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Learning from farmers' knowledge on participatory irrigation management using Q-methodology

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Abstract

To sustain the performance of irrigation schemes, it is important to involve all stakeholders and enhance their management capacity. Using the Q-methodological approach, drivers of farmers' perceptions of the management of public irrigation schemes were explored, taking the Doho rice irrigation scheme as a case study. Thirty-nine male and female scheme farmers were selected from all 11 blocks based on the total number of Q-set items. For each participant, an after-Q-sort interview was conducted to verify the Q-sorting data. Farmers perceived that the establishment of a cooperative society, rehabilitation of the scheme and implementation of punishments for water-user fee defaulters are among the major factors in improving the performance of the scheme and thus the general increase in rice yield. However, there is a need to improve scheme performance by introducing new technology, capacity building through training and incentives. Based on the Q-sorting data analysis, four discourses were identified and summarized: (1) paying farmers; (2) disengaged farmers; (3) maintenance farmers; and (4) accountable farmers. All these factors contribute to key management challenges and thus to scheme performance. Local knowledge of the performance of existing schemes based on farmers' experiences is instrumental in guiding policy-making towards sustaining planned irrigation schemes and thus contributes to improved agricultural production and livelihoods.

KEYWORDS

Doho rice irrigation scheme, farmers' perceptions, livelihoods, local knowledge, performance

Résumé

Pour maintenir la performance des systèmes d'irrigation, il est important d'impliquer toutes les parties prenantes et de renforcer leurs capacités de gestion. En utilisant l'approche Q-méthodologique, les facteurs de perception des agriculteurs de la gestion des périmètres d'irrigation publics ont été explorés, en prenant le périmètre d'irrigation du riz Doho comme étude de cas. Trente-neuf agriculteurs, hommes et femmes, ont été sélectionnés parmi les 11 blocs

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en fonction du nombre total d'articles Q-set. Pour chaque participant, une entrevue de tri après Q a été menée pour vérifier les données de tri Q. Les agriculteurs ont estimé que la création d'une société coopérative, la réhabilitation du programme et la mise en œuvre de sanctions contre les défaillants de la redevance d'utilization de l'eau sont parmi les principaux facteurs d'amélioration des performances du programme et donc de l'augmentation générale du rendement du riz. Toutefois, il est nécessaire d'améliorer les performances du programme en introduisant de nouvelles technologies, en renforçant les capacités par la formation et en incitant. Sur la base de l'analyse des données de tri Q, quatre discours ont été identifiés et résumés: 1- agriculteurs payeurs; 2- agriculteurs désengagés; 3-agriculteurs d'entretien; et 4 agriculteurs responsables. Tous ces facteurs contribuent aux principaux défis de gestion et donc à la performance du programme. Les connaissances locales sur la performance des périmètres existants, fondées sur l'expérience des agriculteurs, sont essentielles pour orienter les décisions politiques en vue de maintenir les périmètres d'irrigation planifiés et contribuent ainsi à l'amélioration de la production agricole et des moyens de subsistance.

MOTS CLÉS

perceptions des agriculteurs, connaissances locales, performance, moyens de subsistance, projet d'irrigation du riz de Doho

1 | INTRODUCTION

Irrigation schemes contribute significantly to increasing agricultural productivity, ensuring food security, reducing poverty levels and promoting economic growth and livelihoods (MAAIF and MWE, 2017; Waalewijn et al., 2020; Yohannes et al., 2017). Effective management of irrigation schemes is required to rationalize further irrigation development and to guarantee sustainability. Participatory irrigation management (PIM) refers to the involvement of stakeholders, particularly the users of an irrigation scheme, in management and operational decisions at all levels (Narayanan, 2014). The strengths of PIM originate from its management cost-effectiveness, provision of incentives for action by users and management efficiency because there is rapid response to problems, promotion of effective and proper planning and a sense of proprietorship and accountability (Pék et al., 2019). These systems include people, institutions, infrastructure, farms and landscapes and beneficiaries or affected communities. There is a need for a proper policy framework at all levels, including policy formulation, implementation, monitoring and evaluation, following an integrated, cross-sectoral and participatory approach (Bjornlund et al., 2020; Wanyama et al., 2017). Participation should always go beyond publicizing irrigation management and research and development information.

In the context of increasing management pressures and the limited performance of irrigation schemes, it is vital to pay attention to the sustainable management and performance of irrigation schemes (Svendsen & Small, 1990; Waalewijn et al., 2020; Yakubov, 2012). The participatory approach of operation and maintenance is a feasible and effective option for sustaining irrigation schemes (Yohannes et al., 2017). To improve agricultural production and productivity, most developing countries have established several institutional support tools and strategies, including irrigation policies. These policies clearly indicate the necessity of establishing a management structure responsible for ensuring adequate water quantity and quality. Despite policies encouraging participation, in some countries such as Nepal, the PIM approach has been considered a 'failure' (Singh et al., 2014).

Globally, there have been various studies on stakeholders' perceptions of irrigation scheme management and performance (Johnson et al., 2023; Muhoyi & Mbonigaba, 2022; Yohannes et al., 2017). However, to the best of our knowledge, no study has focused on understanding the driving factors behind farmers' perceptions of the management and performance of irrigation schemes in Uganda.

The main aim of this study was to examine, using Q-methodology, the factors that influence farmers' perceptions regarding the management and performance of irrigation schemes. The study was guided by the following research question: How do individual farmers perceive irrigation scheme management and performance? The Doho rice irrigation scheme (DRIS) in Uganda was used as a case study with findings applicable to other irrigation schemes in developing countries. The management of DRIS was evaluated by facilitating stakeholder participation through interviews and Q-methodology. The co-produced knowledge on irrigation scheme management and performance can empower actors to make appropriate irrigation management decisions. The findings of this study are crucial for designing customized irrigation management interventions.

2 | METHODOLOGY

2.1 | Description of the study area

The DRIS is located in the Butaleja district, eastern Uganda, at 34^0 02′E and 0^0 56′ N and at an elevation of 1135 m above sea level (Oonyu, 2011). Currently, the DRIS is the largest operational irrigation scheme in Uganda, occupying an area of 2500 ac 1011 ha, of which 963 ha are cultivated with the remaining 48 ha covered by irrigation structures. Rice is the major crop grown year-round within the scheme, with two to three crops planted per year on each field, and approximately 6800 t of rice are harvested each year. Two crops are planted during the two rainy seasons of the year (March–May and August–October), fully utilizing the rainfall with supplementary irrigation. The third crop is planted at the end of the second rainy season, extending into the dry season or in the dry season (January) and is mostly irrigated with the little rainfall (Awio et al., 2022). The DRIS is located in a bimodal rainfall zone; thus, farmers have been engaged in the double cropping of rice for several decades. The average annual rainfall and temperature of the region are 1186 mm and 22.7°C, respectively. Topographically, it is an alluvial land formed by the alluvial action of the Manafwa river, sloping from east to west with a gradient of 23 in 10,000. The soils within the scheme are plinthosols that are reddish brown in colour, sandy loam and loam textured (Tenywa et al., 2016). The Manafwa river, which originates from Mt Elgon, is the major source of water for this region. At the time of the field visit, 4208 registered farmers had benefited from the project, with 3927 owning plots in the scheme, and the average plot size in the scheme was 0.5 ac according to the scheme's technical office.

The DRIS was established with the aim of helping farmers practise irrigated rice farming and of managing persistent flooding and waterlogging that affected the area. However, similar to most of the schemes, the DRIS was abandoned due to several factors, including but not limited to government failure to develop adequate operation and maintenance mechanisms to ensure the sustainability of the irrigation schemes (Namyenya et al., 2014). In 2012, a 21 billion shillings rehabilitation project of the DRIS was undertaken by the Uganda government (MWE, 2011).

2.1.1 | The structure of the DRIS

The scheme is situated in the lowland areas of Butaleja district and is under the ownership of Uganda's government, with the farmers eligible for a 99-year lease of the plots within the scheme. Most farmers are organized into the Doho Irrigation Scheme Farmers' Cooperative Society (DIFACOS), which is managed by farmers' elected boards. At the time of the study, there was a government irrigation management office where several staff members, including technical support teams, were involved. However, apart from their salaries plus periodic support for maintenance of the channels, the government provides no monetary funding for the scheme (Jetter & Kok, 2014; Oonyu, 2011).

There are several land uses in the scheme: from their upland plots, farmers cultivate several crops, and most areas surrounding the scheme are mainly for human settlement. However, some areas act as floodplains and grazing land for animals in the rainy and dry seasons, respectively. The most important economic activities carried out in the scheme in addition to rice cultivation include livestock and poultry keeping, sand mining, fishing, rice milling and processing in addition to handcrafting.

The structure of the DRIS (Figure 1) shows that the scheme was partitioned into 11 blocks (1A, 1B, 2A, 2B, 3, 4A, 4B, 5A, 5B, 6A and 6B) to facilitate water distribution management, with each block interconnected by main, sub and tertiary channels (Bwambale et al., 2019a; Namyenya et al., 2014). At the inlet to the scheme, the main channel abstracts water from the Manafwa river and then divides the irrigation water between the different scheme blocks. Water in the blocks is delivered by the subchannels to the different small irrigation strips. For each of the irrigation strips, there is a tertiary channel for delivering water to farmers' plots. Additionally, each strip has tertiary drainage for removing the used water. From the tertiary and subdrainage, all the drainage water collects in the main drainage channel. From here, the main channel pours the drainage back into the Manafwa river.

