason for seed source	Number of farmers	Percent (%)
Government provides early maturing varieties	26	17.2
Government seed comes late	22	14.6
Government seed is often not sufficient	20	13.2
Farmers prefer traditional landraces	20	13.2
Government seed is free	18	11.9
Did not qualify for Government seed	17	11.3
Seeds from government are available	12	7.9
Lack of experience in crop farming	1	7.0
Government seed is viable and treated with pesticides	8	5.3
Lack of seeds after crop raids by elephants	5	3.3
Preference for a particular variety	2	1.3
Total	151	100

stored seeds combined with seeds from the government (47.7%), or their own seeds, seeds from the government, and seeds obtained from family members (15.2%). Only 22.5% had a single source of seeds, in which case most of them (13.2%) used their own seed. The reasons farmers used particular seed sources varied (Table 3). A high proportion of farmers said they used Government seed because the varieties mature early (17.2%) or because it is free (11.9%). In contrast, many respondents said that Government seeds arrive late (14.6%), are often not sufficient (13.2%), that they did not qualify for Government seeds (11.3%), or they prefer traditional landraces (13.2%). Neither gender ($P=0.18$) nor age ($P=0.12$) were significantly associated with the choice of seed source (Appendix 2). Even though most farmers (83%) said that the seed source does not influence crop damage from elephant raids nor influence yield (42.4%), a few farmers (11.3%) believe that their traditional seeds produced higher yields compared to other seed sources. However, the seed source significantly influenced whether farmers planted early maturing varieties or not ($P=0.02$). Most farmers (71.5%) had used early maturing varieties at least once and these varieties were reported to suffer less elephant raiding and have higher yields, with 76.2% and 51.0% of farmers, respectively.

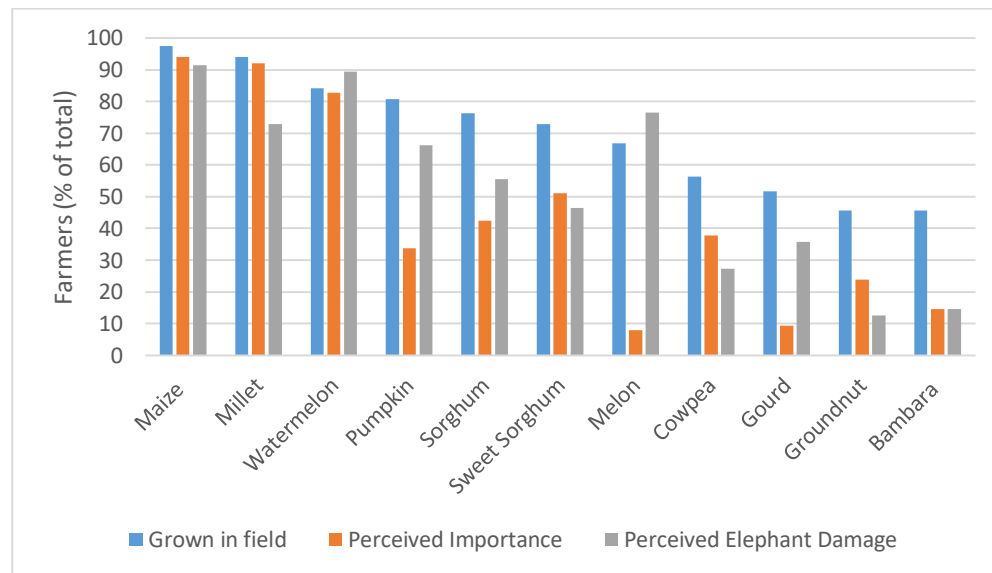
Method of planting

All the respondents reported attempting to change from traditional planting methods (broadcasting) at some point.

