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Exploring farmers' perspectives on desert locust management in Kenya: a comparison of Q and R-methodologies

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Abstract

While desert locust invasions threaten agricultural production and household incomes, a common understanding of how to implement integrated control is missing. This study aimed to provide new insights on targeted policies that address the heterogeneity of perspectives held by farmers. To do so, the study compared both *R* and *Q-methodologies* to identify perspectives on desert locust management from a sample of 473 farmers. Based on internal consistency checks, the Q-methodology was found to better explain farmers' perspectives through ranking and identification of distinguishing statements. The four different perspectives were labelled as "threat-aware but unprepared," "enthusiasts of indigenous control methods," "proponents of information access," and "advocates of timely control and post-recovery assistance." The study also linked the various socio-economic and institutional factors that distinguish farmers across the four perspectives. A key finding is that farmers holding different perspectives agreed that integrated desert locust control is the best strategy. Considering the diversity in farmers' opinions, a mixed-policy framework is essential. Such policies should focus on information access, engagement of community members in desert locust control teams, and targeted post-recovery assistance, which would facilitate the implementation of integrated desert locust management.

JEL Codes: Q000, Q010, Q190

Keywords: consensus, desert locust, distinguishing, perspective, Q-methodology

1 Introduction

The recent invasion of desert locusts (*Schistocerca gregaria*) into mixed farming and pastoral systems from late 2019 to 2020 had a negative impact on resources and livelihoods. Originating from the Arabian Peninsula and favoured by strong winds and rainfall, desert locust swarms moved into Yemen, Eritrea, Somalia, Ethiopia, and Kenya (Kimathi et al., 2020). The pest invasion worsened food security and increased income losses. A total estimated loss of 197,163 hectares of cropland, 1,350,000 hectares of pasture, and 356,286 metric tonnes of cereal loss affected about 806,000 households in Ethiopia (Food and Agricultural Organization of the United Nations [FAO], 2020a). In Kenya, the estimates were much lower compared to Ethiopia, that is, 30,213 hectares of cropland and 579,786 hectares of pasture (FAO, 2020b). In terms of economic losses, according to the FAO (2020c) report, the desert locust invasion caused agricultural losses amounting to US$1.2 billion.

Due to the transboundary nature of desert locust invasions, control involves different international partners. The FAO, in liaison with regional and national agencies, conducted surveillance and control of desert locusts in affected areas. The control approach combined early warning systems and surveillance to detect desert locust populations (Showler et al., 2022). Formal control measures include chemical spraying of locust populations through aircraft, vehicles, or hand-held spray equipment. Chemicals such as organophosphates, carbamates, and organochlorines are effective. However, the use of chemicals is associated with damage to the environment, human and livestock wealth, and non-target organisms (Githae & Kuria, 2021). There remains potential for other environmentally friendly control methods, such as bio-pesticides, though they are costly to develop on a large scale and have a slower reaction time compared to chemicals (Githae & Kuria, 2021; Shuang et al., 2022).

Formal control measures remain unsuccessful due to certain challenges. One key challenge is insecurity, especially in breeding areas that include the Sahara Desert and Mauritania regions, areas along the south Arabian Peninsula, India, and Pakistan, where control efforts are most required. Other challenges include insufficient funding, the unpreparedness of national control agencies, and limited investment in research (Showler & Lecoq, 2021). The lack of timely interventions due to these challenges implies that desert locust invasions would have caused immense damage. At the local level, households implemented indigenous control measures. These included hitting objects such as metallic objects while making sounds, lighting fires (burning of dry material), burying hoppers with soil or trampling over them, avoiding invaded areas (especially for pastoral communities), and cropping farmers use insecticides made for control of other pests (FAO, 2020b; Pandey et al., 2021).

Considering the constraints associated with different desert locust measures, there have been calls for integrated desert locust management. It is a strategy that combines rational use of chemicals, using technologies to improve surveillance, using biological control measures, and indigenous control measures (Githae & Kuria, 2021; Mamo & Bedane, 2021; Pandey et al., 2021; Shuang et al., 2022). This can be achieved through stakeholder involvement, where farmers' perspectives are considered in formulating effective desert locust management plans.

According to Sok et al. (2021), a greater understanding of human decision-making and predicting human behaviour is one way to improve stakeholder engagement.

To date, there remains limited information on farmers' perspectives on the control of invasive pests. Notably, current research has focused on fall-army worms (FAW). For instance, Kalyebi et al. (2023) observed that an area-wide approach is suitable for effective FAW management, while Kansiime et al. (2019) noted that integrated messaging coupled with the use of indigenous control measures offers an effective strategy for improved FAW management. While these studies offer important insights into improved management of invasive pests, they do not account for varying farmer perspectives. Aligned with economic development and improved pest management strategies, the interests of farmers vary based on their social or economic situation. The current study aims to account for this by identifying farmers' perspectives on desert locust management.

