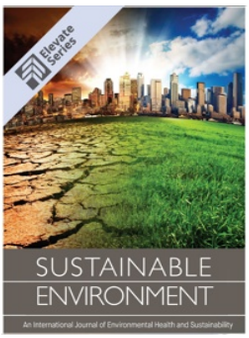

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Exploring knowledge, attitudes and practices of farmers at the edge of Budongo forest on agrochemicals usage

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ABSTRACT

Due to the challenges associated with weeds, pests, and diseases, farmers in Uganda at the edge of wildlife-protected areas are increasingly using agrochemicals to boost production. This study aimed at assessing agrochemical usage at the edge of Budongo Forest and determining farmers' perspectives regarding their use. A cross-sectional study was conducted, and 472 farmers were interviewed about their knowledge, attitudes, and practices related to agrochemical usage. The majority of respondents (96.4%) were knowledgeable about agrochemicals, and 84.1% were actively using them for spraying plants, killing weeds, poisoning rodents, and fertilising soils. The utilised agrochemicals were herbicides (dicamba salt and 2,4-D, glyphosate, glyphosate ammonium, sulfentrazone), pesticides (abamectine, dimethoate-30%, chlorpyrifos, lambda-cyhalothrin 5 % +imidacloprid 15 %), and fertilisers (NPK, NPK + trace elements-Mg, Fe, Zn). Education, readiness to promote agrochemicals, availability of training courses, and abuse of agrochemicals were all characteristics that were found to have a significant correlation ($p < 0.05$) with the usage of agrochemicals. Most farmers (76.1%) purchased agrochemicals from retailers, and the rest from other sources. Generally, farmers (78.80%) had a favourable attitude towards the use of agrochemicals, since they are tremendously useful for improving productivity, but warned that they also contain the potential to cause major harm to people, animals, and the environment when not handled correctly. They therefore emphasised the safe handling, storage, application, and disposal of agrochemicals.

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KEYWORDS
Knowledge; attitudes; practices; farmers; Budongo Forest; agrochemicals

1. Background

Agrochemical is a generic name given to chemicals such as fertilisers, pesticides, insecticides, fungicides, rodenticides, nematicides, commodity chemicals, and some on-farm veterinary products, used in agriculture to improve or protect crops and livestock (Aktar et al., 2009; Sankoh, 2016; Sharma et al., 2019). Agrochemicals are extensively used in modern agriculture and are an effective and economical way to enhance the yield quality and quantity, thus ensuring food security for the ever-growing population around the globe. More than two million tonnes of pesticides are utilised annually worldwide, where China is the major contributing country, followed by the USA, and Argentina (Sharma et al., 2019).

Although it is claimed that Africa is one of the continents that uses the lowest quantity of agrochemicals in farming, the usage is steadily growing (Demi & Sicchia, 2021), since farming is geared towards high crop and animal yields, which they believe can be attained by control of pest by using conventional agrochemicals as opposed to traditional practices. Herbicides and insecticides are the two most dominant categories (Pouokam, 2019). Even if it is true that agrochemicals are used in small quantities by stakeholders (farmers), the frequency and irrationality of their use, as well as overuses and misuses, constitutes serious factors of exposure and health risks (Damalas & Eleftherohorinos, 2011; Demi & Sicchia, 2021). It should also be noted that there is an increase in commercial agricultural enterprises in Africa (Haggblade et al., 2021), evidenced by cutting down of forests to construct large crop farms such as sugarcane, tea, cocoa, coffee and livestock farms which all use synthetic agrochemicals for pest control.

Agrochemicals are beneficial for increased production, but indiscriminate and continued extensive use can pose serious consequences because of their bio-magnification and persistence in nature. Numerous agrochemicals directly or indirectly affect the environment (air, aquatic

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and terrestrial), animal and humans (Damalas & Eleftherohorinos, 2011; Devi et al., 2022; Pathak et al., 2022). Even though some agrochemicals such as pesticides are sprayed on land, or directly to plants, many times, they find their way into a natural water source, such as a stream, swamp, river, lake or pond, consequently, in large amounts causing morbidities and mortalities of aquatic life. Bio magnification nature of agrochemicals poses danger to consumers of aquatic creatures, plants, and ground water (Aktar et al., 2009; Muzafar et al., 2021).

