Locust Infestations and Mobile Phones: Exploring the Potential of Digital Tools to Enhance Early Warning Systems and Response Mechanisms

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***Abstract*— This study aimed to investigate the knowledge levels and prevalence of locusts in the Sikaunzwe Agricultural camp in Zambia, as well as the association between mobile phone ownership and access to locust information. The study found that the majority of the sampled population were male, married, and engaged in farming as their primary occupation, with limited formal education. A significant proportion of the population had experienced locust outbreaks in the year preceding the survey, with the majority able to recognize the signs of locust outbreaks but only a small proportion having received training in locust management. Mobile phones were found to be a valuable tool for accessing and reporting locust information, but a significant proportion of the population did not own mobile phones. These findings have important policy implications for improving agricultural practices and management in the region, increasing training and awareness programs for locust management, and promoting the use of mobile technology to disseminate critical information to farmers in remote areas.**

Keywords*— *Mobile phones, pest management, gender roles, information access, agricultural practices, locusts, rural livelihood.

I. INTRODUCTION

Locusts are a type of grasshopper that are known for their destructive feeding habits, particularly their ability to form swarms and cause widespread damage to crops and vegetation [1][2]. Locusts have had significant socioeconomic consequences in many parts of the world, particularly in regions that rely heavily on agriculture for food security and economic growth [3][4][5][6]. Locusts are known to cause significant damage to crops, leading to reduced yields and total loss of crops. According to the Food and Agriculture Organization (FAO), a swarm of desert locusts measuring one square kilometer can eat the same amount of food in one day as 35,000 people [3][4][5]. This can have devastating consequences for farmers and food security, particularly in regions that are already vulnerable to food insecurity [5]. A study in Ethiopia found that a locust outbreak in 2003 led to a 70% reduction in cereal production, which resulted in food shortages and increased malnutrition [7]. Similarly, a study in Mauritania found that a locust outbreak in 2004 led to a 30% reduction in cereal production, which resulted in food shortages and price increases [1].

Locusts can also have significant impacts on the livelihoods of people who depend on agriculture for income. A study in Yemen found that a locust outbreak in 2003 led to significant economic losses for farmers, who were unable to harvest their crops and suffered a decline in their income [8]. Similarly, a study in Mali found that a locust outbreak in 2004 led to a decline in farmers' income, which resulted in increased poverty and food insecurity [9]. Locust outbreaks can also negatively impact on trade, particularly for countries that rely on agriculture exports. Furthermore, a locust outbreak in West Africa in 2004 led to a decline in cereal production, which resulted in a reduction in exports and a loss of foreign exchange earnings [10]. Locusts can also have health consequences for people who come into contact with them. A study in Sudan found that people exposed to locusts experienced respiratory symptoms, skin allergies, and eye irritations [11] while a study in Ethiopia found that people who came into contact with locusts experienced skin allergies and eye irritations [12].

A. Importance of Locust Knowledge

Locust knowledge is important for preventing and mitigating the negative impacts of locust outbreaks on food security and livelihoods [13]. Understanding the type of locusts that affect a region, their signs, and their management is critical for early warning, preparedness, and response. [14] highlights the use of satellite data for early warning of locust plagues in West Africa, emphasizing the importance of understanding locusts and their behavior for effective response. [15] assesses farmers' knowledge, perception, and management of desert locusts in rural Pakistan, emphasizing the importance of understanding local perspectives and practices for effective management. Furthermore, [16] examined management practices and needs for locust and grasshopper outbreaks in West Africa, emphasizing the

importance of capacity building and knowledge transfer for effective response.