In literature, both quantitative and qualitative methods assess households' perspectives or attitudes toward certain issues. The conventional *R-methodology* (Likert-type survey) is the main quantitative method applied in the literature. While findings from Likert surveys can be generalized to a population, they do not capture the subjective views of respondents (Dijk et al., 2022). An implication of this is that an unrepresentative label is used to capture the continuum of characteristics in a manner that is far from the varied complexities of targeted respondents. On the other hand, qualitative methods, mainly focus group discussions (FGDs), capture diverse views, which are sometimes ambiguous and difficult to analyse (Vecchio et al., 2022).

To address the limitations of both quantitative and qualitative methods, the *Q-methodology* has been proposed. It is a hybrid method that analyses subjective perspectives by identifying typologies (Dieteren et al., 2023; Sneegas et al., 2021; Zabala et al., 2018). It combines both the characteristics of quantitative and qualitative methods to generate perspectives, viewpoints, or attitudes about a topic being studied (Dieteren et al., 2023). Furthermore, the *Q-methodology* application allows the engagement of respondents, allowing them to precisely differentiate the subtle differences in their decisions (Watts & Stenner, 2012). This differs from the abstract assignment of scores used in questionnaires applying the *R-methodology*.

The *Q-methodology* has also been applied in pest and disease management studies to identify key stakeholder views (see, for instance, Lehrer & Sneegas, 2018; Truong et al., 2017; Urquhart et al., 2019; Vaas et al., 2019). While the *Q-methodology* identifies different perspectives, it faces challenges. These include the use of smaller sample sizes and the fact that it offers limited interpretation as perspectives are based on the set of items presented to the respondents (Zabala et al., 2018).

To overcome this challenge, an approach that combines the strengths of the *R and Q methodologies* (mixed-methods) to capture the complexity of farmers' perspectives on different issues is well suited. The most recent study to combine both methods was by Leonhardt et al.

(2022), who observed that other incentives rather than monetary compensations are critical in improving agri-environmental schemes uptake.

The current study aims to contribute to the limited literature on using mixed-methods to identify farmer categories based on their perspectives on desert locust management. Specifically, the study makes two contributions. First, the study categorizes farmers based on their perspectives on desert locust management by employing *R and Q-methodologies* followed by internal consistency tests to identify the best method. Secondly, the study provides a means to guide farmers' socio-economic and institutional characteristics in policy framing for improved desert locust management based on coherent farmer categories. Overall, the findings could be used to improve future desert locust control measures by accounting for farmers' perspectives as key stakeholders.

Understanding the negative impacts of desert locust invasion on agricultural production, food security, and household incomes, this study specifically addresses the theme of the 32nd International Conference of Agricultural Economists (ICAE) *"Transformation towards sustainable agri-food systems"* by assessing farmers' perspectives as key stakeholders in the development of integrated desert locust management.

2 Materials and methods

2.1 Q and R methods

To explore and categorize farmers' perspectives on desert locust management, *Q-method* enables the subjective opinions of respondents to be revealed (Watts & Stenner, 2012). The *Q-method* process involves ranking statements (the *Q-set*) based on a set of questions. Respondents place cards that contain statements on a *Q-sort*, which has a quasi-normal distribution feature based on their level of agreement. Unlike Likert-scale analysis, statistical analysis of the resulting *Q-sorts* follows an inverted approach; that is, the statements become the sample while the respondents are the variables of interest (Watts & Stenner, 2012). The patterns of similarity, known as factors, are derived from the correlation between respondents' *Q-sorts*, which are rotated and characterized by *Q-sorts* that load on each factor. Essentially, the results of *the Q-method* are (i) groups or clusters of discourses or opinions shared by respondents with similar response patterns; (ii) distinct statements, which are unique and define differences between those groups based on the level of agreement; and (iii) consensus statements from all groups, in which respondents have the same level of agreement about one or more statements (Amaruzaman et al., 2017; Sudau et al., 2023). Therefore, in the study context, each category of opinions iterated from the analysis describes a different discourse about desert locust management.

The *Q-method* employed in this study followed the five-step procedure as described by McKeown and Thomas (2013). The first step is the development of a concourse, where the collection of all statements made by individuals about desert locust management is done. The second step involved the development of a *Q-sample* or *Q-set*, where a group of statements that captured all viewpoints were selected for the process of ranking. Thirdly, a *P-sample*, that is, farmers aware of the subject of desert locust management, was selected. The fourth step, *Q-sorting*, involved respondents ranking the set of statements in a grid as shown in Figure 1. The last step entailed the analysis and interpretation of the *Q-sorts* using inverted factor analysis.

Level of agreement	Most disagree		Neutral	Most agree	
Value score of statement	-2	-1	0	1	2
Statement rankings					

Figure 1. *Q-sort* card for statement ranking

Source: Author's conceptualization.