Several research studies have been conducted to examine the knowledge, attitudes, and practices of farmers in relation to agrochemicals. The aforementioned studies have demonstrated a significant enhancement in the understanding of farmers, a favourable disposition towards the utilisation of agrochemicals, and the implementation of diverse associated practices (Rostami et al., 2019). Despite the proliferation of knowledge and the prevalence of positive attitudes, a significant number of farmers continue to engage in risky behaviour and misuse agrochemicals. Furthermore, there exists a subset of farmers who neglect to utilise personal protection equipment during the process of mixing and spraying agrochemicals (Mohanty et al., 2013).

In Uganda, the use of agrochemicals has increased in recent years mostly as a result of increase of smallholder farms and commercial agricultural enterprise units in the country. As such, the frequency of use and promotion of agrochemicals is on the increase (Andersson & Isgren, 2021; Okonya & Kroschel, 2015; Taylor, 2013). The Lake Victoria Environmental Management Project (LVEMP) and other international investigators revealed gross abuse and misuse of agricultural chemicals in Uganda. Even many banned compounds are being utilised by untrained persons while adulteration of some by mixing to generate stronger formulations is also frequent (Semalulu et al., 2005). A number of banned organochlorinated pesticides (e.g. dichlorodiphenyltrichloroethane-DDT, endosulfan, dieldrin and lindane) were detected in air showing that they may still be in use in the Lake Victoria basin (Semalulu et al., 2005), and probably in many parts of the country. Because of the increasing availability and accessibility of agrochemicals in Uganda, some individuals/farmers with agricultural enterprises near wildlife protected areas are using them as a silent, cheap, easy, and effective method to poison wildlife which are considered to pose a threat to crop yield and animal production (Ogada, 2014).

There however exists a dearth of up-to-date data pertaining to the utilisation of agrochemicals by agricultural practitioners, particularly those operating in close proximity to wildlife-protected areas. Furthermore, Uganda's legislative requirement for regulating the use of chemicals lacks enough ability to monitor and evaluate hazards in accordance with the World Health Organisation's (WHO) minimal standards (Maigetter et al., 2015). Therefore, continuous research to avail more relevant information regarding agrochemicals is necessary, since their indiscriminate use may be the next countrywide hazard affecting domestic animals, wildlife, humans, and the environment. Hence, the present study was undertaken with the objective of investigating the viewpoints of farmers residing in the vicinity of Budongo Forest regarding the utilisation of agrochemicals.

2. Materials and methods

2.1. Study area

The study area was conducted in villages that are at the edge of Budongo forest landscape (Figure 1) located in Masindi district. Budongo Forest is a moist, semi-deciduous tropical rain forest located at the top of the Albertine Rift, situated between 1° 37 N – 2° 03 N and 31° 22–31° 46 E. It is classified as a Central Forest Reserve and comprises 435 km^2 of continuous forest cover, which is large by Ugandan standard.

2.2. Study design and sampling strategy

This was a cross-sectional study. Sampling of the households was done systematically by identifying the landmark from where the first house was chosen, thereafter, picking every 3rd household. The respondents were selected based on their economic activity (sugarcane producers, smallholder farmers), nearness and accessibility to Budongo forests reserve.

2.3. Sample size determination

The sample size was determined according to the Andrew fisher's formula (Jung, 2014);

$$n = \frac{Z^{2pq}}{E^2}$$

Where; n is the sample size, Z is the z-score, p is the standard deviation, q is (1-p), E is the error of margin (confidence interval)

Taking; P to be 0.5, q = 0.5, with the confidence level of 95%, the Z score will be 1.96. Confidence interval (margin of error) of 5% = 0.05