According to a report by the Food and Agriculture Organization (FAO), locust outbreaks can cause significant damage to crops and livelihoods, particularly in developing countries where agriculture is a key source of income. The report emphasizes the importance of early warning systems, monitoring, and control measures to help farmers prepare for and respond to locust outbreaks [17]. In an article published in the journal Agriculture, Ecosystems & Environment, researchers from Ethiopia and Kenya note that locust outbreaks can lead to significant crop losses, with the potential to cause food insecurity and even famine in affected areas. The authors stress the importance of community-based monitoring and early warning systems to help farmers prepare for and respond to locust outbreaks [18]. In a report by the International Centre for Insect Physiology and Ecology (ICIPE), researchers highlight the role of traditional knowledge in managing locust outbreaks. The report notes that many farmers in affected areas have developed strategies for coping with locust outbreaks, such as using indigenous plants to repel the insects or using smoke to disperse swarms. The authors suggest that incorporating traditional knowledge into locust management programs can help to improve their effectiveness and sustainability [19]. The objective of this study was to explore the potential of digital tools in enhancing early warning systems and response mechanisms in the Sikaunzwe agricultural camp of Kazungula district, situated in the Southern Province of Zambia. Through these specific objectives, the study aimed to contribute to the development of effective strategies and interventions for managing locusts in the Sikaunzwe agricultural camp, ultimately improving the community's ability to mitigate the negative effects of locust infestations and protect their agricultural livelihoods.

II. Literature Review

A. *Locust Prevalence*

Locusts are a major agricultural pest in many regions of Africa, with significant impacts on food security and livelihoods. The prevalence of locusts in Africa has been well-documented in a number of studies.

A study by [14] used satellite data to map the distribution of locusts in West Africa, finding that outbreaks occurred in several countries in the region, including Mauritania, Mali, Niger, and Senegal. Similarly, [16] found that locust and grasshopper outbreaks were a recurring problem in West Africa, with significant impacts on agricultural productivity and food security. Other studies have focused on specific countries or regions within Africa. For instance, a study by [20] examined the prevalence of desert locusts in the Sahel region of Burkina Faso, finding that the insects were a major problem for farmers in the area. In Tanzania, a study by [21] found that locusts were a recurring problem in the country, with outbreaks occurring on a regular basis and causing significant damage to crops. In addition to examining the prevalence of locusts, many studies have also looked at strategies for managing and controlling these pests. For example, a study by [22] examined the use of biopesticides for controlling desert locusts in Mauritania, finding that these products were effective and environmentally friendly. Another study conducted by [23] assessed the impact of the 2019-2020 locust outbreak in Zambia and found that it affected over 66,000 hectares of land, causing significant damage to crops and pasture. The authors also noted that the outbreak had the potential to spread to neighbouring countries, highlighting the need for regional cooperation in locust control efforts. Furthermore, [24] investigated the prevalence of locusts in the Luangwa Valley of Zambia and found that the red locust was the most common species, followed by the migratory and brown locusts. The authors noted that the region was prone to locust outbreaks, and recommended early warning and surveillance systems to detect and control outbreaks before they cause significant damage. A study by [25] assessed the effectiveness of different locust control measures in Zambia, including the use of pesticides and biological control methods. The authors found that pesticide application was effective in reducing locust populations, but also noted the potential environmental and health risks associated with pesticide use. Biological control methods, such as the use of natural enemies and cultural practices, were found to be less effective but safer and more sustainable in the long term.

B. *Knowledge of locusts*

Locusts are a major threat to agriculture in Africa, and farmers' knowledge about locusts is critical for their control and management. A review of literature indicates that there are knowledge gaps among African farmers regarding locusts, which could negatively affect locust control efforts.

A study by [26] on the knowledge and management practices of Ethiopian farmers regarding desert locusts found that although the majority of farmers had heard of locusts and could identify them, their knowledge about the management of locusts was limited. Similarly, a study by [27] on the awareness and knowledge of desert locusts among smallholder farmers in Sudan found that farmers had limited knowledge about the identification, behavior, and control of desert locusts. [28] on the knowledge, attitudes, and practices of farmers in Kenya regarding desert locust control found that farmers had some knowledge of locusts, but their understanding of locust biology and ecology was limited. The study also found that farmers relied heavily on government interventions and lacked the necessary knowledge and resources to control locusts independently.

In contrast, a study by [29] on the knowledge and practices of farmers in Kenya regarding the control of desert locusts found that farmers had a good understanding of the behavior and ecology of locusts, as well as the importance of early detection and control measures. However, the study also found that farmers faced challenges in accessing timely and accurate information about locust outbreaks and control measures.

A study conducted in Ethiopia found that farmers had a good understanding of locusts and their behavior, but lacked knowledge on how to manage and control them effectively [30]. Similarly, a study in Niger found that farmers had some knowledge of locusts, but lacked specific knowledge on management and control strategies [31].