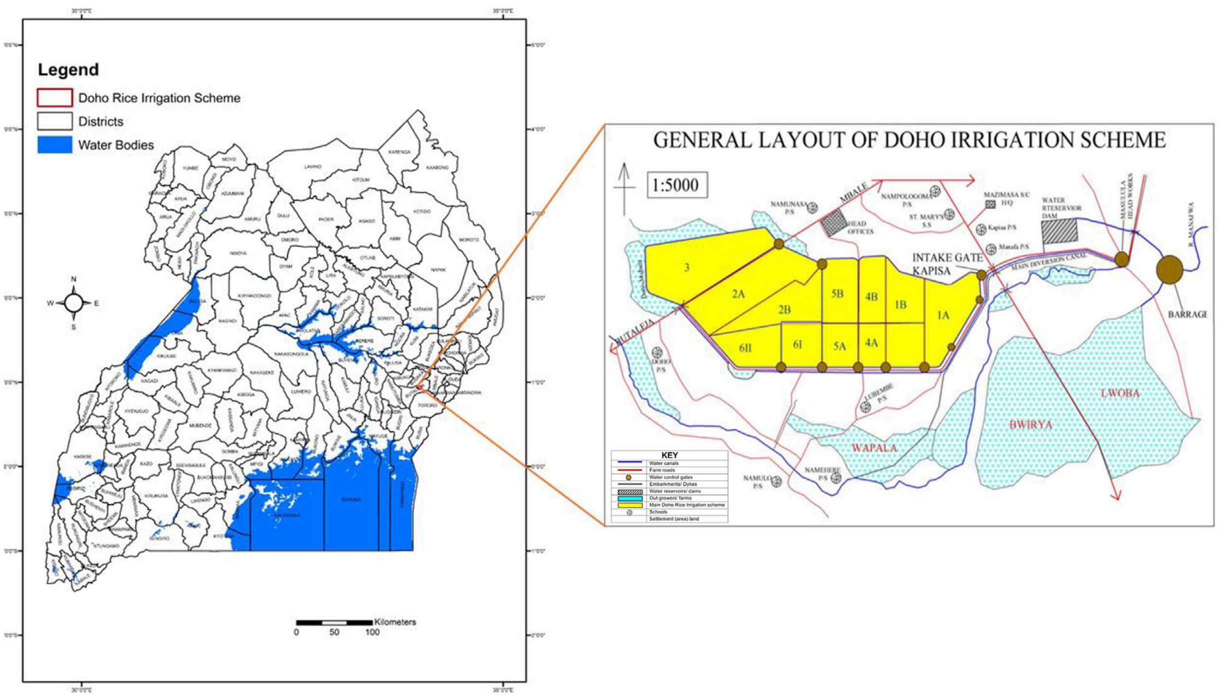

FIGURE 1 Map of Uganda showing the location of study area and general layout of Doho rice irrigation scheme source.

2.2 | General overview of Q-methodology

Q-methodology is a technique developed by William Stephenson in the 1930s to explore viewpoints by participants (Damio, 2016; Watts & Stenner, 2012). The tool recognizes groups of people with interestingly similar or deviating viewpoints and is used for discourse analysis (Brown, 1980; Webler et al., 2009). This approach combines both qualitative and quantitative methods while exploring subjective studies. Q-methodology participants are compelled to rank each statement relative to the other statements generally within a forced distribution (Webler et al., 2009). The Q-sorts, sets of statements arranged by each participant, are comparable for comprehending the subjective perceptions of individuals. All participants' Q-sorts can be statistically correlated, and factors with significantly diverse characteristics representing socially different perceptions of the study objective can be generated (Sudau et al., 2022). This approach has mainly been applied to personal experience, values and beliefs (Damio, 2016), rural sociology (Leonhardt et al., 2022; Sneegas et al., 2021), water resource management, irrigation management and environment-related research (Tariq et al., 2022; van Dijk et al., 2022). While exploring the relationships between policies and farmers' strategies, van Dijk et al. (2022) applied the Q-methodology to explore farmers' viewpoints on decision-making in regard to water transport technologies. This approach has also been used in assessing the performance of irrigation schemes and agricultural production (Esteves et al., 2023; van Dijk et al., 2022) and in exploring farmers' livelihoods (Maurer et al., 2021). Q-methodology is additionally recommended for studying subjectivities (Brown, 1980). The approach enables one to gain knowledge of participants' understanding of the subject under study. In this study, Q-methodology was applied to explore factors that influence farmers' views and experiences with the performance and management of large-scale irrigation schemes using Uganda's DRIS as a case study. To this end, means of translating these management perspectives into relevant indicators for the evaluation of farmers' livelihoods were identified. In this study, irrigation management and performance are acknowledged as related concepts (Oad & Sampath, 1995) and thus can be interchangeably considered to ascertain the sustainability of irrigation schemes.

2.3 | Q-set design and content

DRIS performance reports and related (scientific) literature reviewed (Waalewijn et al., 2020) were used to generate a Q-set, a collection of items (statements). To design 'statement selection', an approach suggested by Watts and Stenner (2005) was considered. Initially, 54 items were developed, which, together with DRIS administration, irrigation experts at water resources engineering and agricultural mechanization and irrigation

TABLE 1 Factor arrays for the study factors.

Item no.	Statement	Factor arrays F1	F2	F3	F4
1	Water distribution rules are well devised.	2	0	2	2
2	Farmers are involved in determining water rates.	−3	2	0	−1
3	Operation and maintenance are adequate in the scheme.	3	−2	0	0
4	Maintenance costs at the scheme are high.	−1	0	-3	2
5	Farmers participate in maintenance activities.	3	-1	−2	0
6	Scheme activities are monitored.	1	4	0	3
7	IWF collections by association are adequate.	4	-1	-2	1
8	Farmers are well coordinated and attend meetings.	2	2	0	1
9	Government support/funding to scheme activities is adequate.	−3	−1	−4	−4
10	Crop produce markets are efficiently available.	−2	2	−3	−1
11	New technology is introduced in the scheme.	−2	0	−1	−2
12	Plots are properly allocated to farmers within the scheme.	1	2	2	−2
13	Political attitude predominates over economic attitude towards cooperative activities.	−4	−4	−3	−4
14	Guidelines and technical documents for irrigation water use are well devised.	0	−1	−2	1
15	Farmers are consulted when establishing water-use committees.	1	3	2	−2
16	Scheme farmers have diverse income sources.	−4	−4	−4	−3
17	Farmers receive enough total quantity of irrigation water.	3	−2	3	0
18	The biological and chemical quality of irrigation water supplied is safe for crops.	0	−2	1	−1
19	Farmers receive water according to the agreed-on schedule and with predictability.	1	−2	3	2
20	Irrigation water is distributed fairly and timely across all scheme farmers' plots.	2	−3	3	−3
21	Farmers decide on cropping and irrigation methods in the scheme.	−3	−3	−1	−3
22	The cost of irrigation service is affordable compared to crop productivity (yield).	2	1	1	0
23	The physical infrastructure is fit to deliver required level of irrigation service.	2	1	0	0
24	Sufficient resources are budgeted for and mobilized to manage, operate, maintain and replace irrigation infrastructure.	−2	0	−1	1
25	Farmers have financial ability to pay IWF.	4	0	2	−1
26	IWF collection mechanisms are enforced.	0	−2	0	1
27	Setting IWF is participatory and effective.	0	3	0	2
28	There is access to finance for scheme management from commercial sources.	−1	−1	−1	−1
29	The organizational structure and decision-making are clear and functional.	1	3	4	4

(Continues)

TABLE 1 (Continued)

		Factor arrays			
Item no.	Statement	F1	F2	F3	F4
30	Scheme staffing composition is adequate to fulfil the scheme mission.	−1	0	1	−2
31	There is an effective staffing plan.	−1	0	1	−2
32	There is a transparent and merit-based staff performance and reward system in the scheme.	−2	1	−1	2
33	Management is transparent and accountable to water users and stakeholders.	0	4	4	4
34	Management involves staff and users in institutional improvement processes.	0	0	0	3
35	There is an effective communication strategy and feedback from management.	0	1	1	0
36	Information on scheme operation and service delivery is routinely and effectively measured and documented.	−2	−1	−2	1
37	Conflict management mechanisms are in place to enable debate and resolve conflict regarding irrigation service.	−1	1	−2	0
38	There is adequate tracking of conflicts and analysis to overcome structural problems.	−1	1	1	0
39	Farmers are engaged in the accountability of the irrigation service delivery agency.	1	−3	−1	3
40	Women, youth and marginalized groups are well represented in water-user groups, empowered and involved in dialogue and in decision-making.	0	2	2	−1

Abbreviation: IWFs, irrigation water fees.

engineering departments of Busitema University, were revised and reduced to 40 items. Involving extensive interest groups in item explanations is a pivotal incentive in providing participants with a wider range of statements and thus wider opinions on PIM. A balanced and unbiased group of seven participants, two from the DRIS administration and five from both departments of Busitema University, were selected based on their experience, knowledge and opinions on irrigation water management, management, operation, maintenance and replacement of irrigation infrastructure and participatory irrigation scheme management. The participants were invited to participate in a 1-day workshop to express their opinions and viewpoints for each of the 54 items, which clearly indicated similarities among the statements. The final list of items is presented in Table 1.

2.3.1 | Preparation and rules followed in Q-sorting and interviews

Prior to sorting the items, each participant (DRIS participant) was requested to sign consent forms and fill out or provide pre-sorting information. The research question was read out to each participant. Additionally, a list of written instructions and a blank Q-sorting distribution table were provided for each participant. Printed (A3) cards illustrating the distribution of ranking values with the highest on the right, zero in the middle and lowest on the left were placed in front of each participant. By explaining their importance to the research question, Q-set cards (same size and colour, numbered using a random number table) were placed in front of each participant in a single pile. Participants were asked to sort the provided items in order of their best experience. Participants were provided with an applicable printed blank sorting distribution to guide them on the number of Q-sorts to be allocated to each ranking value and the general shape of distribution to produce. For each participant, a post-sorting face-to-face interview was conducted using an open-ended questionnaire to enrich and increase the quality of the collected data. Post-sorting information included personal or demographic data that were considered to influence participants' perceptions and was important for factor interpretation. Thirty-nine participants (10 females and 29 males) were interviewed from all 11 blocks of the irrigation scheme.