Therefore; $n = \frac{1.96^{2*0.5*0.5}}{0.05^2}$

$= 384.16$

$= 385$

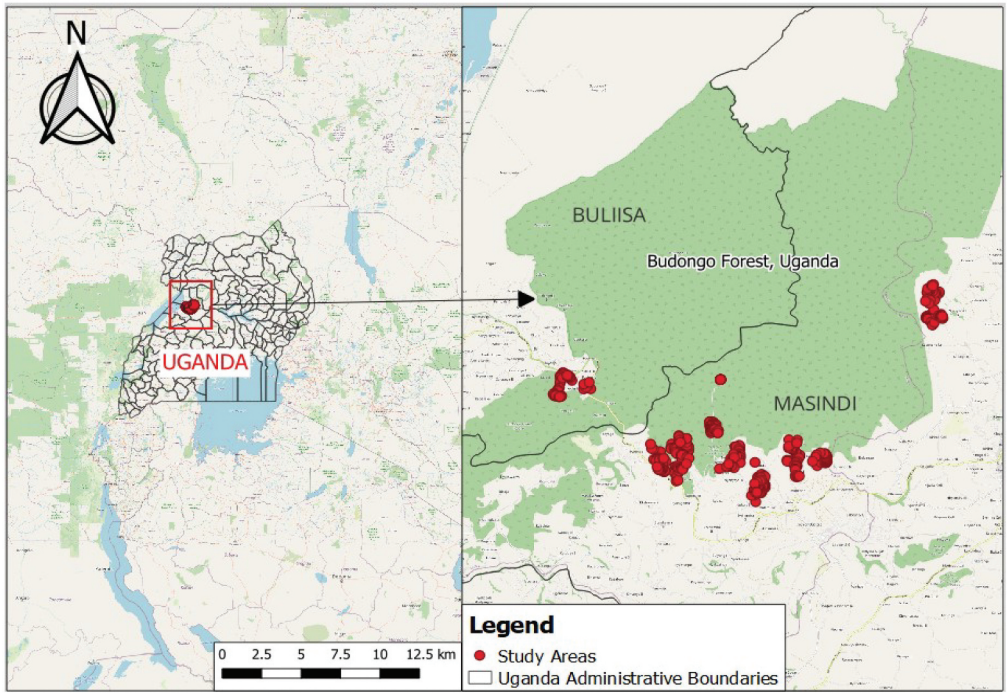

Figure 1. Study sites around Budongo forest.

2.4. Data collection

Data collection involved administration of a questionnaire to the target population, and observation of the type of agrochemicals used or in storage at the farmers' households. The questionnaires had both close and open-ended questions about socioeconomic status and agrochemical usage. The questionnaires were pretested on non-target respondents ($n = 15$) without prior knowledge. These non-target respondents were not informed to avoid biased responses.

The questionnaires had the following sections:

(a) Socio-demographic issues (age, gender, economic activities, educational status, and work experience.
(b) Observation of the type of agrochemicals used or in storage at the farmers' households, record them by name and active ingredients.
(c) Knowledge, attitude (behaviour) and practices of farmers towards the use of agrochemicals and the decision-making mechanism relating to the use of the products (i.e. active ingredients, concentration and date of use, disposal, etc.), and the practices used for agrochemicals (e.g. use type, storage, disposal, recording, reporting, used concentrations, packaging of pesticides and rinsing water from the, sprayer after use, among others).
(d) The knowledge about the awareness and risk of agrochemicals to animals, humans and the environment.

Interviews were conducted in the local language and informed verbal consent was obtained from all participants. Validation of answers on the denomination of agrochemicals used by the participants were confirmed in each area studied by contacting the local agrochemicals dealers/retailers where the farmers get the chemicals.

2.5. Data and analysis

After the interviews, the data was entered it into Microsoft Excel, and exported to SPSS (IBM STATISTICS Version 2020) to analyse, manage, and produce frequency tables. The strength of and nature of association between agrochemical usage with variables such as socio demographics, knowledge and practices were done using bivariate analysis.

3. Results

3.1. Demographic characteristics

The demographic characteristics (age, sex, level of education, and occupation) of the respondents are presented in Table 1.

3.2. Agrochemicals used by farmers in the Budongo forest landscape

The broad agrochemical groups, namely fertilisers, insecticides, pesticides, and herbicides are used by farmers to fertilise soils, expel/kill pests, kill weeds, protect animals from biting insects and spraying plants to kill plant pests (Figure 2). Some specific examples are shown in Figure 3, and Table 2.