There is limited literature on locust knowledge specifically in Zambia, but several studies have investigated locust knowledge in the broader African region. A similar

research conducted by [32] involved a survey of 150 farmers in the Kazungula district and found that mobile phones have played a critical role in enhancing farmers' knowledge and preparedness in locust control. The study found that mobile phones were used by farmers to receive information on locust outbreaks, pest management techniques, and weather conditions. Additionally, mobile phones were used to communicate with agricultural extension officers and other farmers in the area, enabling the sharing of knowledge and experiences. Overall, more research is needed on locust knowledge in Zambia specifically, in order to identify gaps in knowledge and develop effective management strategies.

C. Use of phones by farmers

Several studies have highlighted the use of mobile phones by farmers in reporting locust infestations, which can help to provide early warning and improve response times to locust outbreaks.

In a study conducted in Kenya, mobile phone technology was used to enhance locust monitoring and management by providing real-time reporting of locust sightings [33]. The study found that mobile phone technology was effective in reducing the response time to locust outbreaks, which helped to minimize the negative impacts on food security and livelihoods. Similarly, in another study in Tanzania, mobile phone technology was used to improve locust surveillance and control [34]. The study found that mobile phone-based reporting of locust sightings helped to enhance the effectiveness of locust control measures. In Ethiopia, a study found that mobile phone-based reporting of locust outbreaks helped to provide early warning and improve the response time to locust infestations [35]. The study recommended the use of mobile phones to improve locust surveillance and control in the country. In Morocco, a study found that mobile phone technology was effective in enhancing the efficiency of locust monitoring and control by providing real-time reporting of locust sightings [36]. The study recommended the use of mobile phones as a tool for improving locust surveillance and control in the country. Similarly, a study by [37] explored the use of mobile phones for monitoring and reporting desert locusts in Zambia. The study found that mobile phones were effective in providing real-time information on locust outbreaks, enabling farmers and other stakeholders to take timely and appropriate action. The study recommended the use of mobile phones in locust monitoring and reporting, as well as the need for capacity building and training for farmers and other stakeholders to ensure accurate and reliable data collection. [38] investigated the use of mobile phones for early warning and response to desert locusts in Zambia. The study found that mobile phones were effective in disseminating early warning alerts and enabling farmers to report locusts quickly and accurately. The study highlighted the importance of mobile phones in locust monitoring and recommended their use in locust control and management.

III. METHODOLOGY

A. Study design

The study utilized a quantitative approach in collecting data, which facilitated the acquisition of comprehensive and organized data that accurately reflected the opinions and perspectives of farmers regarding the variables under investigation.

B. Study Area

The research was carried out in the Sikaunzwe Agricultural Camp situated in the Kazungula District of the Southern Province in Zambia. Kazungula is well-known for its agricultural practices, while Sikaunzwe is a small community within the district. This location was selected due to its susceptibility to locust infestations, including the breeding of Red Locust and the recent occurrence of African Migratory Locust invasions, as highlighted by [39].

C. Study population

The study focused on farmers residing in the Sikaunzwe Agricultural Camp of the Kazungula District, which is located in the Southern Province of Zambia. The target group consisted of farmers who had previously encountered locusts, and this criterion was preferred in the selection process.

D. Data collection methods and ethics

The research study employed questionnaires as the data collection tool, which were administered to 260 respondents, resulting in an impressive response rate of 96%. The sampling technique used in this study was purposive sampling, which involves selecting participants based on specific characteristics or attributes that are relevant to the research objectives. In this case, the researchers targeted farmers who reside in the Sikaunzwe Agricultural Camp of the Kazungula District in Zambia and have had experience with locusts.

The study followed strict ethical guidelines to ensure the well-being and privacy of the participants. Prior to their involvement, participants were fully informed about the study's purpose, potential risks and benefits, and their right to withdraw at any time. They were also assured that their responses would be kept confidential and anonymous, and all identifying information would be removed from the data. To prevent any harm, the questionnaire questions were carefully designed to avoid causing any distress or discomfort to the participants. The collected data was securely stored and handled in accordance with data protection legislation, and used solely for research purposes. The researchers were committed to conducting the study in an ethical and responsible manner, and took all necessary precautions to prevent any physical, emotional, or psychological harm to the participants.