The *R-method* based on Likert-scale data entails measuring perceptions and/or attitudes based on the extent to which respondents agree or disagree with a set of statements (McKeown & Thomas, 2013). The *R-method* examines interrelationships among items to identify patterns or factors underlying the variables (by-item analysis), unlike the *Q-method*, which finds patterns where *Q-statements* appear in different *Q-sorts* (by-person items). The collection of *R-method* data was based on a five-point Likert-scale (-2 = strongly disagree; -1 = disagree; 0 = neutral; 1 = agree; 2 = strongly agree).

A key similarity of both methods is that factor analysis procedures can be used to identify respondents' perspectives (Vecchio et al., 2022). The rotation step in factor analysis for the *Q-method* generates two results: factor loadings and *z-scores*. The former can be interpreted in the same way as correlation coefficients. The latter refers to the weighted average of the scores that respondents gave on an item (Zabala et al., 2018). Following Sudau et al. (2023), the *z-scores* can be normalized as follows:

$$ZSC_{-1:1} = \frac{S_{ZSC}}{(\max ZSC) - (\min ZSC)} \qquad (1)$$

where, $ZSC_{-1:1}$ is the normalized *z-score* for the range [-1;1], *S* is the value of the respective statement and S_{ZSC} is the *z-score* of the statement, $\max ZSC$ and $\min ZSC$ are the maximum and minimum *z-score* values across all statements of the *Q-set* of *S*.

Similarly, factor analysis reduces Likert-scale data to obtain factor loadings or components, and rotation is applied to obtain factor scores for ease of interpretation. Following Okello et al. (2021), the factor loadings of the dataset can be specified as:

$$C_n = a_{ni}X_i, \dots\dots\ a_{ik}X_k \qquad (2)$$

where C_n is the factor loading, n represents a number greater than one. The specification a_{ik} is the regression coefficient for the kth variable defined as the eigenvector of the covariance matrix between variables, while X_k is the value of the kth variable.

The robustness of both methods can be analyzed through internal consistency checks by applying the Cronbach alpha test (Taber, 2018).

2.2 Study area

The desert locust invasion in Kenya between 2019 and 2020 affected several counties, especially in the northern part. Counties were mapped into three clusters: Elgeyo Marakwet, Samburu, Turkana, Laikipia, Isiolo, and Baringo were classified in cluster one; Mandera, Wajir, and Marsabit counties were in cluster two; and Embu, Kitui, Tana River, Tharaka Nithi, Meru, Machakos, and Garissa were in cluster three (FAO, 2020b). Isiolo (pastoralist-based production system) and Meru (mixed-farming system) were selected for this study. Before proceeding to the data collection phase, key informant interviews with county agricultural officers and FGDs with farmers were conducted. The information gathered from the sessions provided insights into the desert locust invasion, control measures, and post-recovery measures instituted. This was a crucial step as it provided the statements for the concourse phase of the *Q-method* process and the *R-method* Likert-scale development. Further adjustments were made to the survey, resulting in a final set of fifteen statements that captured the expressed views of households in both counties (completing the second step of the *Q-method* of developing the *Q-set*).

2.3 Sampling, data collection and analysis

The study used a three-stage sampling procedure. In the first stage, Isiolo County, characterized by arid zones with pastoralism as the main livelihood (County government of Isiolo, 2023), and Meru County, a high agricultural potential area with mixed-farming as the main livelihood practice, were purposively selected (County government of Meru, 2023). With the help of county agricultural officers involved in desert locust management, Garbatulla sub-county (Isiolo County) and North Imenti (Meru County) were selected in the second stage. In the third stage, Kinna ward (Garbatulla sub-county) and Nyaki East ward (North Imenti) were selected.

The selection of the sample size followed Cochran's formula (Bartlett & Kotrlik, 2001), resulting in a sample size of 384. To account for non-response, the sample was adjusted upwards by 20 percent (Lindner et al., 2001) to 462. Due to time flexibility within the survey period, a total of 481 households were interviewed. The sample size fell within the range of 465 to 482 households interviewed in studies by Tambo et al. (2020) and Weyori (2021), respectively. According to Webler et al. (2009), in *Q-method* studies, one general guideline is to choose 4 to 6 participants to define each perspective. Thus, for this study, a total sample size of 90 based on 15 statements was selected as respondents for the *Q-sort* part of the study. The other 391 participants were interviewed for the *R-method* part of the questionnaire (Likert-scale). The total sample size was split, resulting in 240 respondents interviewed at each study site. Following pre-testing and validation of the survey tool, the final questionnaire included information on socio-economic and institutional characteristics, effects of desert locust invasion, information on control, control methods used, and a set of 15 statements assessing attitudes and perspectives on desert locust management.

The questionnaires were administered by a set of well-trained enumerators in May 2022. For the *Q-method*, respondents were briefed on how to use the pre-structured *Q-sort* distribution. Respondents expressed their views about desert locust management by ranking their level of agreement with the statements presented. For the *R-method*, enumerators directly asked the respondents about their level of agreement with the statements presented. The initial phase of data collection covered Likert-scale questions, while the second phase focused on the *Q-sort* part of the study. Following data cleaning, 8 observations were dropped due to incomplete information, resulting in a total of 473 observations. This consisted of 391 Likert-scale and 82 *Q-sort* observations.