The planting methods included broadcasting (the traditional method), row planting and conservation agriculture, which mainly involves ripping and planting in basins. The most commonly used method was row planting: 56.3% of farmers solely used this practice, and the remaining had combined it with conservation agriculture and/or broadcasting (Table 4). The majority of farmers (90.7%) who tried row planting continued to use this method, whereas 47.1% of the farmers who tried conservation agriculture discontinued this practice. Many farmers (72.2%) said that row planting produced higher yields than broadcasting, whereas 17.2% said that row planting and broadcasting gave the same yields (Table 4). Only 9.3% of farmers said that yields from broadcasting were higher than from row planting; hence, 37.1% of respondents were still broadcasting seeds during planting. Even though farmers (6.0%) found elephant damage similar, many (54%) claimed that row-planted crops suffered more damage from elephants than broadcasted crops (37.7%) (Table 4). However, only 35.8% attempt to strategically place their crops during planting, whilst 64.2% do not believe that crop layouts or arrangements can be raided differently. Farmers provided various reasons for rejecting or abandoning new planting. Many farmers said that row planting wasted space (50%) or they had not received continued input on row planting from the Government or Non-Government Organizations (42.9%). In contrast, farmers frequently discontinued conservational agriculture because it was tiring and laborious, or because they thought traditional crops did not need new methods,

Table 4: Methods of planting used by farmers in the eastern Okavango.

Method of planting	Number of farmers	Percent (%)
Methods used		
Row	85	56.3
Row+CA	10	6.6
Row+broadcasting	53	35.1
Row+CA+broadcasting	3	2.0
Do you still practice row planting?		
Yes	137	90.7
No	9	6.0
Sometimes	5	3.3
Do you still practice conservation agriculture?		
Yes	5	29.4
No	8	47.1
Sometimes	4	23.5
Perception of yield		
Higher with row planting	109	72.2
Higher with broadcasting	14	9.3
Same with all	26	17.2
Not sure	2	1.3
Perception of elephant damage		
Higher with row planting	81	53.6
Higher with broadcasting	57	37.7
Same with all	9	6.0
Not sure	4	2.6

**Figure 4:** Type of crop categorised by farmers who choose to grow it (blue), perceived importance for livelihood (orange) and perceived elephant damage (grey). X axis: crop type, Y axis: percentage of farmers in the eastern Okavango Panhandle

hence their lack of inclination to adopt these new methods. Neither the gender ($P=0.33$) nor the age of farmers ($P=0.17$) significantly influenced their current planting method (Appendix 2). However, the seed source significantly influenced the method of planting ($P=0.02$), and their willingness to change methods ($P=0.007$) (Appendix 2).

Farmers' choice of crops

Food or consumption was a major determinant of which crop to grow (76.16%), followed by consumption and

selling surplus (11.26%), exchange (6.62%), and lastly, seed availability (5.96%). We found that the farmers in the eastern Okavango grew multiple different types of crops (Figure 4). Maize was the most common crop followed by millet, watermelon, pumpkin (*Cucurbita spp.*), grain sorghum, sweet sorghum (*Sorghum saccharatum* (L.) Pers.), melon, cowpeas (also known as black-eyed peas, *Vigna unguiculata* (L.) Walp.), gourd (*Lagenaria siceraria*), Bambara groundnut (*Vigna subterranea* (L.) Verdc.), and groundnut (also known as peanuts, *Arachis hypogaea* L.). Cumulatively, more than half of the farmers (59.6%) reported that cereal crops experience more elephant

damage than legumes (Figure 4), whereas 23.2% said both legumes and cereals are damaged to the same extent and 17.2% said that legumes suffer more raiding than cereals. In order of severity, farmers reported that they experienced more damage to maize, watermelon, millet and melon compared to other crops, and a small proportion reported elephant raiding damage to Bambara groundnut and groundnut (>15%) (Figure 4). Unfortunately, most farmers also responded that maize, millet and watermelons were the most important crops for their livelihood, followed by sweet sorghum and grain sorghum. Less than 25% of farmers considered groundnuts, Bambara groundnut, and gourd as essential to their livelihoods (Figure 4).

Perceptions and attitudes of farmers with regard to elephant crop raiding

Almost all the respondents (95.4%) had suffered crop loss at some point due to elephant crop raiding. However, other animals also reported to commonly raid farms, included porcupine, cattle, and duiker (Table 5). The majority of farmers (79.5%) described crop raiding by elephants on their farms as a major habitual problem, whereas 19.2% described it as occasional. As a result, farmers (73.51%) displayed an aversion for elephants (Figure 5), but neither previous raiding experiences ($P=0.46$), age ($P=0.37$) nor gender ($P=0.49$) significantly associated with their attitudes towards elephants (Appendix 2).