E. Data analysis procedure

To assess the prevalence rates and level of knowledge regarding locusts in Kazungula, the study employed descriptive statistics. Furthermore, to determine the correlation between locust knowledge and the use of mobile phones in Kazungula, the study utilized the Chi-square test. STATA 15 software was used to perform the data analysis.

IV. Empirical findings

In this section, the study presents the empirical findings based on the descriptive and Chi-square analyses. The descriptive statistics provide an overview of the sample and enable us to understand the prevalence and knowledge about locusts among the respondents.

A. Description of the sample

According to the descriptive analysis, the sampled individuals can be described in terms of their sex, age, marital status, education level, occupation, and household income. Figure 1.1 illustrates that the majority of respondents were male, comprising 62.5% of the sample. In terms of marital status, about 64% of respondents were married. Regarding age, 21.74% of respondents fell within the age categories of 26 to 30 years or above 40 years, while only 17% were aged between 31 and 35 years. With respect to education level, the majority of respondents had primary education, accounting for approximately 32% of the sample. Conversely, very few respondents (1.56%) had attained a diploma or higher level of education. In terms of occupation, approximately 84% of respondents were engaged in farming, while only 2% were government workers. Regarding monthly household income, the majority of households (88%) fell within the low-income category, earning less than K5000 per month.

TABLE I. Sample Characteristics

Variable	n	Percent
Sex		
Male	160	62.5
Female	96	37.5
Marital Status		
Married	158	64.23
Single	46	18.7
Divorced	21	8.54
Widowed	21	8.54
Age		
Years 21-25	52	20.55
Years 26-30	55	21.74
Years 31-35	43	17
Years 36-40	48	18.97
Years above 41	55	21.74
Education level		
Primary	82	32.03
School Leaver	81	31.64
Certificate	55	21.48
Diploma or more	4	1.56
Never been to school	34	13.28
Occupation type		
Farming	213	
Trading	33	
Government worker	6	
Others (specify)	2	
Household income		
below 5000	219	
6000-10000	23	
11000-20000	6	
26000 and above	1	

The study investigated the knowledge levels of locusts and their prevalence in Sikaunzwe. Table 1.2 presents the frequencies of the variables of interest. More than half (58.47%) of the respondents received locust alerts on their phones. The majority of respondents (78%) reported that locusts affected crop fields more than grazing land. Only a small proportion (8%) of respondents had received training in locust management. A significant proportion of the population (72.44%) experienced locusts in the year preceding the survey. When asked about the most prevalent locust in the area, the majority of respondents (80%) indicated red locusts, while only 11% identified migratory locusts. Additionally, almost 70% of respondents stated that the government provided information on locusts in the region. Many people could recognize the signs of locust outbreaks, with 56% tracing the outbreak through eaten crops or grass, and 35% recognizing the outbreaks through the presence of flying swarms. Regarding prevention and control measures for locusts, most respondents (75%) indicated the use of chemical sprays, while about 11% suggested burning the affected areas. Furthermore, over half (57%) of the respondents were able to predict locust outbreaks.

TABLE II. Knowledge of locusts, management and control

Variable	N	Percent
Locust alert on phone		
Yes	107	58.47
No	76	41.53
Locust effect		
Grazing land	55	22
Crop fields	195	78
Locust management training		
Yes	17	8.17
No	191	91.83
Last experienced locust		
This year	45	17.72
Last year	184	72.44
2 years ago	16	6.3
every year	9	3.54
Knowledge of types of locusts		
Migratory locust	28	11.02

Red locust	203	79.92
Others(specify)	23	9.06
Signs of locusts outbreak		
Presence of a flying swam	89	34.77
Eaten crops/grass	144	56.25
Presence of locusts on the ground	21	8.2
others(specify)	2	0.78
Government provide locust information		
Yes	176	69.57
No	77	30.43
Prevention measures		
Burning affected areas	28	10.98
Spraying chemicals	192	75.29
Harvesting for food	2	0.78
Beating drums	17	6.67
Others (specify)	16	6.27
Contacts with local control team		
Yes	172	68.25
No	80	31.75
Ability to Predict locust		
Yes	146	57.03
No	110	42.97

B. Association between mobile phone ownership and locust information access

To investigate the relationship between mobile phone ownership and access to locust information, this study conducted cross-tabulation and the Pearson-Chi Square Test. The findings, presented in Table 1.3, indicate that approximately 64% of phone owners accessed locust information through their mobile phones. Similarly, around 65% of phone owners reported locust information using their phones, while 92% of those without phones had to walk to locust camps to report the information. In addition, slightly over half (55%) of respondents with phones received agriculture-related information via their mobile devices.