Q-sort data are usually analysed using software such as PQ-method and KADE (Sneegas et al., 2021). However, analysis using the stated software only has two-factor extraction techniques: centroid factor analysis and principal component analysis. Additionally, only two-factor rotation methods are available: varimax and manual rotation (Akhtar-Danesh, 2018). Newer programs that offer more options for rotation and analysis have been developed. Specifically, the "qmethod" for R-software and "qfactor" for Stata provide for a more robust analysis of Q-based data (Akhtar-Danesh, 2023). The "qfactor" and "factor" commands in Stata version 15 were applied for the analysis of *Q-sort* data and Likert-scale *data*, respectively. Furthermore, the "alpha" command checked for internal consistency of both methods.

3 Results and discussions

3.1 Factor characteristics

The identification of shared perspectives involved reducing the complexity of the data set based on the following criteria as applied in studies by Braito et al. (2020) and Reichenspurner et al. (2023). First, the Kaiser-Guttmann criterion states that each factor's eigenvalue has to be greater than one. Secondly, the factors account for at least 35% of the variance. Thirdly, that at least two Q-sorts load per factor and have to be significantly high ($\rho < 0.05$). Additionally, the significance threshold value for each Q-sort was set at +/- .50. Following the application of these criteria, by-person factor analysis through *promax* rotation was employed. Twenty-one *Q-sorts* out of the total 82 did not load significantly, four factors were extracted and are depicted in Table 1. Table 1 further presents the results of the 15 statements, *Q-sort* values, and average *z-scores*.

Table 1: Factor characteristics of the *Q-sorts*

Statements	Factor 1		Factor 2		Factor 3		Factor 4	
	Q-value	Z-score	Q-value	Z-score	Q-value	Z-score	Q-value	Z-score
Desert locust is a serious threat	+2	1.74	-2	-1.77	+1	0.99	-2	-1.27
Desert locust invasion reduces incomes	+2	1.78	+1	0.43	0	0.22	+2	1.25
Information about control was available	-2	-1.30	0	-0.26	+1	0.97	0	0.18
Aware of better control management	0	0.04	0	0.19	+2	1.60	+1	0.90
Recovery assistance was offered following the invasion	-2	-1.73	-1	-0.74	+2	1.09	+2	1.47
Indigenous control measures reduced losses	+1	0.32	+1	0.45	+1	0.53	-2	-1.80
Community involved in desert locust control	0	0.27	+2	1.94	0	0.16	-1	-0.73
Indigenous control measures take time	+1	0.88	+2	1.23	0	-0.36	+1	1.19
Indigenous control measures require labour	0	0.30	+1	1.15	0	0.37	0	0.24
Formal control was timely	-1	-1.02	-2	-1.44	-2	-1.85	+1	0.51
Formal control was appropriately targeted	-1	-0.71	-1	-0.50	-1	-1.07	0	-0.08
Farmers were advised not to graze livestock in sprayed areas	-1	-0.40	-1	-0.89	-2	-1.34	0	0.50
Care was taken to limit side effects from chemical sprays	0	-0.22	0	0.03	-1	-1.06	-1	-1.10
Livestock affected by grazing in sprayed areas	+1	0.41	0	-0.15	-1	-0.40	-1	-0.81
Integrated desert control is the best strategy	0	-0.35	0	0.33	0	0.16	0	-0.43
Number of Q-sorts	16		15		12		18	
Eigen-value	23		12		8		6	
Explained variance (%)	22		18		16		15	

Criteria were met: Q-sorts that loaded +/- 0.50; Eigen-values greater than 1; the set of factors explained at least 35% of the variance

Table 2 presents the results of the Likert-scale analysis. Two criteria were applied: the Kaiser-Meyer-Olkin (KMO) test and Bartlett's test of sphericity. The KMO was 0.69 and fell within the range of 0.5 to 1, while Bartlett's test of sphericity was significant at the 1% level, indicating that component loading in each group had a significant relationship. Factor 1 defines statements related to the process of formal control and was labelled as "*formal control.*" Factor 2 defines issues related to the threat of desert locusts and information; this was labelled as "*risk awareness and information.*" Factor 3 highlights issues related to the positive use of indigenous control methods and combining them with formal control measures, thus labelled as "*integrated desert locust control management.*" Factor 4 describes the concerns held by farmers about the use of either indigenous or formal control measures; this can be labelled as "*control critics.*"

Table 2: Factor characteristics of Likert-scale data

Statements	Rotated components			
	Factor 1	Factor 2	Factor 3	Factor 4
Desert locust is a serious threat		0.89		
Desert locust invasion reduces incomes		0.88		
Information about control was available		0.80		
Aware of better control management		0.75		
Recovery assistance was offered following the invasion	0.75			
Indigenous control measures reduced losses			0.92	
Community involved in desert locust control			0.86	
Indigenous control measures take time				0.92
Indigenous control measures require labour				0.87
Formal control was timely	0.89			
Formal control was appropriately targeted	0.83			
Farmers were advised not to graze livestock in sprayed areas	0.78			
Care was taken to limit side effects from chemical sprays	0.77			
Livestock affected by grazing in sprayed areas				0.8
Integrated desert control is the best strategy			0.83	
Eigenvalues	3.27	2.8	2.3	2.27
Variance explained (%)	21.79	18.7	15.34	15.17
Cumulative variance explained (%)	21.79	40.48	55.82	70.99

Notes: Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy = 0.69; Bartlett's test of sphericity: Chi-square (df) = 2974.57 (105).