All the agrochemicals that were used at the edge of Budongo forest at the time of the study are detailed in Table 2. On the list of herbicides, weed master and 2,4-D were the most commonly used in reference to the frequency of use. Dudu accelamectin, ant killer and rocket were the most commonly used insecticides while super green was the most commonly used fertiliser.

3.3. Knowledge, attitude and practices regarding agrochemicals

The majority of respondents (96.4%), were knowledgeable about agrochemicals, and 84.1% were actively using them on their farms. The largest number of farmers (76.1%) bought the agrochemicals from retailers, while others received them from extension workers, vendors, and Non-Governmental Organisation (NGO) support, upon which many (81.8%) mixed themselves according to the provided guidelines. Sixty percent of the farmers agreed that agrochemicals may be misused, and many (63.8%) also agreed of their impending danger to wildlife, with a consequence of morbidity and mortality (Table 3). The farmers identified some training programs on the correct use of agrochemicals and were willing to promote the use of agrochemicals to other farmers. The training was mainly done by the retailers, extension workers and NGOs (Figure 4).

Normally after the use of agrochemicals, the empties, and expired chemicals were disposed of by throwing them in latrines, rubbish pit, garden and bush, while some farmers chose to burn them. Other farmers went ahead and re-used the containers for storing salt and sugar and other home use applications (Figure 5).

Wild animals were reported to move to nearby communities and raid their crops. The main wild animals that were implicated for crop raiding around Budongo forest include; baboons, chimpanzees, monkeys, bush pigs and porcupines in that order. These animals moved to communities to majorly raid maize, sugarcane, mangoes, pawpaws, cassava beans and sweet potatoes.

> The animals raid and destroy our crops at different stages of growth and also in different seasons. Most times, the wild animals raid the crops in times when there is no food for them in the forest or when it is a season for a crop they like most; for example, chimpanzees like sugarcane, monkeys like maize and mangoes, and bush pigs like cassava, so they normally move to the villages when it's their season.

Farmers revealed that these animals come to raid the crops even after they have sprayed agrochemicals. They also mentioned that these chemicals may cause serious problems to these wild animals (Table 3).

The farmers observed that there was no compliance with regard to the correct use of the agrochemicals, and that some of them lacked valuable information on the correct usage. On the other hand, some people had the opinion that the use of certain agrochemicals was to blame for the decline in fertility in their soils. In addition, they pointed out that there was a lack of information regarding the appropriate agrochemical usage. Consequently, they proposed the following (Figure 6):

- additional training on the correct application of agrochemicals,
- sensitisation on the benefits and dangers of agrochemicals,
- careful adherence to the instructions provided by the manufacturer or to those provided by suppliers and extension workers,
- measures of stringent regulation imposed by the responsible authorities of the government, and
- cessation on the use of the agrochemicals that are known to have detrimental effects.

Table 1. Demographic characteristics

Parameters	Frequency (*n*=472)	Percentage
Age		
16–25	84	17.8
26–35	124	26.3
36–45	109	23.1
46–55	85	18
>55	70	14.8
Sex		
Female	260	55.1
Male	212	44.9
Education		
None	62	13.1
Primary	334	70.8
Secondary	68	14.4
Tertiary	8	1.7
Occupation		
Peasant farmer	466	98.7
Teacher	1	0.2
Business man	5	1.1