TABLE III. OWNERSHIP OF MOBILE PHONE AND ACCESS TO LOCUST INFORMATION

		Own mobile phone				
		Yes		No		
		n	Percent	n	Percent	p-value
Alerts on locusts on mobile						
	Yes	97	63.82	10	33.33	0.002
	No	55	36.18	20	66.67	
Agric related information on phone						
	Yes	84	54.55	9	29.03	0.010
	No	70	45.45	22	70.97	
Report locust information						
	Mobile phone	86	65.15	5	6.76	0.000
	Walk to locust camp	36	27.27	68	91.89	
	Cycle to the locust c	9	6.82	1	1.35	
	Drive to the locust c	1	0.76	0		

V. DISCUSSION OF FINDINGS

The findings of the study suggest that the majority of the sampled individuals were male, married, and engaged in farming as their primary occupation. This implies that farming is the primary livelihood activity in the Sikaunzwe Agricultural camp. The majority of the respondents had a low level of education, with most having only primary education. This suggests that efforts to improve agricultural practices and management in the region must take into account the limited level of formal education of the majority of the population.

In terms of locust knowledge and prevalence, the study found that a significant proportion of the population had experienced locusts in the year preceding the survey. The majority of respondents were able to recognize the signs of locust outbreaks and knew the most prevalent locust species in the area. However, only a small proportion of respondents had received training in locust management, highlighting the need for increased training and awareness programs to control and prevent locust outbreaks.

The study also found that mobile phones were a valuable tool for accessing locust information, with the majority of phone owners accessing and reporting locust information through their mobile devices. This finding suggests that the use of mobile technology can help to disseminate critical information to farmers in remote areas. However, the study also found that a significant proportion of the population did not own mobile phones, which may limit their ability to access information and report locust outbreaks.

VI. CONCLUSION AND POLICY IMPLICATIONS

The policy implications of this research are significant, as they can inform the development of policies and strategies aimed at mitigating the impact of locust outbreaks on the agricultural sector and the livelihoods of rural communities.

Firstly, the study shows that mobile phone ownership is associated with access to locust information. This suggests that policy-makers could leverage the widespread use of mobile phones to disseminate locust-related information and provide early warnings of outbreaks, enabling farmers to take appropriate measures to protect their crops and reduce losses. This could be achieved through the development of mobile-based applications, SMS services, or other forms of digital platforms that deliver timely information to farmers.

Secondly, the study highlights the need for increased training in locust management. The low proportion of

respondents who had received training in locust management suggests that there is a need for government and other stakeholders to invest in training programs aimed at equipping farmers with the knowledge and skills required to detect, monitor and control locust outbreaks. Such training could be delivered through workshops, extension services, and other capacity-building initiatives.

Thirdly, the study suggests that chemical sprays are the most commonly used method for preventing and controlling locusts. However, there is a need to ensure that such measures are used in a safe and sustainable manner to avoid harmful impacts on the environment, human health, and non-target organisms. Policy-makers could therefore consider developing guidelines and regulations for the safe use of chemical sprays and promoting the adoption of alternative methods such as biological control and cultural practices.

Finally, the study highlights the importance of involving communities in locust management and control efforts. Community participation and ownership can enhance the effectiveness and sustainability of locust control measures, and foster a sense of responsibility and accountability among farmers. Policymakers could therefore consider developing community-based approaches that involve farmers in decision-making, planning, and implementation of locust management strategies.

ACKNOWLEDGMENT

The authors hereby acknowledge the immense help received from Scholarship funders - International Development Research Centre (IDRC) and Swedish International Development Cooperation Agency (SIDA); Scholarship Programme- Artificial Intelligence for Development (AI4D) Africa Scholarship Fund Manager-Africa Center for Technology Studies (ACTS); and lastly but not the least Mulungushi University and the University of Zambia.

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