2.3.2 | Q-sorting

Each participant was asked to read through all statements and make three piles: (1) positive/agree with, (2) negative/disagree and (3) neutral/neither agree or disagree with the items. To avoid confusing the piles, a negative item pile was placed above (−4), and a neutral item pile was placed above (0). If participants could not read, statements were read out for them. By referring to the distribution, each participant was asked to pick up the agreed-with pile, read through the statements again and select the two statements they agreed with most and place them on the pyramid on the 'most agreed' (+4). Each participant was then asked to pick up the remaining statements of the agreed pile, read through the statements again and select the three statements they agreed with most and place them on the pyramid on the 'agreed' (+3). This was continued until each participant had finished placing all 'agreed statements' on the pyramid. Then, each participant was asked to pick up the disagreed pile, read through the statements again, select the two statements they disagreed with most and place it on the pyramid on the 'most disagreed' (−4). Each participant was asked to pick up the remaining statements of the disagreed pile, read through the statements again, select the three statements they agreed with most and place them on the pyramid on the 'agreed' (−3). This was continued until each participant finished placing all disagreed statements on the pyramid. Later, each participant was asked to pick up the statements that were piled neutral and read through the statements. In the case of any agreed-upon boxes still being blank, a participant was asked to select those statements with which they agreed and place them in the empty agreed-upon boxes. If a participant had more items he/she would like to put in a given ranking than available slots/boxes, he/she was encouraged to put extra to the next ranking value(s). All participants were encouraged to refer to the research team if they did not understand a particular word or entire item(s). The logic of sorting the negative items immediately after the positive ones was explained to each participant. Finally, each participant was asked to place the remaining statements in the empty boxes in the neutral zone of the distribution. A selection of pictures of some farmers who participated in Q-sorting and post-sorting face-to-face interviews is presented in Figure 2.

2.3.3 | Recording the Q-sort

Upon completion of each Q-sort, participants were asked to have a final look at the configuration, checking whether the correct number of items appeared at the appropriate ranking values. Then, the appropriate numbers were recorded by the researcher as the blank distribution. On the distribution table, lines delineating the extent of the three preliminary categories were drawn by the research team. A note with the participant's name next to the pyramid was placed by the research team, and a picture was taken. After ensuring that all statements were readable, each participant participated in a post-sorting interview.

2.4 | Study participants and administering the Q-sort

An inception meeting with DRIS farmers and managers was conducted at the scheme offices to identify and recruit potential Q-methodology participants. Q-sorted participants were selected following recommendations by Watts and Stenner (2005), that is, a minimum of one participant for every pair of Q-set items. Each participant independently sorted the Q-set and was interviewed by the researcher at the end of the Q-sorting. To understand the participants' rankings, each participant was given an opportunity to express views that were not captured in the Q-set. This information was useful in interpreting the factors from the statistical analyses. The frequency distributions used during the study are presented in Table 2.

2.5 | Statistical analysis

This study aimed to explore as much as possible more factors driving farmers' voices regarding the management and performance of the scheme. Watts and Stenner (2012) recommended a method of analysis that is sensitive and responds to participants' perceptions in the data sets, satisfies the study aims, is statistically and theoretically suitable and benefits the target audience of the study findings. In this study, PQMethod version 2.35 with PQROT 2.0 http://schmolck.org/qmethod/downpqwin.htm (Schmolck, 2002) was used to analyse the data sets.

2.5.1 | Factor extraction and analysis

The correlation matrix, a measure of nature and extent including similarities of each Q-sort with each other in the Q-set, was determined. Centroid factor analysis was performed. Extracting two centroids/factors gave a higher average squared residual correlation of 0.023. According to Watts and Stenner (2014b), the process of factor extraction involves identifying patterns of similarity among Q-sort arrangements. Factor loadings expressed as

FIGURE 2 A selection of pictures of some farmers who participated in Q-sorting and post-sorting face-to-face interviews.

TABLE 2 Frequency distribution.

Forced-choice frequency distribution									
Ranking value	−4	−3	−2	−1	0	+1	+2	+3	+4
Number of items	2	3	5	6	8	6	5	3	2

correlation coefficients were extracted from the DRIS data set, with the first factor accounting for the largest study variance. The decision on the number of factors to be extracted from the data set and retained in the final solution was based on Webler et al. (2009). According to the Kaiser–Guttman criterion, eigenvalues less than 1.00 were considered the cut-off for the extraction and retention of factors because they account for less variance than a single sort (Watts & Stenner, 2014a). However, the Kaiser–Guttman method can lead to the extraction of meaningless factors; thus, a 'magic number 7' is considered a starting point (Watts & Stenner, 2005). Factors were extracted considering statistical guidelines, a factor's substantive meaning and configuration (Watts & Stenner, 2014b). Additionally, extracting one factor for every six–eight participants is recommended by Watts and Stenner (2014b); thus, four–five factors could be extracted for our study. However, Balch and Brown (1982) and Watts and Stenner (2005, 2014b) emphasize the significance of extracting more factors ahead of time, and thus, magic number 7 was started with

$$\text{Residual correlation} = \text{original correlation} - (\text{Factor loading first Q sort} \times \text{Factor loading second Q sort}) \quad (1)$$

$$\textit{E}\text{igen values (EV) for Factor 1} = (\text{Q sort 1 loading on Factor 1})^2 + (\text{Q sort 2 loading on Factor 1})^2 + \ldots(\text{Q sort } N \text{ loading on Factor 1})^2 \quad (2)$$

$$\text{A factor's variance} = 100 \times (\text{EV/No. Q sorts in study}) \quad (3)$$

Both EV and factor variances potentially indicate how strong and powerful an extracted factor is (Watts & Stenner, 2014b). According to Brown (1980) and Kline (1994), factors account for an overall percentage of 35–40 or above. When calculating significant factor loadings for studies considering the 40 statements, we considered two or more factor loadings that were significant at the 0.01

level. Therefore, the significant loading for our study was as follows:

$$2.58 \times ((1/\text{sqrt}(\text{no.of items in Q} - \text{set} = 2.58 \times (1/\text{sqrt}(40)) = 0.408 \text{ rounded to } 0.41 \quad (4)$$

The factor loadings listed in the PQMethod 'unrotated factor matrix' were then checked to verify whether the study factors satisfied the criteria. Brown (1980) emphasized that according to the Humphrey rule, a factor is significant if the cross-product of its highest loadings, ignoring the sign, exceeds twice the standard error. From the current study,

$$\text{Standard error} = 1/(\text{square root}\,(\text{number of items in Q} - \text{set})) = 1/(\text{square root}\,(40)) = 0.158 \quad (5)$$

$$\textbf{rounded to 0.16, and thus twice} = \mathbf{0.32}$$

2.5.2 | Factor rotation

Factor rotation aims to position each study factor such that its viewpoint closely approximates the viewpoint of a particular group of Q-sorts or any Q-sort(s) of certain importance (Watts & Stenner, 2012, 2014b). The factor rotation method can be by hand (PQROT) or by the varimax method, which rotates factors, positioning them based on statistical criteria so that factors collectively account for maximum study variance and thus allowing a researcher to recover a mathematically preferable solution (Watts & Stenner, 2014b). By hand, this approach is preferable in the case of interest in minority/marginalized viewpoints of the study (Brown, 2006). Since a considerably larger data set ($N = 40$) was considered, (objective) varimax rotation was chosen. For the current study, an inductive analytic strategy involving the viewpoints of the majority of the participants was used. The factors were rotated by the varimax method to explore whether the viewpoints of several factors were satisfactorily focused from the perspective of the post-Q-sorting interview. According to Equation (4), the significant factor loadings are greater than 0.41. Factor estimates are determined by a weighted averaging of all the Q-sorts that load significantly on a given factor. Factor estimates can be created, for instance, by considering factor loadings of 0.5/0.6 for the relevant factor and less than 0.5/0.4 for all other factors (Taherdoost et al., 2014). Reliability decreases as the number of defining Q-sorts decreases (Watts & Stenner, 2014b). According to Webler et al. (2009), a factor estimate comprising three or more Q-sorts is safer. Factor weights and Z-scores were calculated using Equations (6) and (7):

$$\text{Initial factor weight (Q sort 1)} = \text{Factor loading} \div \left(1 - \text{Factor loading}^2\right) \quad (6)$$

$$\begin{aligned}\text{Score for item 1(in relation to factor 1)} &= (\text{Total weighted score for item 1} \\ &\quad - \text{Mean of total weighted scores for all items}) \\ &\quad \div \text{SD of total weighted scores for all items}\end{aligned} \quad (7)$$

Factor arrays form the basis of factor interpretation because they imitate the format in which a data set was originally collected (Brown, 1980). Factors are also considered viewpoints and thus need to be represented in the form of a single Q-sort (Watts & Stenner, 2014b). Factor interpretation can be effectively carried out based on Z-scores. The communication (h^2) was calculated using Equation (8):

$$H\text{\^{}}2\,(\text{Q sort 1}) = (\text{Q sort 1 loading on Factor 1})\text{\^{}}(2) + (\text{on } F2)\text{\^{}}2 + (\text{on } F3)\text{\^{}}2 + (\text{on } F4)\text{\^{}}2 \quad (8)$$

A high communality implies that a given Q-sort highly represents the group as a whole (Watts & Stenner, 2014b).