To better interpret the factor loadings as shown in Tables 1 and 2, both the *Q-sort* and Likert-scale data were subjected to internal consistency checks, and their results were compared. Table 3 presents the results of the Cronbach alpha test. Overall, the *Q-sort* data had higher values across all factors compared to the Likert-scale data. A plausible reason for this finding is that the *Q-method* employs by-person factor analysis to understand the shared viewpoints of individuals about a certain topic, making it more reliable compared to the conventional *R-method* (Maurer et al., 2020). Additionally, *Q-method* analysis identifies shared viewpoints by distinguishing or comparing them, unlike the *R-method,* which only estimates the proportion of the population that shares certain opinions. Based on these findings, the next section of the study discusses results based on the *Q-method*.

Table 3: Internal consistency checks

Q-sort technique		Likert-scaling	
Factors	Cronbach's alpha	Factors	Cronbach's alpha
Factor 1	0.98	Factor 1	0.86
Factor 2	0.87	Factor 2	0.84
Factor 3	0.94	Factor 3	0.84
Factor 4	0.99	Factor 4	0.82
Overall	0.94	Overall	0.72

3.2 Socio-economic and institutional characteristics

This section describes the socio-economic and institutional characteristics of households based on the four factors, herein defined as perspectives, derived from *Q-sort* analysis. Overall, the majority of the respondents were men (79%), slightly lower compared to the 85% reported by Tambo et al. (2019). A third of the respondents were over the age of 35, with a higher percentage falling under factor 4 (44%). Respondents on average had 12 years of farming experience, implying that most households start farming in adulthood (Table 4). Over 60% of the households had attained primary school education. Over 80% of the respondents owned private land, either in the form of a title deed or an allotment letter. The average TLU per household was 6; this was close compared to the average of 7 reported by Musungu et al. (2021). Over two-thirds of the respondents had experienced either a drought or pest or disease shock over the past five years, with an average of two waves of desert locust invasions between 2019 and 2020. The majority of the respondents were in social development groups (46%), compared to 10% in farmer groups. About 35% of the respondents had informal access to desert locust information, compared to 28% who had formal access. The main source of informal information was through verbal communication with other community members. The average distance to the nearest tarmacked road was 6 kilometres (km). Three-fifths of the respondents perceived that indigenous desert control methods had no or minimal costs. The average monthly household income (Ksh. 15,915) was lower than the national average of Ksh. 20,123 (KNBS, 2022).

Table 4: Socio-economic and institutional characteristics

Variables	Perspective 1	Perspective 2	Perspective 3	Perspective 4	Full sample
Gender of HH (1 =male)	0.75(0.45)	0.73(0.46)	0.75(0.45)	0.89(0.32)	0.79(0.41)
Age category (1 = Over 35)	0.25(0.45)	0.33(0.49)	0.25(0.45)	0.44(0.51)	0.33(0.47)
Years of farming	11.56(6.09)	13.47(8.16)	11.67(6.88)	11.78(7.76)	12.11(7.15)
Farming practice (1 = mixed-farming)	0.63(0.50)	0.40(0.51)	0.67(0.49)	0.39(0.50)	0.51(0.50)
Education (1 = Above primary)	0.44(0.51)	0.60(0.51)	0.75(0.45)	0.83(0.38)	0.66(0.48)
Tropical livestock units (TLUs)ᵖ	5.13(5.24)	7.08 (6.76)	5.68(5.48))	5.88(5.16)	5.93(5.58)
Land tenure (1 = private)	0.94(0.25)	0.80(0.41)	0.83(0.39)	0.83(0.38)	0.85(0.36)
No. of invasions	1.38(0.50)	1.60(0.51)	1.33(0.49)	1.56(0.51)	1.48(0.50)
Experienced drought (1 = yes)	0.63(0.50)	0.80(0.41)	0.58(0.51)	0.72(0.46)	0.69(0.47)
Experienced pest/animal shock (1 = yes)	0.63(0.50)	0.73(0.46)	0.92(0.29)	0.67(0.49)	0.72(0.45)
Farmer group (1 = yes)	0.13(0.34)	0.07(0.26)	0.17(0.39)	0.06(0.24)	0.10(0.30)
Social group (1 = yes)	0.38(0.50)	0.60(0.51)	0.67(0.49)	0.28(0.46)	0.46(0.50)
Sales farm produce (1 = yes)	0.81(0.40)	0.93(0.26)	0.83(0.39)	0.83(0.38)	0.85(0.36)
Formal access to desert locust information (1 = yes)	0.31(0.48)	0.13(0.35)	0.58(0.51)	0.17(0.38)	0.28(0.45)
Informal access to desert locust information (1 = yes)	0.31(0.48)	0.40(0.51)	0.17(0.39)	0.44(0.51)	0.34(0.48)
Location (1 = Meru)	0.63(0.50)	0.40(0.51)	0.67(0.49)	0.39(0.50)	0.51(0.50)
Tarmac distance (kilometres)	4.60(2.50)	7.00(2.49)	5.67(3.96)	6.32(4.41)	5.91(3.50)
Cost of control method (1 = Low cost)	0.56(0.51)	0.64(0.50)	0.70(0.48)	0.56(0.51)	0.57(.50)
Average monthly household income (Ksh)ᵘ	15106.75 (8981.42)	14800.00 (9465.73)	15483.30 (10218.15)	17850.00 (9988.08)	15914.75 (9493.49)
No. of observations	16	15	12	18	61