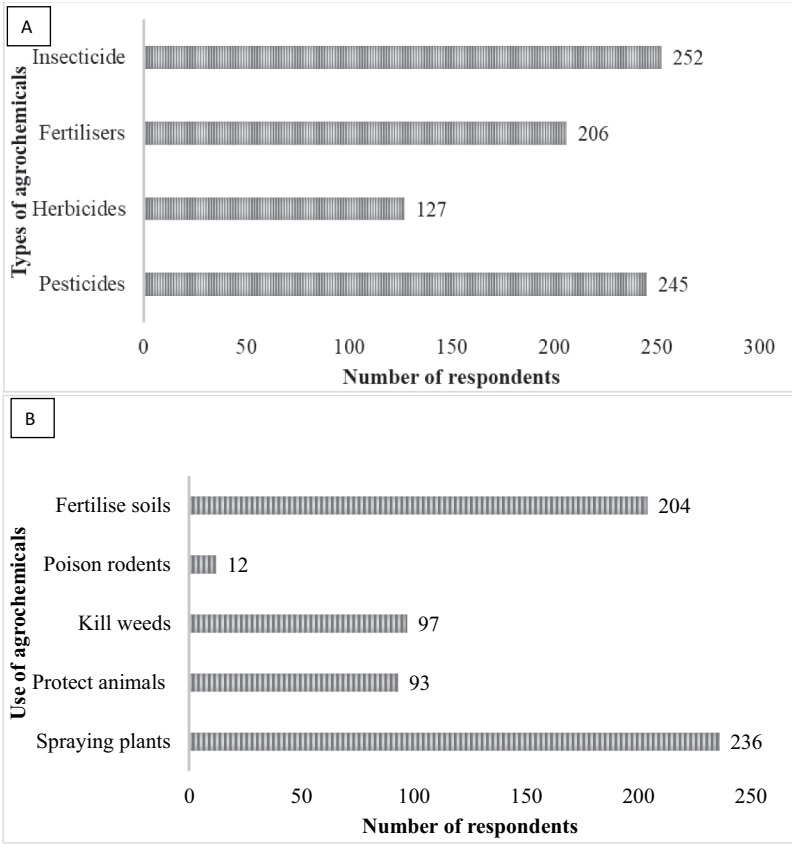

Figure 2. Broad category of agrochemicals used by farmers (A), and the forms of use (B).

4. Discussion

4.1. Demographic characteristics

Almost all the respondents interviewed identified themselves as peasant farmers; they were more female, and the largest group were between 26 and 45 years old. Uganda and most of Africa are characterised by a peasant economy, which mainly involves self-sufficiency and the consumption of a substantial part of the produce, while some of the output may be sold in the market (Olomola, 2006; Tramel & Mwesigye, 2013). Previous studies have reported a higher percentage of women (78%) engaged in farming compared to men (62%) (Bowen et al., 2015). Women are considered to have a crucial and indispensable role in the rural agricultural sector of Uganda, making a disproportionately significant contribution to crop labour. Moreover, women constitute the majority of Uganda's agricultural labour force, accounting for over half of the workforce (Bowen et al., 2015). The age category involved in farming in our study is contrary to what has been reported in Uganda (>50 years) (NewVision, 2021), and globally (40–50 years) (Alam et al., 2010). A growing number of subsistence farmers in developing nations are now moving away from subsistence hunting and gathering to focus more on crop and livestock production (Morton, 2007), thereby inclining more towards reliance on agrochemicals for the management of weeds and pests. It is feared that their risky handling practices of agrochemicals will result in increased exposure to the environment, which may have negative repercussions for human and animal health (Damalas & Eleftherohorinos, 2011).

4.2. Agrochemicals used by farmers in the Budongo forest landscape

The present study identified a broad group of agrochemicals, namely fertilisers, insecticides, pesticides, and herbicides, that are used by the peasant farmers at the edge of Budongo Forest to maximise production. Due to the widespread application of agrochemicals and the high prevalence of illiteracy among peasant farmers, it is feared that an unsafe level of exposure is occurring to humans, animals, and the environment. These findings concur with previous research that explains that agrochemicals are extensively used in smallholder and modern agriculture as an effective and economical way to enhance yield quality and quantity, but they possess serious consequences because of their biomagnification and persistent nature (Sankoh, 2016; Sharma et al., 2019).

Figure 3. Some agrochemicals found at the farmers' premises in the Budongo forest landscape (from top- rocket, super green and butanil, weed master, Dudu).