3 | RESULTS

3.1 | Factor loadings and interpretation

The unrotated factor loadings are presented in Table 3. Guided by Taherdoost et al. (2014), seven factors were initially extracted, but only four (1, 2, 3 and 4) had two or more significant loadings. However, Factor 2 passed with only two significant loadings. Considering the estimated standard error of 0.32, the cross-products of the highest Factor 1 loadings were 0.6 (0.8 × 0.75) and thus passed. The cross-products for the highest factor loadings for Factors 2, 3 and 4 were 0.36, 0.25 and 0.28, respectively. Obviously, only the cross-products of Factors 1 and 2 passed this criterion. The communality, an indicator of how much a particular Q-sort holds in common with other Q-sorts, was also calculated (Table 3). It should be noted that each participant is associated with a code (Table 3). For instance, participant 1 is DRIS01M78PF. DRIS01 stands for farmer 01 in the DRIS, gender

TABLE 3 Calculating factor loadings, eigenvalues and variance.

Q-sort	Code	Factor 1	Factor 2	Factor 3	Factor 4	Communality (h^2)	(h^2) (%)
1	DRIS01M78PF	0.15	0.23	−0.21	0.15	0.14	14
2	DRIS02M26P F	0.29	0.39	0.11	0.21	0.29	29
3	DRIS03M24UF	0.35	0.08	0.19	0.09	0.17	17
4	DRIS04M36SOF	0.57	0.36	0.17	0.10	0.49	49
5	DRIS05M50SOL	0.44	−0.11	0.47	0.21	0.47	47
6	DRIS06M64PL	0.75	0.25	−0.16	0.20	0.68	68
7	DRIS07M50PF	0.63	0.42	−0.19	0.21	0.65	65
8	DRIS08M38PL	0.57	0.55	0.19	0.01	0.66	66
9	DRIS09M65PF	0.65	0.52	−0.19	−0.06	0.73	73
10	DRIS10M50PL	0.67	0.28	−0.03	−0.19	0.57	57
11	DRIS11M38SOF	0.57	0.10	0.04	−0.15	0.36	36
12	DRIS12M42PL	0.57	0.08	−0.02	0.05	0.33	33
13	DRIS13F72PF	0.71	0.23	0.43	−0.19	0.78	78
14	DRIS14M62SOF	0.59	−0.05	−0.32	−0.26	0.52	52
15	DRIS15M56PL	0.69	0.46	0.06	−0.15	0.71	71
16	DRIS16M42PF	0.80	0.38	0.15	−0.09	0.82	82
17	DRIS17M34SOF	0.33	0.14	0.27	0.21	0.24	24
18	DRIS18M52PL	0.60	0.39	−0.14	−0.49	0.77	77
19	DRIS19F48PF	0.20	−0.30	−0.26	0.18	0.23	23
20	DRIS20F32SOL	0.41	−0.32	−0.08	0.25	0.33	33
21	DRIS21M70SOL	0.46	−0.28	0.24	0.05	0.34	34
22	DRIS22F34PF	0.53	−0.17	0.20	0.05	0.35	35
23	DRIS23F30PF	0.32	−0.33	−0.38	−0.22	0.41	41
24	DRIS24F32SOF	0.43	−0.06	0.54	−0.12	0.50	50
25	DRIS25F45PF	0.65	−0.20	0.33	−0.10	0.58	58
26	DRIS26M54SOL	0.58	−0.27	0.12	0.02	0.43	43
27	DRIS27M43SOF	0.38	−0.24	−0.12	0.23	0.27	27
28	DRIS28M44PF	0.53	−0.36	0.21	−0.08	0.45	45
29	DRIS29F24SOL	0.45	−0.36	−0.27	−0.57	0.72	72
30	DRIS30M35SOL	0.60	−0.31	0.13	−0.06	0.48	48
31	DRIS31F32UL	0.19	−0.56	−0.11	0.11	0.38	38
32	DRIS32M54PL	0.50	−0.41	−0.10	−0.29	0.51	51
33	DRIS33M30SOL	0.25	0.30	−0.09	0.06	0.16	16
34	DRIS34M31UL	0.37	0.37	−0.23	0.23	0.38	38
35	DRIS35M33PF	0.44	−0.19	−0.25	0.24	0.35	35
36	DRIS36F53PF	0.52	−0.65	−0.20	0.23	0.79	79
37	DRIS37M40PF	0.70	−0.27	−0.13	0.06	0.58	58
38	DRIS38M28PF	0.66	−0.16	−0.02	0.09	0.47	47
39	DRIS39M70PF	0.52	0.09	−0.34	−0.20	0.43	43
Eigenvalue		10.84	4.06	2.07	1.56		
Explained variance in %		28	10	5	4		
Number of defining Q-sorts		13	7	11	6		

TABLE 3 (Continued)

Q-sort	Code	Factor 1	Factor 2	Factor 3	Factor 4	Communality (h^2)	(h^2) (%)
Correlation between factor scores							
Factor 1			0.18	0.54	0.41		
Factor 2				0.46	0.45		
Factor 3					0.42		

Abbreviation: DRIS, Doho rice irrigation scheme.

TABLE 4 Characteristics of the Q-sorted participants.

Respondents' characteristics	Whole sample	Factor 1	Factor 2	Factor 3	Factor 4
Number of farmers	39	13	7	11	6
Average age	44.64 (24–78)	46.77	40.14	44.91	48.67
Gender (female)	10 (26%)	_	4	4	2
Level of education					
Primary/vocational	23 (59%)	10	4	4	4
Secondary	13 (33%)	2	3	6	1
University	3 (8%)	1	_	1	1
Member of DIFACOS	35 (90%)	11	6	10	6
Farmer leaders	16 (41%)	7	2	4	2

Abbreviation: DIFACOS, Doho Irrigation Scheme Farmers' Cooperative Society.

(M = male), age (=78), level of education (P = primary) and role in the scheme (F = farmer).

From Table 3, Factor 1 accounts for 28% (over a quarter) of the study variance that all the Q-sorts have in common. One of the most important characteristics of each of the final factors is to account for as much variability/variance in the original correlation matrix as possible. The four factors considered to date account for 47% of the study variance. This is above the 35% value suggested in Kline (1994) and thus likely to offer a comprehensive solution considering common factors. The solution accounted for 37 out of 39 study Q-sorts, and the number of non- significant Q-sorts was 2. The factor arrays for the four study factors are presented in Table 1. The characteristics of the Q-sorting participants for the whole sample and the four study factors are presented in Table 4.

3.2 | Factor interpretation and analysis

3.2.1 | Factor 1: Paying farmers; adequate water-user (irrigation) fee collections

Factor 1 has an eigenvalue of 10.84 and explains 28% of the study variance. Thirteen participants were significantly associated with this factor. These patients were all males, with an average age of 46.77 years. Seven are farmer leaders. One farmer was an undergraduate student, two had secondary-level education and 10 had primary-level. Eleven farmers are members of the farmers' association (DIFACOS). All plots were used for farming in the study area.

At the time of the field visit, the management of the DRIS was working well (item 29 ranked at +1). However, it was clear that scheme management was experiencing financial challenges in operating, maintaining and replacing irrigation infrastructures (item 24 ranked at −2). In addition, the government does not provide adequate financial support (item 9: −3). It is vital in the context of Factor 1 that collections from water-user fees are adequate due to the capability of farmers to pay for irrigation services (item 7: +4; item 25: +4). Additionally, because farmers participate in operation and maintenance activities in the scheme, maintenance is adequate (item 3: +3; item 5: +3). The technical team and DIFACOS are responsible for determining the water rates and volume of water to be delivered in each scheme block (item 2: −3). Despite the technical team devising good water distribution rules (item 1: +2), water-related conflict is very common between upstream and downstream farmers.

There is a conflict management mechanism in the scheme but it is not adequate to track conflicts and resolve them effectively. In addition, in the context of Factor 1, farmers indicated that DRIS employees are not transparently rewarded based on their performance (item 32: −2). Item 29, ranked at +1, suggests that farmers feel that DRIS organizational structure and decision-making are not adequately clear and functional and that as a result, Factor 1 seems to understand their feelings. This is clearly reflected in the similarly positive (+1) ranking of items 15 and 39. This indicates inadequate consultation and involvement of farmers when establishing water-user committees; thus, the irrigation service delivery agency is less accountable or not accountable to farmers. This implies that DRIS management makes most key decisions without involving all the farmers. From the context of Factor 1, transparency and accountability of DRIS management to farmers and other stakeholders were not clear (item 33: 0). In addition, the involvement of marginalized groups in dialogue and decision-making is not given the required attention (item 40: 0). It should be noted that most government financial support was provided only during rehabilitation. This affects scheme performance, and thus the scheme may not be able to afford modern technology (item 11: −2). According to the results of the 'after-sort' interviews, farmers associated with Factor 1 generally perceive scheme management as being satisfactorily transparent and effective in terms of communication (through block chairpersons, radio adverts, public address systems, posters in all major trading centres, phone SMS, etc.) and payments to scheme farmers. Management consults farmers to improve performance; for instance, farmers were consulted before the rice milling machine was bought (item 29 ranked at +1). In addition to the financial ability of farmers to pay for irrigation water, most farmers recognize management support to farmers, which enables them to produce more rice. Perhaps such farmers find it important to pay for irrigation water on time to accelerate operation and maintenance channels. Moreover, the DRIS employs more extension workers, field assistants and security officers for proper enforcement of activities. Undoubtedly, DRIS management has a good reward system in which some farmers (DIFACOS members) are rewarded with certificates, hoes, tarpaulins, sprayers, boots and T-shirts, among other rewards, for their outstanding performance. However, at the time of the field visit, the participants indicated that outstanding farmers no longer received prizes, partly due to the financial effects of COVID-19. This is confirmed by the negative ranking (item 32: −2). None of the participants associated with Factor 1 were women. According to the participants, it was not clear whether women were allowed to participate freely in the scheme activities (item 40: 0). Farmers generally perceived new technology as changes such as fertilizer application, introduction of resistant varieties, milling and grading machines, tractors and vehicles besides construction of new stores at the scheme. However, there is a need for management to introduce new technology, especially equipment for cultivating and harvesting, among others. According to farmers associated with Factor 1, the marketing sector needs improvement as available markets offer low prices most of the time. Through DIFACOS, farmers mill their rice and sell it to cooperatives at fair prices. There is a lack of access to agricultural financing in the form of subsidized credit facilities to support the investment of farmers in irrigation activities. Where credit is available, farmers are required by commercial financial institutions to provide collateral and a well-documented track record of business transactions, which they usually lack. In addition, annual interest rates are usually high (above 20%). There is funding access to farmers from a SACCO at the DRIS; however, management needs to invest more in the SACCO because the interest charged on loans given to farmers is high. In addition, a processing fee of 30,000 UGX must be paid for each 100,000 UGX loan.