Standard deviations are in parentheses.

[ρ] Tropical livestock units (TLU) computed as: cattle = 1, camels = 1, donkeys = 0.8, goats and sheep = 0.2 & poultry = 0.04 (WISP, 2010).

[μ] 1 USD was equivalent to KES 116 at the time of the study

3.3 Interpretation of the four perspectives

This section characterizes farmers' perspectives based on their socio-economic and institutional characteristics. The Q-sort analysis allowed for the identification of the highest and lowest-ranked statements across the four perspectives. The numbers in parentheses refer to the statements and their respective positions in the hypothetical *Q-sorts*. For example, farmers loading on perspective 1 held the view that desert locust invasion reduces incomes (2: +2). Here, 2 is the statement number and +2 means that the household strongly agreed with the statement. Furthermore, the distinguishing statements that define a certain perspective are also shown.

3.3.1 Perspective 1: Threat-aware but unprepared

In the first perspective (Table 5), the results show farmers who understand the threat caused by desert locust invasion (2: +2), invasion reduces incomes (2: +2). Two viewpoints distinguish perspective 1 from the other categories: information control was available (3: -2) and recovery assistance was offered (5: -2). Sixteen farmers loaded significantly on perspective 1, characterized by a higher number of households owning private land (94%) compared to the other three groups, with the majority practicing mixed-farming. Farmers in this group disagreed that they either received control information or received any recovery assistance following the desert locust invasion. While acknowledging that indigenous control takes time (8: +1), they asserted that the use of these methods helped reduce losses (6: +1).

Table 5: Significant factor scores for perspective 1: Threat-aware but unprepared

Statement No.		Q-sort value	Z-score	Distinguishing statements
	Highest ranked statements			
2	Desert locust invasion reduces incomes	+2	1.78	
1	Desert locust is a serious threat	+2	1.74	
8	Indigenous control use takes time	+1	0.88	
14	Livestock affected by grazing in sprayed areas	+1	0.41	
6	Indigenous control reduced losses	+1	0.32	
	Least ranked statements			
12	Farmers were advised not to graze livestock in sprayed areas	-1	-0.40	
11	Formal control was appropriately targeted	-1	-0.71	
10	Formal control was timely	-1	-1.02	
3	Information about control was available	-2	-1.30	D*
5	Recovery assistance was offered following the invasion	-2	-1.73	D*

D* - Distinguishing statements ($p < 0.01$)

3.3.2 Perspective 2: Enthusiasts of indigenous control methods

The second perspective had 15 farmers loading significantly and is characterized by farmers with more years of farming experience, more livestock units (TLUs), and a greater percentage engaged in the sale of farm produce compared to the other perspectives (Table 6). On the other hand, most farmers experienced drought and had the lowest average monthly household incomes compared to the rest of the factors. Farmers loading on this perspective were much interested in the use of indigenous control methods, asserting that community members participated in desert locust control (7: +2). They acknowledged the flaws of indigenous control methods in terms of time (8: +2) and labour (9: +1). Respondents agree with those holding perspective one, disassociating themselves with the viewpoint that they received recovery assistance following the desert locust invasion (5: -1); this was their key distinguishing statement compared to perspectives 3 and 4. Overall, respondents were least concerned and disagreed with statements about formal control measures. They noted that formal control was not timely (10: -2), was not appropriately targeted (11: -1), and had no advice on grazing livestock in sprayed areas (12: -1). This underscores the challenge of unpreparedness in desert control, as highlighted by Showler (2019). Interestingly, farmers in this category show opposing views in that they strongly assert that desert locust invasion reduces incomes (2: +1), but also disagree that it is a serious threat (1: -2). A possible explanation is that farmers in this category consider drought (80% of them) to be a much more serious threat, as shown in Table 4.