Although 95.4% of respondents reported elephants as the leading problem animal in terms of crop loss, other animals also raid crops in the eastern Okavango (Table 5). The major non-elephant raiders identified were porcupine, cattle, and duiker. Elephant crop raiding reportedly occurred during the ripening (38.0%) or flowering stage (32.5%), more (Table 5). Only 1.3% reported elephant raiding at the seedling stage, although 18% said that elephant raiding occurred at all stages of crop growth. Almost 80% of farmers stated that elephants never raided their crop storage facilities (Table 6).

Farmers were willing to grow new crops (87.4%) and to adopt new planting methods (84.1%) that are believed to be less susceptible to elephant raiding (Table 6). More women (70.87%) were willing to adopt new planting methods than men (29.1%). Intriguingly, gender ($P=0.00$), labour availability ($P=0.04$), and seed source ($P=0.01$) significantly correlated with the farmer's willingness to adopt new planting methods (Appendix 2). In contrast, age did not influence the willingness to adopt new cropping methods for either males ($P=0.32$) or females ($P=0.45$).

DISCUSSION

Crop production is the primary source of livelihood in the eastern Okavango region of Botswana. However, we found that farmers in eastern Okavango do not use any machinery despite the objectives of the Botswana Government's Integrated Support Programme for Arable

Agriculture Development (ISPAAD), which was to assist farmers with subsidies on mechanisation and other necessary farm inputs (Marumo *et al.* 2014). Unfortunately, ISPAAD subsidies do not reach the eastern Okavango, primarily due to infrastructure challenges such as a lack of proper roads, fuel stations, mechanical workshops and suppliers. The use of traditional methods reduces the efficiency of farm operations in many parts of sub-Saharan Africa (Oluwole and Odogola 2018), resulting in minimal yields despite farmers' hard work and efforts.

Our data suggest that more women than men are crop farmers in the eastern Okavango. The findings are consistent with cultural role allocation in families in Botswana as reported by CSO (2011). Traditionally, men look after cattle, whereas women work in crop fields. Many youths and able-bodied community members prefer to work in the tourism and hospitality industry rather than in the fields. Hill and Vigneri (2014) also reported female dominance in arable agriculture, especially in rural communities of Uganda and Ghana. In that study, the women were reportedly focused on cash crop production and sales. However, the women in the eastern Okavango do not focus on income generation, rather on food production for household consumption. Bahta *et al.* (2019) recently reported that empowering women in farming significantly reduced food insecurity in South Africa, and this can also be the case in the eastern Okavango, where women lead arable farming.

Household food preference determines crop choice

The study found that the farmers in the eastern Okavango grew diverse crops per season. Mainly, cereals and fruit are more preferred despite these crops being similarly preferred by elephants (Monney *et al.* 2010; Jadhav and Barua 2012). It is common that farmers often prioritise and grow crops that provide for their staple food needs to satisfy their traditional dietary needs (Allara *et al.* 2012). However, this diversity reflected household consumption needs, rather than a strategy to improve soil fertility or mitigate elephant crop raiding. As in other regions, the farmers in the eastern Okavango similarly grew crops densely to attain a better harvest for household sustenance (Lithourgidis *et al.* 201).

In addition, farmers whose choice of crop was influenced by both "consumption and sale" grew the conventional staple crops rather than cash or alternative crops, which are perceived as undesirable by elephants. The sale of produce is mainly done as a containment strategy, only when they have harvested more than they can consume or store. This finding is consistent with Zakaria (2017), who also found that a small proportion of respondents sold or exchanged only when there was excess produce. Similar findings by Songhurst (2023) reported subsistence and household consumption as a major driver for growing a particular crop rather than growing for sale. In this regard, elephant raiding does not influence the choice of crop in this area, but the food and traditional cuisine do.