3.2.2 | Factor 2: Disengaged farmers; farmers neither decide on cropping and irrigation methods nor engage in accountability

Factor 2 has an eigenvalue of 4.06 and explains 10% of the study variance. Seven participants were significantly associated with this factor. There were three males and four females, with an average age of 40.14 years. Two are farmer leaders. Three farmers had secondary-level education, and four had primary-level. Six of the farmers are DIFACOS members. All plots were used for farming in the study area.

There is a structured conflict management system in which conflicts are resolved through a disciplinary committee at the block/strip level led by a block chairperson. The disciplinary committee tracks sources of conflicts. In the case of defaulters of irrigation water fees (IWFs), the defaulted plot is hired by another farmer for one to two seasons. However, farmers associated with Factor 2 indicated that such extreme by-laws are rarely implemented (item 26: −2). The Butaleja district is one where people derive their livelihood primarily from rice production, and there is always a readily available market for rice. However, the market value offered by middlemen/local traders is usually too low. Irrigation does not make economic sense to most scheme farmers in Uganda because of the usually low returns and unstable market prices in farming. The prices of irrigated crop products should increase due to the investment, energy and costs involved. However, middlemen (bulky produce buyers) do not want to factor in this aspect and always offer the same price, leading to the demotivation of farmers. In addition, there is limited or no value added to crop production. This in the end results in delayed or zero payment for operation and maintenance costs by farmers.

There is inadequate operation and maintenance in the scheme (item 3: −2). DIFACOS is responsible for maintaining the main irrigation/drainage canals and farmers for irrigation/drainage channels. However, some farmers do not participate in maintenance activities (item 5: −1), which affects the total amount of irrigation water received (item 17: −2) or the duration of water delivery (item 19: −2). In some sections of the scheme, there are many bends in the water channels that affect efficient water delivery and thus physical water scarcity. There is a need to improve the levelling of gardens in a timely manner. There is a clear weekly water allocation timetable issued to chairpersons. Despite the need for a cropping calendar to minimize crop losses, farmers neither decide on cropping and irrigation methods nor engage in accountability (21: −3; 39: −3). Rice is the only crop allowed to grow in the scheme. However, some farmers are rearing livestock and growing bananas/maize, attracting birds that destroy rice. Water rates are determined by the scheme's technical team alone. There is a timetable for water schedules pinned up in the blocks and copies given to block leaders. Each block received water for three consecutive days, and the block vice chairperson was responsible for distributing water among the strips.

At the time of the scheme visit, some gates did not operate in most blocks; however, the board was trying to work on them. Farmers communicate to block/strip leaders in the case of excess/limited irrigation water supply. One farmer indicated that '... when selecting members of the water users committee (WUC), management just organizes meetings for themselves and communicates the outcomes to farmers without consulting ...' DRIS management calls for meetings between strip leaders and block chairpersons followed by general annual (accountability) meetings.

3.2.3 | Factor 3: Maintenance farmers; maintenance costs are low when farmers participate in maintenance activities

Factor 3 has an eigenvalue of 2.07 and explains 5% of the study variance. Eleven participants were significantly associated with this factor. There were seven males and four females, with an average age of 44.91 years. Four are farmer leaders. One farmer was an undergraduate student, six farmers had secondary (ordinary) education and four had primary. Four farmers are DIFACOS members. All plots were used for farming in the study area.

DRIS management calls for only one annual general meeting with communication focusing on accountability and discussing decisions affecting the service delivery of the scheme. As a result, farmers associated with Factor 3 feel less engaged in accountability by management (item 39: −1). In addition, there was no major financial support provided by the government for rehabilitation in 2012. Obviously, government funding for scheme activities is inadequate (item 9: −4). This implies that farmers are encouraged to participate in maintaining channels, as DIFACOS uses tractors and other equipment to work on scheme canals. Each farmer allocated to a plot in the scheme is supposed to pay approximately 40,000 $UGXha^{-1}$ for the IWF. In contrast, farmers associated with Factor 1 did not participate in maintenance activities (item 5: −2). Arguably, these farmers have the financial ability to pay for irrigation services (item 25: +2) and feel that maintenance costs in the scheme are too low to be met by the IWF (item 4: −3); thus, they find no reason to participate in maintenance activities. At the time of the field visit, for instance, one Namulo bridge was broken but had not yet been repaired due to insufficient funds (item 4:−3 and item 9: −4). Slashing, desilting and tractor operation increase the operation and maintenance costs. In truth, maintenance costs may be difficult to determine due to fluctuations in fuel costs. Training in the best ways farmers can benefit from the rice-growing enterprise is normally planned for the scheme's social workers and block chairpersons (item 31: +1). Additionally, technical people train farmers about water management and scheduling.

3.2.4 | Factor 4: Accountable farmers; farmers are engaged in accountability and institutional improvement processes

Factor 4 has an eigenvalue of 1.56 and explains 4% of the study variance. The presence of six participants was significantly associated with this factor. There were four males and two females, with an average age of 48.67 years. Two are farmer leaders. One farmer was an undergraduate student, one had secondary (ordinary) education and four had primary. All farmers are DIFACOS members and have plots for farming in the scheme.

Looking at seasonal variation in the rice harvest, one participant noted, '... during dry season, we get less yield and during wet season, we get more ...'. In the context of Factor 4, crop produce markets are not readily available (item 10: −1). For instance, one participant described '… we get good rice harvest, but we do not have where to sell …'. In case there is no readily available market for rice (offered by middlemen/local traders), SACCO provides loans (for a short time, financial solutions) to farmers as they await better market value. These farmers feel that maintenance costs in the scheme are high (item 4: +2), yet government funding for the scheme activities is inadequate (item 9: −4). Clearly, farmers in this category feel that they are not consulted when establishing WUCs (item 15: −2). Similarly, they also perceive inappropriate allocation of plots to farmers within the scheme (item 12: −2). This affected earlier plot allocation where culturally, plots were generally allocated to men but cultivated by women (item 40: −1). Uganda's current land tenure system does not clearly define women's rights to landownership; thus, these women are vulnerable to being deprived access to land (Doss & Meinzen-Dick, 2020). Moreover, farmers neither participate in maintenance activities (item 5: 0) nor receive enough irrigation water (item 17: 0). Water availability is limited, especially in the dry season, and thus some farmers do not receive water as per their schedule (Bwambale et al., 2019b). Possibly because farmers are not involved in determining water rates (item 2: −1), they feel that they do not receive enough irrigation water. The introduction of the dam improved the quality of water (by allowing it to settle) and contributed to water availability, especially during the dry season. Despite farmers lacking the financial ability to pay for irrigation services (item 25: −1), they perceive adequate IWF collections by the association (item 7: +1). From the results of the 'Q-sort' interviews, it was clear that some farmers did not pay the IWF. This can be attributed to the fact that the cost of irrigation water is high compared to the return from rice yield (item 22: 0). In addition, there is a high level of IWF defaulters during drought due to a reduction in rice yield compared to that in the wet season; thus, farmers fail to pay. Clearly, farmers are engaged in accountability (item 39: +3) and institutional improvement processes (item 39: +3). The DRIS board, together with block chairpersons, gathers and documents information (item 36: +1). Guidelines/technical documents (to guide irrigation water flow), including weekly irrigation water allocation timetables issued to chairpersons, are pinned on notice boards with copies always given to block chairpersons. The board sets and decides on the IWF. It is always collected by strip leaders, extension workers and block chairpersons. When an IWF is paid, management accounts for and utilizes it well (item 24: +1).

Notably, 33% of the participants associated with Factor 4 were also farmer leaders; thus, the perceptions and views represent the farmers more reliably given that 41% of the total sample of participants were also farmer leaders.

There were a few items that farmers thought were missing and suggested that they could be included in the Q-set. For instance, livestock/animal rearing and maize/banana cultivation by some farmers attract birds that destroy rice. Additionally, farmers noted an urgent need to increase the number of (concrete) drying bays to provide more drying space. One farmer, for instance, emphasized '… drying from scheme bays, reduces losses from home visitors who keep asking for some rice…'. It was clear to us that politicking at DRIS stopped in the year 2012/2013 when DIFACOS and scheme by-laws were introduced. This explains why item 13 was considered non-significant and ranked at −4. The scheme farmers complained that part of the scheme is covered by poor waterlogged soils that cannot support diverse agricultural enterprises. Such soils promote excessive weed growth and thus harbour rodents and snakes, among others.