Table 6: Significant factor scores for perspective 2: Enthusiasts of indigenous control methods

Statement No.		Q-sort value	Z-score	Distinguishing statements
	Highest ranked statements			
7	Community involved in desert locust control	+2	1.94	
8	Indigenous control use takes time	+2	1.23	
9	Indigenous control requires labour	+1	1.14	
6	Indigenous control reduced losses	+1	0.45	
2	Desert locust invasion reduces incomes	+1	0.43	
	Least ranked statements			
11	Formal control was appropriately targeted	-1	-0.50	
5	Recovery assistance was offered following the invasion	-1	-0.74	D*
12	Farmers were advised not to graze livestock in sprayed areas	-1	-0.89	
10	Formal control was timely	-2	-1.44	
1	Desert locust is a serious threat	-2	-1.77	

D* - Distinguishing statements ($p < 0.01$)

3.3.3 Perspective 3: Proponents of information access

Twelve farmers loaded significantly on the third perspective. This perspective is held by mixed farmers with greater participation in social groups and markets who are located in Meru, with the highest percentage of those who perceived indigenous control to be less costly, had better access to formal information on control compared to those holding different perspectives, and had the second highest level of household income (Table 7). Farmers holding this perspective are emphatic about information and its importance in desert control. This is asserted by their viewpoints: they are aware of better desert locust control (4: +2) and that this information is readily available (3: +1). This is in line with Mwenda et al. (2023), who highlighted the importance of information in improving awareness of pest control. Furthermore, farmers in this category understand that desert locust is a threat (1: +1) and that the use of indigenous control methods reduces losses (6: +1); this viewpoint distinguishes them from perspectives 1 and 4 but aligns them with perspective 2. Moreover, they disassociate from the effectiveness of formal control measures. Unlike farmers in perspective 4, they disagree that formal control was timely (10: -2) and appropriately targeted (11: -1).

Table 7: Significant factor scores for perspective 3: Proponents of information access and use in desert locust control

Statement No.		Q-sort value	Z-score	Distinguishing statements
	Highest ranked statements			
4	Aware of better control management	+2	1.60	
5	Recovery assistance was offered following the invasion	+2	1.09	
1	Desert locust is a serious threat	+1	0.99	
3	Information about control was available	+1	0.97	
6	Indigenous control reduced losses	+1	0.53	
	Distinguishing statement			
8	Indigenous control is labour-intensive	0	-0.36	D*
	Least ranked statements			
14	Livestock affected by grazing in sprayed areas	-1	-0.40	
13	Care was taken to limit chemical use side effects	-1	-1.06	
11	Formal control was appropriately targeted	-1	-1.07	
12	Farmers were advised not to graze livestock in sprayed areas	-2	-1.34	
10	Formal control was timely	-2	-1.85	

D* - Distinguishing statements ($p < 0.01$)

3.3.4 Perspective 4: Advocates of timely control and post-recovery assistance

Eighteen farmers loaded significantly on the fourth perspective (Table 8). Compared to the others, those holding this perspective are mainly older males, with the highest percentage having informal access to desert locust information and the highest average household income. Unlike perspectives 1 and 2, farmers in this group assert that there was recovery assistance following the desert locust invasion (5: +2). They hold the view that formal control was timely (10: +1), differing from the other categories that lowly ranked this statement. Farmers holding this perspective are not much influenced by the use of indigenous control methods. They agree that indigenous control methods take time (8: +1), a distinguishing statement, further viewing these methods as not being effective (6: -2). Despite the positive view of formal control, they disassociate from the perspective that chemicals used in formal control had no side effects (13: -1).

Table 8: Significant factor scores for perspective 4: Advocates of timely control intervention and post-recovery assistance following desert locust invasion

Statement No.		Q-sort value	Z-score	Distinguishing statements
	Highest ranked statements			
5	Recovery assistance was offered following the invasion	+2	1.47	
2	Desert locust invasion reduces incomes	+2	1.25	
8	Indigenous control use takes time	+1	1.19	D*
4	Aware of better control management	+1	0.90	
10	Formal control was timely	+1	0.51	D*
	Least ranked statements			
7	Community involved in desert locust control	-1	-0.73	D*
14	Livestock affected by grazing in sprayed areas	-1	-0.81	
13	Care was taken to limit chemical use side effects	-1	-1.10	D*
1	Desert locust is a serious threat	-2	-1.27	
6	Indigenous control reduced losses	-2	-1.80	

D* - Distinguishing statements ($p < 0.01$)

3.3.5 Consensus statement

The analysis process also involved identifying any consensus statements, that is, statements that do not distinguish between any pair of factors (Table 9). Among the 15 statements, all farmers in the four categories were indifferent and held similar views about integrating desert locust control measures. Farmers held neutral views concerning the combination of formal and indigenous control methods in the management of desert locusts, implying a shared perspective. This finding agrees with previous studies such as Shuang et al. (2022), Pandey et al. (2021), and Githae and Kuria (2021), who observed that a strategy that combines surveillance, chemical, biological, and indigenous control methods is the most effective in desert locust management.