Table 2. Specific agrochemicals used by the farmers in the Budongo forest landscape

Category	Common names/trade names	Active ingredients	Frequency of use
Herbicides	Weed master	Dicamba salt and 2,4-D	27
	Weed all	Glyphosate	09
	Force up	Glyphosate	11
	2,4-D	2,4-dichlorophenoxyacetic acid	49
	Roundup	Glyphosate	23
	Weed solution	Glyphosate, triclopyr, fluxopyr, saflufenacyl, sulfentrazone	03
	Jembe	Glyphosate ammonium	03
Pesticides/insecticides	Dudu acelamectin	Abamectine	93
	Rocket	Chlorpyrifos	54
	Tafgor	Dimethoate 30%	10
	Antikiller	Chlorpyrifos	81
	Laraforce	Lambda-Cyhalothrin 5 % + Imidacloprid 15 % SC	04
Fertilizers	Supergro	NPK	89
	Super green	NPK + trace elements (Mg, Fe, Zn)	117
Dewormers	Levafas diamond	Levamisole and oxyclozanide	57
Acaricides	Duodip	Chlorpyrifos + cypermethrin	36
Rodenticide	Ratox	Zinc phosphide	12

Table 3. Knowledge and attitude regarding agrochemical use

Parameter	Frequency	%age	X^2	*p*-value
Knowledge of agrochemicals				
Yes	455	96.4	93.349	0.000
No	17	3.6		
Use of agrochemicals				
Yes	397	84.1		
No	75	15.9		
Source of agrochemicals				
Retailer shops	359	76.1	472.000	0.000
Extension workers	15	3.2		
Vendors	22	4.7		
NGOs	10	2.1		
Other	66	13.9		
Knowledge of mixing agrochemicals				
Yes	386	81.8	2.336	0.126
No	86	18.2		
Season of use of agrochemicals				
Anytime	109	23.1		
Dry	68	14.9		
Rainy	228	43.8	0.022	0.881
Possibility of misuse of agrochemicals				
Yes	284	60.2	19.483	0.000
No	173	36.7		
Not sure	15	3.2		
Possibility of agrochemicals causing problem to wildlife				
Yes	301	65.8	8.670	0.003
No	158	33.5		
Consequence to wildlife				
Morbidity	244	51.7	0.285	0.593
Mortality	171	36.2		
Not sure	77	12.1		
Availability of training program on the use of agrochemicals				
Yes	328	69.5	93.408	0.000
No	130	27.5		
Not sure	14	3		
Willingness to promote use of agrochemicals to other farmers				
Yes	372	78.8	53.551	0.000
No	100	21.2		

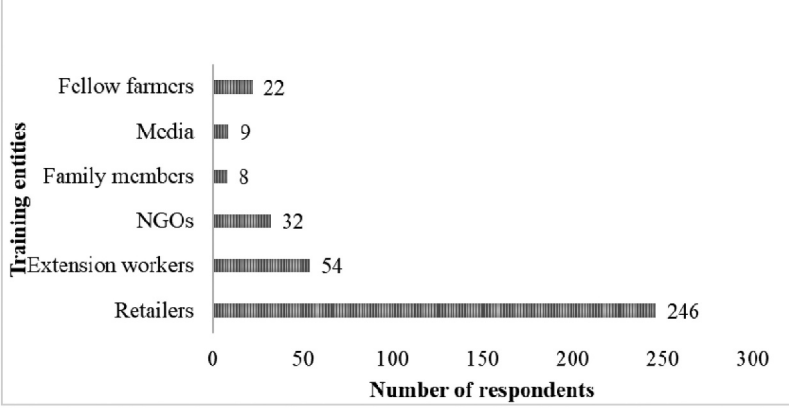

Figure 4. Entities offering agrochemical training services.

4.3. Agrochemical usage, knowledge, attitude and practices

The peasant farmers had adequate knowledge about agrochemicals and were actively using them on their farms. The availability of training programmes on the proper application of agrochemicals, which are facilitated by suppliers, extension workers, and non-governmental organisations (NGOs), is largely responsible for the current level of knowledge. This is true elsewhere in Uganda and East Africa; agricultural producers are being encouraged to safely use agrochemicals to increase production by protecting their crops from weeds, disease, pests, insects, and other pathogens (Andersson & Isgren, 2021; Okonya & Kroschel, 2015; Taylor, 2013). However, adherence to safe use by the farmers is questionable.