4 | DISCUSSION

4.1 | Factor interpretations and discussion

Similarities and differences among the four factors were noted. The most apparent positive similarity across all four factors/viewpoints is that the organizational structure and decision-making are clear and functional (item 29). In addition to the 'paying farmers', DRIS management was perceived to be transparent and accountable to water users and stakeholders (item 33: +4). This can be attributed to the introduction of DIFACOS, a cooperative society that brings all scheme farmers together. Clearly, there is a moderate correlation (in the same range) among all factors other than between Factors 1 and 2 arrays (Table 3). According to Watts and Stenner (2005), '… if two factor arrays are significantly correlated this may mean they are too alike to interpret as separate factors and that they could, in fact, simply be alternative manifestations of a single viewpoint …'. Thus, our discussion is primarily focused on Factors 1 and 2. Our findings are in agreement with those of Yakubov (2012), who noted poor contributions by farmers and their representative bodies to decision-making that were attributed to limited experience, expertise and confidence in management. However, irrigation scheme management tends to be more accountable to government ministries/departments/agents than to farmers/farmer groups (Svendsen & Small, 1990). Confirming Oonyu (2011), farmers across all four factors agree that government funding for scheme activities is inadequate. It was noted that the rehabilitation of the scheme during the 2012–2014 period led to the 'birth' of DIFACOS, putting an end to politicking in the scheme. In addition, it was not surprising that all participants noted that scheme farmers primarily survive on rice farming; thus, there are no diverse sources of income (item 16). This is well reported in the limited literature (Kitunzi, 2021, 2022; Oonyu, 2011; Samilu, 2021). Our study showed that the choices and decisions regarding irrigation methods and cropping calendars for irrigation schemes (item 21) are limited to the technical team. The authors argue that some management and/or performance challenges in the DRIS can be partly explained by the country's changes in political regime (Mukhtarov et al., 2015) since the scheme was constructed in the early 1970s. For instance, although the cropping pattern has not changed since then, more than three-quarters of respondents suggested the need for management to encourage the growth of more profitable vegetables in some parts of the scheme. To ensure food sustainability and resilience, farmers who do not own plots in the scheme can be encouraged to grow more crops other than rice to avoid the risk of famine. The discussion about engaging farmers in water-related decisions in schemes is well established in the literature (Bjornlund et al., 2020; Nalumu et al., 2021). It should be noted that the DRIS is a rice scheme, despite some farmers illegally introducing banana plantations and animal grazing in recent years.

A conceptual space diagram was generated considering the distinguishing statements common to all four factors of the Q-sort study (Figure 2). Considering, for instance, participants associated with Factor 1 (all males), men are considered providers/leaders at the household level and are thus responsible for key (financial) decision-making. Since, in most cases, men pay the IWF themselves, they perceive that IWF collections by the association are adequate. Accordingly, because this group perceives a sufficient total quantity of irrigation water (item 17: +3), they may be motivated to pay the IWF and thus participate in maintenance activities (item 5: +3) to allow the flow of water to reach their plots. Less anticipated, these (male) farmers disagreed that management is transparent and accountable to water users and stakeholders (item 33:0) compared to other factors. Given that more than half of the participants in this category are farmer leaders, their perceptions could be more reliable. This can be explained by the fact that scheme management calls for only one annual general meeting to present the work plan and performance of the scheme. It can be argued that such meetings should be conducted at least quarterly. It is also worth noting that since male farmers mainly engage in crop produce marketing, they perceive that crop produce markets are not efficiently available.

Despite the diversity in viewpoints, farmers associated with Factor 2 neither decide on cropping and irrigation methods nor engage in accountability. Most of these farmers consider rice farming less profitable and find themselves incapable of and/or unwilling to pay for (item 25: 0) and participate in maintenance activities in the scheme (item 5: −1). Regarding the 'after-Q-sort' interview findings, since hired labour is expensive, some parents resort to using their children for weeding, scaring off birds and transplanting at the expense of school time. In addition, clearly from the perspectives of farmers associated with all four factors (Figure 3), government funding is inadequate (item 9), which in turn affects other items, such as the introduction of new technologies, operation and maintenance. This has led to poor performance and/or underutilization of most irrigation schemes in Uganda and/or Africa despite heavy investment in renovation (Bjornlund et al., 2020; Pék et al., 2019). Our argument agrees with the data from the after-Q-sorting interviews indicating that some registered scheme farmers illegally introduced banana plantations and animal rearing as alternative sources of income. Surprisingly, Factor 2 farmers felt that farmers were involved in determining water use rates under the scheme (item 2: +2). However, this factor had the highest proportion of female participants (57%), the youngest average age (40.15) years and only two farmer leaders (all female). Arguably, Factor 2 represented the viewpoints of the female participants, given that only 20% of the total registered scheme farmers in the scheme were females. When interpreting factor results, it was noted that individual farmers' perceptions are related to the quality of their day-to-day (social) life (Alt & Phillips, 2022). Most of the women interviewed indicated that after the introduction of the DIFACOS, women became more involved in scheme activities (item 40: +2). Considering farmers associated with Factor 2 and following the guidance of Brown (1980) and Watts and Stenner (2014b), items 3, 17, 20 and 39 were considered. For instance, despite efforts to mobilize all farmers to attend annual general meetings, in most cases such meetings are attended by family heads. Consequently, even in situations where plots are allocated to male farmers in the scheme, most of the farmwork is still left to women. Notably, women perceive that during the dry season, when water is not enough for all scheme farmers, women farmers tend to be marginalized in regard to water access. This subsequently results in intra- and inter-block water-related conflicts.

Among all four viewpoints, *accountable farmers* strongly agree that maintenance costs are high. This finding is similar to that of Bjornlund et al. (2020), who also reported that farmers lack the financial ability to pay for

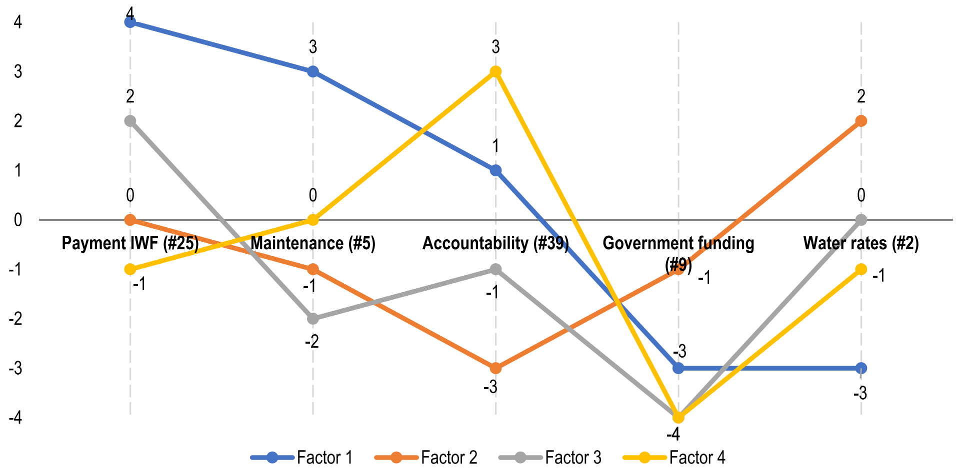

FIGURE 3 Conceptual space diagram for the Q-sort study.

irrigation services. When evaluating the effect of farmers' participation in irrigation management on farm productivity and profitability under the Mubuku irrigation scheme in Uganda, Pék et al. (2019) noted that farmers participate in operation, maintenance and management based on facilities in terms of their exposure, expertise, knowledge and financial capability. 'Factor 4 farmers' seem to be the only ones from our sample who strongly agree that management involves staff and users in institutional improvement processes. This finding supports the argument of Pék et al. (2019) and Wanyama et al. (2017) that scheme farmers' contributions are institutionalized through irrigation water users' associations rather than through individual efforts.

Our analysis of 'after-sort' data is reliable. For instance, more than 40% of participants associated with Factor 1 are also farmer leaders who are responsible for the collection of the IWF. According to the analysis of the after-Q-sorting data, 0, 57, 36 and 33% of the participants were female, which was associated with Factors 1, 2, 3 and 4, respectively. Apart from Factor 1, other factors were associated with a greater proportion of females than a total of 26% of female participants in the Q-sorting study. This implies that the female farmers' views and/or perceptions were well represented given that the proportion of female farmers was low (only 826) out of the total 4208 registered farmers at the time of field visit. To verify Q-sorting item 40, DRIS records were cross-checked. Out of the 4208 registered farmers, 1254 (30%) were young. Additionally, slightly fewer female youths were involved in rice farming (214, 17%) under the scheme. It was clear that despite women, youth and marginalized groups being empowered and involved in water-user groups, dialogue and decision-making, the proportion of these categories was still low.

There is limited information on the performance assessment of irrigation schemes in Uganda and the successes and challenges associated with the operation and maintenance of public and private irrigation schemes. This requires broader-based and integrated planning approaches by line Ministries, Departments and Agencies. The results are representative of the real situation in the scheme. For instance, inadequate maintenance and a lack of farmers' maintenance activities due to limited technical skills are evident in damaged and non-operational gates and canals accumulated with silt, among other disasters. A lack of sustainable marketing strategies is seen from middlemen who normally buy rice when still in farmers' fields at reasonably low prices.

The estimated respondent yield of 2915 kgha^{-1} is relatively close to the average yield output of 2965 kgha^{-1} season^{-1} recorded by the scheme officials. Additionally, most scheme reports and documents were prepared in English, yet according to the results of the Q-sort interviews, the farmers' literacy rate was 41%. This partly explains some farmers' negative perceptions about joining the cooperative (DIFACOS), citing scheme management's deliberate intention to avoid effective dissemination of scheme information. However, after field walking and reviewing irrigation scheme reports and/or documents, the authors discovered that some of the respondents' information was biased in regard to exact ground observations. For instance, only 56% of the sampled farmers claimed that farmers had the ability to pay for irrigation services (considering a positive ranking of the item from 1 to 4), and approximately 90% of the interviewed farmers were DIFACOS members. However, 76 and 79% of the IWFs were collected in 2021 and 2022, respectively.