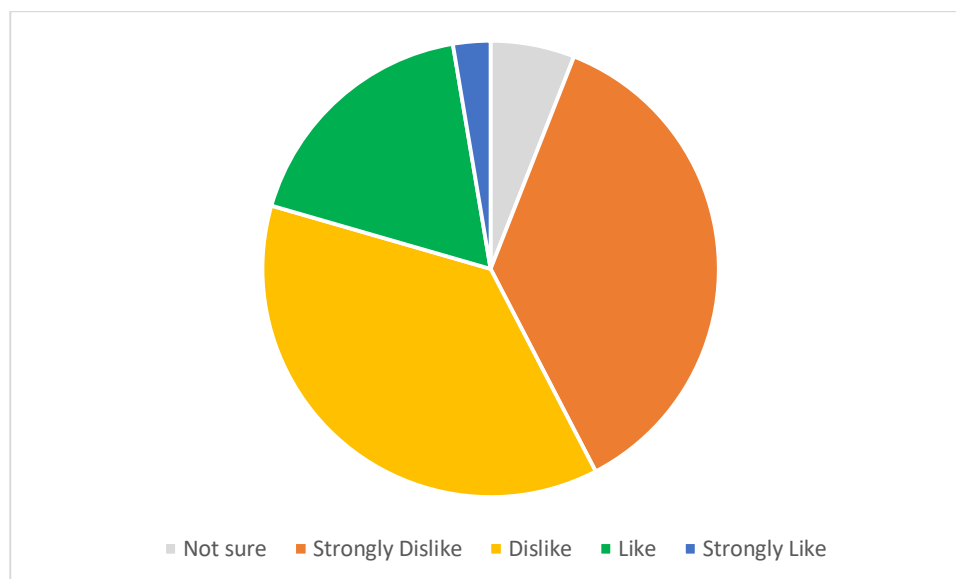


Figure 5 Attitude of farmers towards elephants.

Table 5: Farmer reports of animals that raid crops in the eastern Okavango.

Type of Animal	Number of Farmers	Percent
Elephants	144	95.4
Porcupine	83	54.97
Cattle	34	22.52
Duiker	33	21.85
Springhead	8	5.30
Antelope	6	3.97
Monkey	5	3.31
Hippo, francolin	3	1.99
Duck	2	1.32
Livestock, skunk, rat, rabbit, squirrel, pigeon, striped polecat, jackal, birds	1	0.66

Table 6: Farmers' reflection on crop raiding and willingness to adopt measures.

Perceptions of elephant crop raiding	Percent (%)
When does raiding occur	
At seedling stage	1.3
During ripening	38.0
Flowering	32.5
After maturity	9.9
All stages of growth	18.3
Damage to stored produce	
Storage facilities never raided	79.5
Storage facilities raided	20.5
Willingness to try new crops	
Willing	87.4
Not willing	10.6
Undecided	2.0
Willingness to try new planting methods	
Willing	84.1
Not willing	11.3
Undecided	4.6

In this study, seed availability from various sources significantly influenced the crop planted and whether it was row planted or broadcast. In particular, farmers collected seeds from the government simply because they were available and free. However, government seeds came with a no-broadcasting condition; therefore, row planting and

constant monitoring from extension officers were required. The justification also implies that some of these could have been collected but not planted. Most farmers reported using a combination of Government seeds and their own seed reserves from the previous harvest. This diversity of seed sources is important for improved crop yields

(Godfray *et al.* 2010), which is also critical in ensuring food security for farmers. Although early maturing varieties were not intended to reduce incidents of elephant crop raiding, they were given to farmers to mitigate the impacts of shortened rainy seasons and droughts, farmers benefit from the windfall outcome of harvesting before the elephant raid intensifies (Matsika *et al.* 2024). In Mozambique, many of the early maturing varieties reportedly evade crop raiding better than traditional varieties (Rusinamhodzi *et al.* 2012) and lead to improved yield (Fischer and Connor 2018).

Despite the government providing seeds with superior yield characteristics and early maturity, a few farmers still opted to augment with their traditional varieties. Among the several justifications provided by farmers, government supply systems failing to meet the seed demand for different crops, seeds being delivered late or lacking crops that they needed, influenced the seed sources and combinations. In the eastern Okavango, short rainy seasons and long dry spells worsen crop raiding by elephants (Mosojane 2004). Since farmers in the area grow early maturing varieties ostensibly to evade harsh extreme weathers rather than elephant raiding (Müller *et al.* 2011), farmers may lose this benefit if early maturing seeds are planted late. The delay can lead to farmers only depending on their traditional varieties, thus increasing vulnerability due to the prolonged stay of crops on the farms.