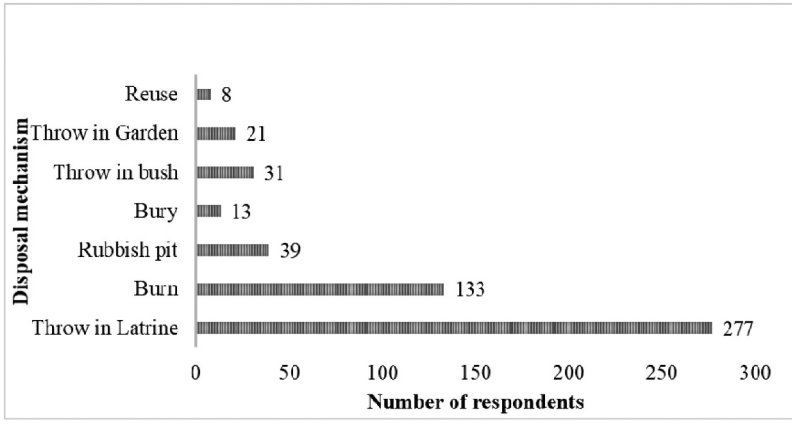

Figure 5. Agrochemical disposal mechanism of containers after use.

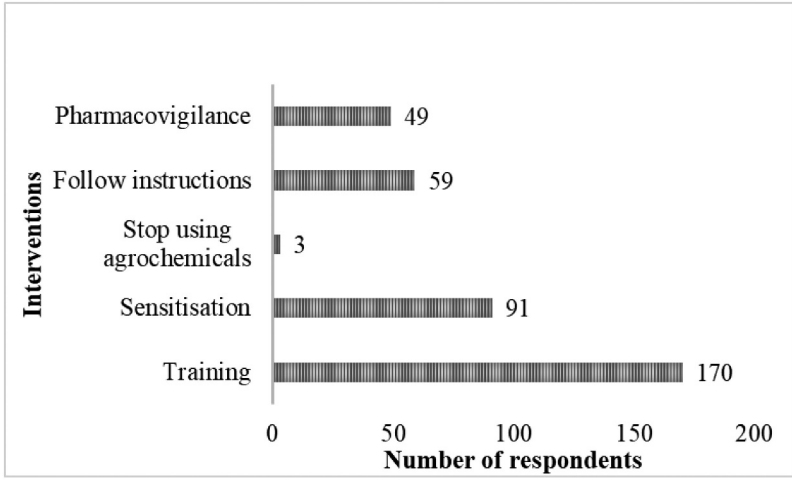

Figure 6. Suggested interventions for compliance to agrochemical usage.

The respondents also believed in the possibility of misusing the agrochemicals as a result of ignorance, with a high probability of environmental contamination, putting wildlife in Budongo Forest, particularly the endangered chimpanzees (*Pan troglodytes*), the forest's main inhabitant, in danger. Previous research in Uganda documented that agricultural expansion with the use of pesticides poses a risk to endangered wildlife and has been associated with facial dysplasia in chimpanzees and baboons in Kibale National Park (Krief et al., 2017). Elsewhere, agrochemicals have repeatedly been implicated in the poisoning of wild animals at the interface between wildlife, domestic animals, and humans (Pruvot & Wcs, 2016). The farmers made the discovery that, in addition to agrochemicals making their way into the environment unintentionally and through improper disposal of the empty containers, some people also intentionally use them to kill specific wildlife (especially those that raid crops and kill livestock). The consequence of this effect is that many species that are not the intended targets end up being killed as well, which threatens the entire ecosystem's biodiversity. This agrees with the findings of previous research, which demonstrated that anthropogenic factors, such as an increase in the use of agrochemicals, have an effect on the status of wildlife species at a variety of interfaces (Brain & Anderson, 2020; Harsimran Kaur & Harsh, 2014; USAID, 2006).

The mushrooming retailers and vendors, who sometimes even give agrochemicals to the farmers on a loan basis, have made it so easy that even the poorest farmers can easily access them. The reported prevalence (84.1%) of peasant farmers using agrochemicals at the Budongo Forest edge is almost in conformity with a study among small-scale farmers in western Ethiopia, which reported a prevalence of 87.15% agrochemical usage (Mergia et al., 2021).