4.2 | Policy implications and recommendations

Our study findings may have implications for the current management of irrigation schemes in Uganda, with particular consideration given to promoting the performance of irrigation schemes and thus farmers' livelihoods. First, whether developing a new or renovating an old irrigation scheme, irrigation management should involve all stakeholders at all levels. In addition, attention should be drawn to introducing new technology, but rather the technology must be targeted specifically and affordably designed by locally based engineers and scientists to suit the rural economy. Second, the government structures and institutional arrangements should also be designed and focused on to respond to unstable produce markets, enabling farmers to profit from their efforts and thus pay for irrigation water and other operational costs with the capability to withstand risks. With policies centred on rural economic development, irrigation scheme farmers can benefit, for instance, from appropriate storage, processing and transportation infrastructure, thus promoting timely availability of high-quality produce to existing local and regional markets (Bjornlund et al., 2020; Yakubov, 2012; Yohannes et al., 2017). This can in turn promote access to improved agricultural guidance, inputs, equipment and financial support (Wanyama et al., 2017). Third, lending and trade policies can be designed to focus on promoting rural economic development. In this way, farmers' and local people's livelihoods can be promoted through policies that protect a country's agricultural sector, for instance lending institutions offering loans to farmers at low/subsidized interest in addition to limiting the import of agricultural produce (MAAIF and MWE, 2017; Pék et al., 2019).

This study can further contribute to advancing theoretical knowledge on PIM in irrigation schemes of developing countries such as the DRIS. Such knowledge can empower local farmer communities, together with other irrigation scheme stakeholders, to take timely and informed action to anticipate and respond to hydrological extremes (especially droughts) regarding the planning and use of available (sometimes limited) water resources. This can minimize up-, mid- and downstream water-use conflicts. Our findings are in agreement with those of Bwambale et al. (2019a, 2019b) and Wamala et al. (2023). When conflicts occur, they are not adequately tracked and analysed (item 38: −1). Following the participatory approach used in planning the study, the results may contribute to increasing awareness of the importance and role of farmers' participation in irrigation management, thus sustaining irrigation schemes, water resource use and environmental conservation. In addition, there is likely to be an increased understanding of how to effectively engage multi-level stakeholders in integrated irrigation scheme management options and scenario planning, negotiation and implementation (Leys & Vanclay, 2011).

Regarding irrigation schemes in Uganda, the government has, through existing policies, institutionally established farmer societies that are entrusted with the proper operation and maintenance of irrigation infrastructure and the marketing of produce, among other roles. However, there are significant gaps between the formed farmers' societies and the government body, especially in the case of emergencies, for instance breakdown of the major component parts of an irrigation system. Currently, any such breakdowns are managed through established government systems that require the procurement of component parts or firms, which normally takes a long time. There is little or limited technological and human capacity development in the irrigation sector. This has affected the operation and maintenance of the equipment. Additionally, there is limited access for farmers to credit facilities and financial assistance, yet the new irrigation infrastructure requires high initial capital. Additionally, there is limited education and training on irrigation practices restricting irrigation advancement. In summary, there has been limited research and development effort in line with suitable irrigation technologies and best practices.

As a means of avoiding and/or minimizing negative impacts, DRIS management can introduce collective measures to assist in curbing environmental degradation (Mukhtarov et al., 2015) in most parts of Bunyole, where people have greatly encroached on wetlands for rice growing. The results of the study may also promote partnerships with local research institutions, including the government of Uganda's Ministry of Water and Environment (MWE)—Water for Production, for continued knowledge and learning regarding sustainable irrigation management.

5 | CONCLUSIONS

This study has focused on the driving factors of farmers' perceptions of the role played by key stakeholders in the management and performance of irrigation schemes using Uganda's DRIS as a case study. The study results help us to derive some applicable policy recommendations that can improve the management and performance of irrigation schemes while sustainably promoting farmer communities' livelihoods. By applying Q-methodology, four viewpoints were identified and explored based on farmers' perceptions of the management and performance of an irrigation scheme. The four groups of farmers associated with the viewpoints were summarized as paying, disengaged, maintenance and accountable farmers. Our study showed that male and female perceptions of the management and performance of irrigation schemes differed slightly. Based on the correlation between factor scores, only Factors 1 and 3 could be interpreted as a single viewpoint, and the other two factors were considered to alternatively manifest a single viewpoint. For future improvements in the management and development of irrigation schemes, it is suggested that farmers be considered and involved as major and/or equal stakeholders at stages of irrigation scheme development, from planning to management. The development of large irrigation schemes is hindered by the challenges associated with land acquisition in addition to the limited capacity for planning, designing and constructing irrigation schemes. To ensure national and regional food security in addition to improving farmer household income through increased and sustainable irrigated rice production, there is a need to increase the capacity for irrigation management among the different stakeholder categories. With respect to Uganda's irrigation and related policies and frameworks, there is an urgent need to adopt the integrated water resources management approach in irrigation planning, development and management at all levels to enable water resource evaluation, water allocation to several demand actors and planning. Additionally, advanced rainwater harvesting and valley tank and dam construction can be carried out to increase irrigation water availability, especially during the dry season. Furthermore, there is a need for support programmes to promote all irrigation-related studies and data dissemination to improve the availability of data for irrigation system design. In summary, developing countries should focus on promoting and building irrigation and institutional capacity, streamlining extension services to farmers, responding to economic aspects of irrigation development and management, improving farmers' access to irrigation water, streamlining land tenure systems and ensuring reforms and developing national irrigation guidelines and tools such as PIM and WUCs. There is also a need to promote public–private partnerships to enable substantial investment in irrigation schemes. There is a need for significant university and other irrigation research and training institution funding to enable reliable training of irrigation experts at all levels to smooth irrigation system operation and maintenance.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known or potential conflicts of interest with respect to the research, authorship and/or publication of this work.

DATA AVAILABILITY STATEMENT

All data used in this study are available. Q-methodology analysis was based on datasets for thirty-nine (39) Doho Rice Irrigation Scheme (DRIS), Butaleja district, Uganda. The Full analysis is also available. The data can be provided upon request by the 1st Author (georg.kimb@gmail.com).

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REFERENCES

Alt, N. & Phillips, L. (2022) Person perception, meet people perception: exploring the social vision of groups. *Perspectives on Psychological Science*, 17(3), 768–787. Available from: https://doi.org/10.1177/17456916211017858

Awio, T., Senthilkumar, K., Dimkpa, C.O., Otim-Nape, G.W., Struik, P.C. & Stomph, T.J. (2022) Yields and yield gaps in lowland rice systems and options to improve smallholder production. *Agronomy*, 12(3), 552. Available from: https://doi.org/10.3390/agronomy12030552

Balch, G. & Brown, S.R. (1982) Political subjectivity: applications of Q methodology in political science. *Journal of Marketing Research*, 19(1), 162. Available from: https://doi.org/10.2307/3151542

Bjornlund, V., Bjornlund, H. & van Rooyen, A.F. (2020) Exploring the factors causing the poor performance of most irrigation schemes in post-independence sub-Saharan Africa. *International Journal of Water Resources Development*, 36(sup1), S54–S101. Available from: https://doi.org/10.1080/07900627.2020.1808448

Brown, S. R. (1980) *Political subjectivity: Applications of Q methodology in political science*. New Haven: Yale University Press.

Brown, T.A. (2006) *Confirmatory factor analysis for applied research*. New York, NY, US: The Guilford Press.

Bwambale, E., Home, P.G., Raude, J.M. & Wanyama, J. (2019b) Development of a water allocation model for equitable water distribution at Doho rice irrigation scheme, Uganda. *Hydrology*, 7(4), 62. Available from: https://doi.org/10.11648/j.hyd.20190704.12

Bwambale, E., Home, P., Raude, J., Wanyama, J., Home, P.G. & Raude, J.M. (2019a) Hydraulic performance evaluation of the water conveyance system of Doho rice irrigation scheme in Uganda riparian Sedment Managment in Lake Victoria catchments view project Volkswagen Stiftung project view project hydraulic performance evaluation of the W. *Open Access Journal Journal of Sustainable Research in Engineering*, 5(2), 101–112.

Damio, S.M. (2016) Q methodology: an overview and steps to implementation. *Asian Journal of University Education*, 1(2), 24–28. Available from: http://roar.uel.ac.uk/1414/1/2046-1240_1-2_pp24-28.pdf

Doss, C. & Meinzen-Dick, R. (2020) Land tenure security for women: a conceptual framework. *Land Use Policy*, 99, 105080. Available from: https://doi.org/10.1016/j.landusepol.2020.105080

Esteves, R., Jo, M. & Ros, M. (2023) "Framework for assessing collective irrigation systems resilience to climate change—The Maiorga case study," 1–30.

Jetter, A.J. & Kok, K. (2014) Fuzzy cognitive maps for futures studies—a methodological assessment of concepts and methods. *Futures*, 61, 45–57. Available from: https://doi.org/10.1016/j.futures.2014.05.002

Johnson, J.M., Becker, M., Dossou-Yovo, E.R. & Saito, K. (2023) Farmers' perception and management of water scarcity in irrigated rice-based systems in dry climatic zones of West Africa. *Agronomy for Sustainable Development*, 43(2), 32. Available from: https://doi.org/10.1007/s13593-023-00878-9

Kitunzi, Y. (2021) "Butaleja farmers appeal to Govt over low prices for rice." Daily Monitor, [accessed May 26, 2021].