Respondents observed crop raiding mostly at the flowering and ripening stages, irrespective of the seed source. These stages coincide with the period when natural forage has deteriorated in quality, making crops a better alternative (Monney *et al.* 2010; Singh and Kumara 2025). In areas prone to elephant raiding, it is important to ensure that crops reach flowering and ripening stages before natural forage deteriorates. Conversely, farmers believe these stages are vulnerable because elephants can see their crops from afar. In lots of instances, elephants visit their farms to check if the crops are ripe, at which during this ripening stage, the bulls bring the whole herd to consume the crops. Gayo (2025) reported that elephant crop depredation is mainly limited to live crops in farms, not harvested produce. These findings were also proven true in our study area, as the majority of the farmers attested to elephants not raiding their storage. Consistent with this, we found that only 20.5% of farmers encountered elephant attacks on their storage facilities. Overall, these findings suggest that early maturing varieties, planted early, represent a potential mitigation strategy for harvesting before natural forage deteriorates and produce is stored in storage facilities before the dry season, where elephant raids escalate.

This study appreciated that the use of these hybrid varieties strips farmers of their self-reliance, a reason that farmers also provided upon further probing during interviews, mainly because they cannot be kept as seed for next season. The yearly need to source seed can be financially demanding and leave farmers in a lot of

uncertainty during cropping seasons (Guei *et al.* 2011). The hybrid seeds also require other agronomic inputs to achieve their full potential, which was not feasible for many smallholder farmers (Choudhary *et al.* 2025), similar to the eastern Okavango. On the contrary, traditional varieties offered an economic advantage and reliability because they are often mutually shared within families or communities and they generate seed supply for the next growing, successive cropping seasons with little to no deterioration in quality and yield (Warburton *et al.* 2010), are adapted to local conditions, and do not require agrochemical use. Hybrids were reported as expensive and technically challenging, an obstacle for financially challenged smallholder farmers (Guei *et al.* 2011). Nevertheless, traditional or informal seed systems ensure sufficient seed supply to many farmers in Africa (Deu *et al.* 2014), similar to the reliable informal seed system within the community in the eastern Okavango.

Farmers' willingness to adopt new crops or cropping strategies varied in this study. Justification varied from farmers explaining that they and their families did not like the proposed alternatives, or they did not have household use for the proposed additional crops. Such responses imply that farmers would consider mitigation measures that are pivoted on or protect their preferred important crops from elephant damage rather than a completely different crop. Our findings align with Owen *et al.* (2024), who reported low alternative crop adoption rates influenced by local misconceptions on how the elephants will respond to the proposed alternative crops and limited confidence on the crop reducing elephant raiding in Asia. Moreover, farmers who changed from the traditional broadcasting to either row planting or conservation agriculture methods, reverted to broadcasting because they perceived row planting as wasting space or found newer methods to be exhausting and laborious (Kashe *et al.* 2023). For instance, 53.6% of farmers attributed significant elephant damage to row planting, with some respondents suggesting that row planting led to easier, organised feeding by elephants as they just follow the rows. Another 8.4% of farmers strongly believed that traditional crops do not need new planting methods. Hence, farmers only row planted when using seeds obtained from government and ceased row planting if they used their own seeds. They decried a feeling of ownership of their crops and way of cropping rather than the constant supervision by extension officers, which they equated to forced adoption and policing. Thus, farmers' compliance was often temporary, leading to failure in long-term sustenance. This mismatch was also identified by Kei *et al.* (2005), highlighting community-inclusive, local knowledge utilisation and community ownership as enhancing uptake and sustainability of mitigation measures. These negative perceptions can make it impossible and discourage farmers from adopting newer measures.

Many farmers in the eastern Okavango area discontinued using row planting and conservation

agriculture, depicting an overreliance on the free Government provisions, which is pronounced in our study area. For instance, 44.9% of farmers ceased practising conservation agriculture because they were not provided with new inputs when the first tools provided were no longer usable despite possessing new technical knowledge. Conservation agriculture can be beneficial on highly sophisticated farms (Giller *et al.* 2015), but disappointing when introduced to smallholder farmers (Findlater *et al.* 2019). This also emphasises that the adoption and sustenance of strategies is highly dependent on their complexity and cost (Hedges and Gunaryadi 2010), and it is difficult for farmers to adopt and sustain practices that do not provide immediate benefits (Mayberry 2015; Gunaryadi *et al.* 2017). Unfortunately, in this regard, benefits from sustainable practices such as conservation agriculture often take time (Vanlauwe *et al.* 2014).