A number of farmers voiced their desire to take part in additional training sessions that will assist them in

mastering the guidelines and enable them to effectively encourage other farmers to adopt safe agrochemical use. In particular, they demanded that more information be made available about the appropriate agrochemical disposal mechanisms (for empty bottles and chemicals that have passed their expiration dates) in order to prevent contamination of the environment. It has been revealed by other researchers that farmers' training is associated with good agrochemical practices as a result of elevated safety behaviour (Damalas & Koutroubas, 2017; Demi & Sicchia, 2021).

5. Conclusions

The study highlights that the majority of the peasant farmers at the Budongo Forest edge easily accessed agrochemicals to manage weeds, pests, insects, and diseases. The knowledge level of the peasant farmers was adequate, but this did not reflect in their practices. They reported the possibility of a lot of non-adherence to the proper use of the agrochemicals by some farmers. The farmers demanded the availability of more training opportunities available to them so that they could increase their knowledge about how to use the agrochemicals in a way that poses the least amount of risk to not only themselves but also to other humans, the environment, and animals.

6. Key policy highlights

The following are the primary areas in which it is necessary to concentrate and formulate new policies or upgrade existing ones:

- Conducting refresher courses to train trainers who will in turn continually train individuals who use agrochemicals regularly. This must also constitute training on adherence to personal protective devices, personal hygiene, and sanitation practices during and after the application of agrochemicals.
- Pharmacovigilance must be emphasised. Rules and guidelines regarding the proper use and disposal of agrochemicals should be developed and enforced.
- A policy on the use of alternative pest control strategies, such as the application of biopesticides, can be introduced. This would reduce the dependency on chemical pesticides as well as their adverse impact on human health and the environment.
- Policy should specify the relevance of regular studies on agrochemical bio-accumulation and toxicity levels in wild animals, domestic animals, humans, and the environment.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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Notes on contributors

Elizabeth Owemigisha is a graduate veterinarian from Makerere University's College of Veterinary Medicine, Animal Resources, and Biosecurity (COVAB). Elizabeth and a team from COVAB, Makerere University, and Budongo Conservation Field Station observed a chronic problem of indiscriminate pesticide use in agriculture, but the degree of understanding among end users, particularly farmers, remained unknown. In general, our team is involved in identifying agrochemical hotspots and potential dangers to domestic animals, wild animals, and the environment in and near protected areas. Our current work is unique, and it is likely to pique the interest of other researchers.

Elizabeth Owemigisha is a graduate of veterinary medicine at the College of Veterinary Medicine, Animal Resources, and Biosecurity (COVAB) at Makerere University.

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Public interest statement

Farmers in Uganda on the outskirts of wildlife-protected areas are increasingly adopting agrochemicals to enhance productivity due to the obstacles connected with weeds, pests, and diseases. We interacted with 472 farmers on the outskirts of Budongo Forest to learn about the nature of their pesticide use and the risks associated with indiscriminate use. Herbicides, pesticides, and fertilisers were the most frequently used agrochemicals. The majority of farmers thought that pesticide misuse posed an imminent threat to humans and wildlife. Understanding the most appropriate use of agrochemicals to prevent environmental pollution could only be accomplished through farmer training programmes, effective usage education, and the promotion of the right agrochemical brands. When used appropriately, agrochemicals are tremendously beneficial to increase productivity; nevertheless, when used incorrectly, they have the potential to cause catastrophic harm to people, animals, and the environment.

Author contribution

E.O., D.S. and C.M.B. collected field data from the respondents. A.T. and E.O. performed data analysis and interpretation. Projected administration was done by A.O.R. C.S. and BM supervised the research project. Project visualisation was by A.R.O., B.M. and C.S. C.S. and E.O. drafted the original manuscript. G.D. drew the maps. All authors indicated contributed to the article and approved the submitted version of the manuscript.

Ethics approval and consent to participate

The work was presented before a research panel for approval at the College of Veterinary Medicine, Animal Resources, and Biosecurity. The purpose of the research and the content of the questionnaires were explained to each respondent to obtain their consent before the interview was carried out.

Availability of data and materials

The majority of the information created or analysed during this retrospective study is presented in this article. The associated authors will provide the remaining data upon reasonable request.

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