Table 9: Consensus statements

		Category 1		Category 2		Category 3		Category 4	
No.	Statement	Q-sort	Z-score	Q-sort	Z-score	Q-sort	Z-score	Q-sort	Z-score
15	Integrated desert control is the best strategy	0[a]	-0.35	0[a]	0.33	0[a]	0.16	0[a]	-0.43

[a] Consensus statement ($p > 0.01$)

3.4 Discussion

From the above description of the four farmer perspectives derived from *Q-method* analysis, three key aspects emerge. First, farmers holding perspectives 1 and 3 present the urgency for decision-makers to improve surveillance and leverage advanced technologies and information to mitigate desert locust losses. Brown et al. (2022) highlighted the importance of designing user-friendly early warning systems to mitigate against huge pest losses. This argument is supported by Showler and Lecoq (2021), who observed that the prevention of desert locust invasions requires timely intervention measures through utilizing existing information. Secondly, perspective 4 highlights the importance of post-recovery assistance in helping farmers steadily get back to farming activities. This implies that farmers are usually left vulnerable following desert locust invasions, and there is a need to safeguard their livelihoods (FAO, 2020b). Lastly, a key theme that cuts across all four perspectives is related to desert locust control methods. Farmers holding perspective 2 highlight the importance and challenges of using indigenous control methods.

Additionally, the findings revealed some considerable parallels. Across all the discussed perspectives, except for those holding perspective 4, farmers held the perception that formal control measures were not timely and that implementation had negative effects on human and livestock health. These particular statements are ranked lower in perspectives 1, 2, and 3. These findings point out the challenges of desert locust control in terms of the lack of coordinated efforts, funding, and use of harmful chemicals (Githae & Kuria, 2021; Showler et al., 2022). A key result is that farmers in all the perspectives described agree that integrated desert locust control is the best strategy. This requires a combination of both formal and indigenous control measures. The rational use of chemicals, bio-control measures (for example, the use of microorganisms), and indigenous control measures have been suggested as the best control strategies (Githae & Kuria, 2021; Pandey et al., 2021; Showler et al., 2022; Shuang et al., 2022).

3.5 Conclusion and recommendations

The need for greater stakeholder engagement has emerged as one important avenue in policymaking and implementation. Understanding farmers' perspectives or their perceptions is critical, as it allows for their inclusion in improving agricultural practices. The *R-method* identifies perceptions as patterns through by-item analysis, while the *Q-method* provides a "bottom-up" approach as it allows for farmers to express their subjective viewpoints on a certain issue (by-person analysis). The study compared both methods through Likert-scaling and *Q-sort* techniques; the latter provided better internal consistency scores and was used subsequently. The study identified four farmer perspectives on desert locust management. Further analysis enabled the identification of socio-economic and institutional characteristics based on the farmer categories. Rather than a standardized one-size-fits-all policy process that predefines what farmers need based on unrepresentative criteria, there is a need to account for varying perspectives associated with farming complexities. Adapting measures to respective farmers' contexts while accounting for different perspectives would help in the uptake of integrated desert locust control measures.

Although farmers' perspectives are not observable and policymakers need to treat all equally, a mix of policies can accommodate the existing diversity. One important insight from the findings is the importance of information in making farmers aware of control measures and community engagement in implementation. While the interpretation of early warning system information may be complex for farmers, tailoring messages related to possible desert locust invasion and mitigation efforts simply and clearly would ensure farmers adhere. Local community leaders can be trained in desert locust management and act as information agents for other community members. This will ensure the identification and use of the most effective indigenous control measures as well as adherence to guidelines required during and after formal control measures such as spraying. This would help minimize the negative effects of chemical spraying on human and livestock health.

This study confirmed that desert locust is a threat and reduces households' incomes. While there are strategies to prevent desert locust invasion, pertinent challenges such as lack of resources may limit swift control of multiple waves of invasion. Another insight from this study is that post-recovery assistance is important. In this regard, local and national authorities should identify the most vulnerable farmers and formulate possible recovery measures. This could include the provision of inputs, for example, crop and pasture seeds, alternative feed for livestock, and unconditional cash transfer programs to help safeguard livelihoods.

While this study employed a mixed-methods approach, it faced some challenges. First, the study did not capture the perspectives of other stakeholders, such as desert locust management staff at the local and national level as well as transboundary pest management specialists. Future research could focus on assessing perspectives from other stakeholders to gain clear insights that would improve desert locust management. Secondly, the duration of the study did not allow a detailed assessment based on Likert-based survey interviews for the households that participated in the *Q-sort* process. Future studies could pay attention to this issue by interviewing the same set of farmers and other stakeholders separately using a Likert-based survey followed up by a *Q-sort* survey or vice-versa. Nevertheless, the present study made the first step in characterizing farmers and identifying the range of perspectives among them. It then compared both the *R* and *Q-methods,* building on the strengths of both methods, so that future research on examining perceptions and pest management policies can build upon the foundation of this study.

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Conflict of interest

None.

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