Although farmers are the major stakeholders in the adoption and success of mitigation measures. They are often left out in the crucial steps before implementation (Noga *et al.* 2017), and the exclusion can complicate the acceptance and adoption process. We found that 64.2% of farmers randomly place the different crops they grow simultaneously, without considering elephant raiding. They argued that elephants are very intelligent and determined, and that they could not strategically place or hide crops from elephants. Reliance on strong perceptions as such may further aggravate the non-acceptance of proposed measures (Kansky and Knight 2014). In alignment with our study, Zhao *et al.* (2025) reported that farmers who experience a higher risk perception from elephants respond by reducing agricultural capital inputs. However, the reduction only reduces land use efficiency and compromises the farmers' socio-economic status rather than reducing HEC (Zhao *et al.* 2025). These rigid livelihood systems of farmers (Kolawole *et al.* 2016) and perceptions actively hinder the farmers' flexibility in adopting new mitigation measures and planting methods, such as using deterrence buffer crops or growing important crops further from easy elephant access. Findings indicating the success of protecting important crops with buffer crops yielded desirable results (Matsika *et al.* 2023).

Even though elephants damage crops, other animals such as porcupines, cattle and duiker were reported as important pests in crop raiding. In the eastern Okavango, elephants cause over 40% of crop damage compared to other wildlife species (Mosojane 2004). Mayberry *et al.* (2017) reported that farmers developed a dislike for elephants as a result of human-elephant conflict. Most of the surveyed farmers disliked elephants and said that crop raiding by elephants was habitual and a single elephant raid causes severe damage (Gayo 2025) compared to other species. Nijman and Nekaris (2010) reported that many farmers who experience crop raiding became intolerant of wildlife and conservation-associated initiatives. Although other reports and Kansky and Knight (2014) reported that previous experiences of elephant

raiding determined attitudes, we found their findings not true in our case since farmers' negative attitudes towards elephants were not significantly associated with prior raiding experience. The findings highlight a need for tailor made community mitigations (Schwarz *et al.* 2025). Our findings align with Songhurst (2023), who equally emphasised that an array of direct and indirect factors, rather than one factor, influences people's attitude towards elephants. In the case of this study, some farmers disliked elephants for having killed their relatives. However, the attitude balances off, especially when people appreciate elephants as a source of employment for the youth and the able-bodied in their community and families.

Conclusion

Crop production is an integral contributor to source of income and food for farmers in the eastern Okavango. Household food preferences and free seed cost influenced crop selection, which was primarily maize, millet, and watermelon. These crops are the same crops that farmers incurred more elephant raiding on. Over 95% of farmers have actually lost crops to elephants at some point. However, these actual losses, and perception of damage or yield does not influence farmers' choice of strategic planting methods or adoption of new crops based on their perceived elephant resilience. Although many farmers attempted to change from broadcasting, the sustenance of the mitigation was determined by the continued supply and provision of inputs. Our work emphasises the significance of perceptions in attitude formation, hence impacting the adoption and duration of the sustenance of proposed mitigation measures. Crafting of mitigations needs to be inclusive and participatory in order to increase ownership, trust, and long-term sustenance of proposed resilient measures. Otherwise, the mitigation strategies can be ineffective if they do not consider local livelihood attributes, such as food, cultural practices, social significance of the crop, costs, as well as farmers' expectations and efforts. Consequently, culture, beliefs and perceptions seem to be important aspects as they tend to influence and lead to the adoption of proposed crop and cropping patterns. To this end, mitigation studies need to focus equally on the often hard and mainly neglected people issues as we focus on scientific-technological issues. Successfully weaving these social aspects into mitigations will potentially improve smallholder farmers' resilience to elephant crop raiding, enhance food security and rural livelihoods.

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Conflicts of interest

The authors declare no conflict of interest associated with this work.

Data availability statement

The data for this manuscript are stored at Botswana University of Agriculture and Natural Resources Library, Gaborone, Botswana and Ecoexist Trust offices in Maun, and deposited in the Mendeley repository.

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Appendices

1. Introduction of the principal researcher and a brief background on the work.
2. Seek consent
3. If agreed, explain the respondent's rights during and after the session.