Kitunzi, Y. (2022) "Butaleja Rice Farmers Oppose Gov't Ban in Swamps." The Cooperator, [accessed August 20, 2022]. Available from: https://thecooperator.news/butaleja-rice-farmers-oppose-govt-ban-in-swamps/#:~:text=BUTALEJA-Rice farmers in Butaleja,major source of their income.

Kline, P. (1994) *An easy guide to factor analysis*, 1st ed. London: Routledge. Available from: https://doi.org/10.4324/9781315788135

Leonhardt, H., Braito, M. & Uehleke, R. (2022) Combining the best of two methodological worlds? Integrating Q methodology-based farmer archetypes in a quantitative model of agri-environmental scheme uptake. *Agriculture and Human Values*, 39(1), 217–232. Available from: https://doi.org/10.1007/s10460-021-10242-w

Leys, A.J. & Vanclay, J.K. (2011) Social learning: a knowledge and capacity building approach for adaptive co-management of contested landscapes. *Land Use Policy*, 28(3), 574–584. Available from: https://doi.org/10.1016/j.landusepol.2010.11.006

MAAIF and MWE. (2017) "National Irrigation Policy: Agricultural Transformation Through Irrigation Development."

Maurer, L., Schenkenfelder, J. & Winckler, C. (2021) Resource, collaborator, or individual cow? Applying Q methodology to investigate Austrian farmers' viewpoints on motivational aspects of improving animal welfare. *Frontiers in Veterinary Science*, 7, 607925. Available from: https://doi.org/10.3389/fvets.2020.607925

Muhoyi, E. & Mbonigaba, J. (2022) Stakeholder consultations on small-scale irrigation schemes' constraints in Zimbabwe. *Environment, Development and Sustainability*, 24(11), 13198–13217. Available from: https://doi.org/10.1007/s10668-021-01987-9

Mukhtarov, F., Fox, S., Mukhamedova, N. & Wegerich, K. (2015) Interactive institutional design and contextual relevance: water user groups in Turkey, Azerbaijan and Uzbekistan. *Environmental Science and Policy*, 53, 206–214. Available from: https://doi.org/10.1016/j.envsci.2014.10.006

MWE. (2011) "Doho Irrigation Scheme Turns Butaleja into Food Basket." Available from: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwj3sMfalIXxAhWOxYUKHcG2AOkQFjAOegQIEhAD&url=https%3A%2F%2Fmwe.go.ug%2Fsites%2Fdefault%2Ffiles%2FDoho%2520Irrigation%2520Scheme.pdf&usg=AOvVaw0EYE9wSAQINqvtiun8mu0_

Nalumu, D.J., Mensah, H., Amponsah, O. & Takyi, S.A. (2021) Stakeholder collaboration and irrigation practices in Ghana: issues, challenges, and the way forward. *SN Applied Sciences*, 3(5), 1–16. Available from: https://doi.org/10.1007/s42452-021-04407-9

Namyenya, A., Sserunkuuma, D. & Bagamba, F. (2014) Willingness to pay for irrigation water and its determinants among rice farmers at Doho rice irrigation scheme (DRIS) in Uganda. *Journal of Development and Agricultural Economics*, 6(8), 345–355. Available from: https://doi.org/10.5897/JDAE2014.0580

Narayanan, K. (2014) "Impact of participatory irrigation management—case study: Cocurirwa cooperative, Rwamagana Rice Project," 1 (3): 1–8.

Oad, R. & Sampath, R.K. (1995) Performance measure for improving irrigation management. *Irrigation and Drainage Systems*, 9(4), 357–370. Available from: https://doi.org/10.1007/BF00881621

Oonyu, J. (2011) Upland Rice growing: a potential solution to declining crop yields and the degradation of the Doho wetlands, Butaleja District-Uganda. *African Journal of Agricultural Research*, 6(12), 2774–2783. Available from: https://doi.org/10.5897/AJAR10.806

Pék, É., Fertö, I. & Alobid, M. (2019) Evaluating the effect of farmers' participation in irrigation management on farm productivity and profitability in the Mubuku irrigation scheme, Uganda. *Water (Switzerland)*, 11(11), 1–18. Available from: https://doi.org/10.3390/w11112413

Samilu, B. (2021) "Butaleja: MP wants Gov't to rescind ban on wetland rice growing." ChimpReports, August 2, 2021.

Schmolck, P. (2002) PQmethod (Version 2.35).

Singh, M., Liebrand, J. & Joshi, D. (2014) Cultivating 'success' and 'failure' in policy: participatory irrigation management in Nepal. *Development in Practice*, 24(2), 155–173. Available from: https://doi.org/10.1080/09614524.2014.885494

Sneegas, G., Beckner, S., Brannstrom, C., Jepson, W., Lee, K. & Seghezzo, L. (2021) Using Q-methodology in environmental sustainability research: a bibliometric analysis and systematic review. *Ecological Economics*, 180 (August 2020, 106864. Available from: https://doi.org/10.1016/j.ecolecon.2020.106864

Sudau, M., Celio, E., & Grêt-Regamey, A. (2022) Application of Q-methodology for identifying factors of acceptance of spatial planning instruments of spatial planning instruments. *Journal of Environmental Planning and Management*, 66(9), 1890–1917. Available from: https://doi.org/10.1080/09640568.2022.2043259

Svendsen, M. & Small, L.E. (1990) Farmer's perspective on irrigation performance. *Irrigation and Drainage Systems*, 4(4), 385–402. Available from: https://doi.org/10.1007/BF01103716

Taherdoost, H., Sahibuddin, S., Jalaliyoon, N., Taherdoost, H., Sahibuddin, S., Jalaliyoon, N., et al. (2014) Exploratory factor analysis; Concepts and theory and theory. *Advances in Applied and Pure Mathematics*, 27(WSEAS), 375–382. Available from: https://hal.science/hal-02557344

Tariq, H., Pathirage, C., Fernando, T., Sulaiman, N., Nazir, U., Latib, S.K.K.A., et al. (2022) Measuring environmental resilience using Q-methods: a Malaysian perspective. *Sustainability (Switzerland)*, 14(22), 1–20. Available from: https://doi.org/10.3390/su142214749

Tenywa, M.M., Majaliwa, J.G.M., Yazidhi, B., Luswata, K.C. & Geofrey, G.I. (2016) The effect of land use practices on pollution dynamics in the highlands of Uganda. In: *Management and area-wide evaluation of water conservation zones in agricultural catchments for biomass production*. Vienna, Austria: International Atomic Energy Agency, pp. 79–102. Available from:

http://www-pub.iaea.org/MTCD/Publications/PDF/TE_1784_web.pdf

van Dijk, R., Zambrano, J.C.I., Diehl, J.C. & Ertsen, M.W. (2022) Q-methodology and farmers' decision-making. *Frontiers in Sustainable Food Systems*, 6. Available from: https://doi.org/10.3389/fsufs.2022.954934

Waalewijn, P., Trier, R., Denison, J. & Siddiqi, Y. (2020) "Governance in Irrigation and Drainage: Concepts, Cases, and Action-Oriented Approaches—A Practitioner's Resource."

Wamala, F., Gidudu, A., Wanyama, J., Nakawuka, P., Bwambale, E. & Chukalla, A.D. (2023) Assessment of irrigation water distribution using remotely sensed indicators: a case study of Doho rice irrigation scheme, Uganda. *Smart Agricultural Technology*, 4(January), 100184. Available from: https://doi.org/10.1016/j.atech.2023.100184

Wanyama, J., Ssegane, H., Kisekka, I., Komakech, A.J., Banadda, N., Zziwa, A., et al. (2017) Irrigation development in Uganda: constraints, lessons learned, and future perspectives. *Journal of Irrigation and Drainage Engineering*, 143(5). Available from: https://doi.org/10.1061/(ASCE)IR.1943-4774.0001159

Watts, S. & Stenner, P. (2005) Doing Q methodology: theory, method and interpretation. *Qualitative Research in Psychology*, 2(1), 67–91. Available from: https://doi.org/10.1191/1478088705qp022oa

Watts, S. & Stenner, P. (2012) "Doing Q methodological research: theory, method and interpretation LK - https://wur.on.worldcat.org/oclc/918558269." Los Angeles: SAGE. Available from: http://srmo.sagepub.com/view/doing-q-methodological-research/SAGE.xml

Watts, S. & Stenner, P. (2014a) Doing the fieldwork: participants, materials and procedure. In: *Doing Q methodological research: Theory, method and interpretation*pp. 69–90. SAGE Publications Ltd. Available from: https://doi.org/10.4135/9781446251911.n4

Watts, S. & Stenner, P. (2014b) Understanding the analytic process (1): factor extraction. In: *Doing Q methodological research: Theory, method and interpretation*. London: SAGE Publications Ltd., pp. 91–112. Available from: https://doi.org/10.4135/9781446251911

Webler, T., Danielson, S. & Tuler, S. (2009) *Using Q method to reveal social perspectives in environmental research*. Greenfield, MA: Social and Environmental Research Institute. Available from: https://www.betterevaluation.org/sites/default/files/Qprimer.pdf

Yakubov, M. (2012) Assessing irrigation performance from the farmers' perspective: a qualitative study. *Irrigation and Drainage*, 61(3), 316–329. Available from: https://doi.org/10.1002/ird.649

Yohannes, D.F., Ritsema, C.J., Solomon, H., Froebrich, J. & van Dam, J.C. (2017) Irrigation water management: Farmers' practices, perceptions and adaptations at Gumselassa irrigation scheme, North Ethiopia. *Agricultural Water Management*, 191(2017), 16–28. Available from: https://doi.org/10.1016/j.agwat.2017.05.009

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