Appendix 1. Questionnaire used for data collection

Questions	Variable name	Variable label	Variable type	Data values
Demographic				
	Name	Name of the Head of the household:		
	Village Head	Name of the village head of household is from		
	Fields	Name of the farming area		
	Gender	Gender of the respondent		1. Male 2. Female 3. Other
	Age	Years	Numerical	
	Marital	Marital status of the respondent		1. Married 2. Divorced 3. Separated 4. Other
	Labour capacity	Distance from village/house to farm Do you have anybody to help you in the fields?	String	1. Yes 2. No
	Mechanization	Do you own or use advanced tools or machines do you have		3. Yes, list 4. No-Oxen
Crops and farming strategies				
		What crops do you normally plant?		
		Reason?		
	Source	What was the source of the seeds?		Government subsidies Bought: SeedCo etc., Supplied by someone, e.g relative, friend etc
		Why the source/preference provided in Q2.2?		
		Do elephants damage the seeds from these sources differently?		Yes: More or less
		Is the quality & quantity of the harvest different?		No, it is the same
Cropping Systems & implications				
		How have you been planting your seeds:		1. broadcasting, 2. row planting, 3. CA basins, ripping etc.
		If answered 1 at Q3.1:		Yes
		Have you ever tried changing from the traditional planting methods?		No
		To conventional methods such as CA (basins, ripping), row planting, early planting etc.		
		If answered 2 or 3 at Q3.1:		
		How long have you experimented on them?		
		If answered 2 or 3 at Q3.1:		Yes
		Are you still practising?		No
		If answered no at Q3.4, Why?		
		Was the harvest more/less from the previous cropping strategy?	String	Yes: More or less No, it is the same
		Were the damage or loss incidences more or less?	String	Yes: More or less No, it is the same
		Have you tried early maturing varieties?		1. Yes 2. No

Table 1 Contd.

	Was the harvest more/less from the late maturing varieties? Do you think early maturing varieties efficiently reduce crop raiding?		Yes: More or less No, it is the same 1. Yes 2. No
Elephants and Crop damage			
	Which crops did elephants damage in your field?		List: 1.Maize 2. Sorghum 3.Millet 4.Beans 5.Cowpeas 6.Groundnuts 7.Sweet sorghum 8.Watermelons 9. Pumpkin
	At what stage was your crops on (i.e. size prior to damage event)		1. Seedling - if the crop is at a very early stage up to just before flowering 2. Intermediary - if the crop is on flowering or transition between vegetative and fruiting stage 3. Mature - if the crop had started bearing fruits, ripening and already ripe
	Were neighbouring fields were raided?		1. Yes 2.No
Alternatives	Apart from elephants, are there other animals raiding your crops?	List	1. Yes 2. No 3. Other
Elephants	Do you have any problems with elephants Has your farm been raided before?		1. Yes 2. No 1. Yes 2. No
	How many times were you raided in a year? (Focused on the last 3yrs) Would you say it habitual or it happens once in a while? Have they raided your harvest storage? What was in it?	Number	
Willingness to change			
	Which crops are the most important to you?		List: 1 Maize 2. Sorghum 3.Millet 4.Beans 5.Cowpeas 6.Groundnuts 7.Sweet sorghum 8.Watermelons 9. Pumpkin
	Are you willing to try new crops, even cash crops –ginger and chilli, safflower etc.? If answered No at Q3.2: Are you willing to try new cropping systems (mixes, sequence & layouts) e.g. Conservation agriculture – basins, ripping etc? Why?		Yes No, why? Yes No
	Which crops damage more upon, the comparison between legumes (beans) & cereals (maize, millet, sorghum)		Legumes Or Cereals
	Do elephants raiding influence the way you arrange and place crops in the field?		Yes No

Appendix 2. Summary Output for Pearson's Correlation

Factors	n	Coefficient	P value
Age vs. adoption of new crops	151	0.04	0.32
Age vs. adoption of new cropping systems	151	0.05	0.27
Age vs. tolerance to elephants	151	0.27	0.37
Age vs. method of planting	151	0.79	0.17
Age vs. choice of crops	151	-0.01	0.47
Age vs. seed source preference	151	0.96	0.12
Age vs. row planting continuity	151	0.05	0.29
Age vs. CA continuity	151	-0.06	0.23
Gender vs method of planting	151	0.36	0.33
Gender vs seed source	151	0.76	0.18
Available labour vs distance	151	-0.29	0.00
Available labour vs tolerance to elephants	151	0.17	0.02
Seed source vs method of planting	151	-0.18	0.02
Seed source vs adoption of new cropping systems	151	-0.16	0.00
Available labour vs adoption of new cropping systems	151	-0.12	0.65