

RESEARCH PAPER

Access to Agricultural Knowledge in Sub-Saharan Africa in the Absence of a Central Supplier of Knowledge: The Case of the Gezira Scheme in Sudan

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CITATION: Musa, N. S. A., Kyazze, F. B., Sseguya, H., Kampen, J. K. and Elwasila, E. M. M. (2026): Access to Agricultural Knowledge in Sub-Saharan Africa in the Absence of a Central Supplier of Knowledge: The Case of the Gezira Scheme in Sudan. *International Journal of Innovation and Knowledge Management in the Middle East and North Africa (IJKMMENA)*, Vol. 11, Nos. 1/2, pp.01-17.

RECEIVED: 28 May 2025 / **REVISED:** 4 August 2025 / **ACCEPTED:** 2 June 2026 / **PUBLISHED:** 10 July 2026

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ABSTRACT

PURPOSE: This study assesses farmers' access to agricultural knowledge after a reduction in government support in the Gezira Irrigation Scheme, Sudan.

DESIGN/METHODOLOGY/APPROACH: An explanatory cross-sectional study was designed to conceptualise farmers' access to agricultural knowledge in terms of availability, reachability, findability, comprehensibility and usability. Data were collected from 381 randomly selected farmers using a questionnaire. The study was conducted in seven purposively selected sites of the Gezira Irrigation Scheme in Sudan. Data were analysed using descriptive and multivariate statistical methods.

FINDINGS: Farmers in the Gezira irrigation Scheme accessed knowledge on land preparation, appropriate seeds and fertilisers, credit sources, crop pest and disease management, irrigation, and weeding, mostly from fellow farmers, neighbours and relatives. The majority of farmers perceived agricultural knowledge to be adequate. The adequacy of knowledge was influenced by a variety of factors, including number of crops grown, number of knowledge sources, farmers' education level and possession of off-farm income sources.

PRACTICAL IMPLICATION: With increased interest in farmers' access to agricultural knowledge, the findings indicate the diversity of types and sources of knowledge and the importance of strengthening farmer-to-farmer communication in the context of reduced government support.

THEORETICAL IMPLICATION: The paper contributes to understanding how farmers continue to access agricultural knowledge in the context of reduced government support to agricultural extension services.

ORIGINALITY/VALUE: This study highlights how farmers access and perceive agricultural knowledge after reduced government support to agricultural extension services in the Gezira Irrigation Scheme. The results indicate that paying attention to the informal sources of agricultural knowledge can enhance the quality and quantity of knowledge accessed by farmers.

KEYWORDS: *Agricultural Knowledge; Knowledge Access; Farmers' Perceptions; Knowledge Adequacy; Sub-Saharan Africa; Sudan.*

INTRODUCTION

In sub-Saharan Africa, access to relevant and usable agricultural knowledge remains central to agricultural productivity, sustainability and livelihood improvement. Recent studies show that farmers obtain such knowledge through a combination of extension services, research and education institutions, radio, digital tools, markets, and interpersonal networks (Awuah-Frimpong *et al.*, 2024; Maldayo *et al.*, 2024; Shitaye *et al.*, 2024). However, availability does not necessarily imply effective access: knowledge must also be reachable, understandable and perceived as useful if it is to influence practice (Lwoga *et al.*, 2011; Mtega *et al.*, 2016).

In many African settings, formal extension systems remain uneven in coverage, while digital platforms have expanded possibilities for agricultural advice but remain constrained by connectivity, infrastructure and digital literacy (Choruma *et al.*, 2024; Dlamini and Ngulube, 2024; Komba, 2024). These constraints make social and informal knowledge channels especially important. Evidence on farmer-to-farmer communication and social networks shows that farmers often learn through trusted peers and reference groups rather than through formal suppliers alone (Appiah *et al.*, 2025; Githinji *et al.*, 2024; Izuchukwu *et al.*, 2023). A typical example is the Gezira Scheme in Sudan, where farmers had limited knowledge supply after reduced government support to the

scheme in favour of oil production (FAO, 2015; Mahgoub, 2014). Farmers' demand for knowledge expanded as they increased the number of crops grown after government control reduced. This led to seeking knowledge outside the usual sources. Therefore, this study aims to determine how farmers in the scheme access knowledge for agricultural production and marketing after the withdrawal of government support in an explanatory cross-sectional study of the scheme.

Conceptualisation of the Study

Access is understood here as the opportunity to obtain, use and benefit from knowledge needed for farming decisions (Mathiesen, 2014). Because knowledge affects practice only when users perceive it as relevant, credible and usable, the study treats perceived adequacy as a practical indicator of knowledge quality (Lemos *et al.*, 2012; Wale and Mkuna, 2023).

The study uses Mathiesen's (2014) Physical, Intellectual and Socio-cultural (PhIS) framework. In this framework, access has five facets: availability, reachability, findability, comprehensibility and usability. Availability mainly concerns the production side of the knowledge system and is reflected in the diversity of knowledge sources. The remaining facets depend on both the knowledge available and the farmers' capacity and context.

The conceptual framework (Figure 1) therefore links perceived knowledge adequacy to the types of knowledge accessed, sources used, and farmer and farm characteristics. Since farmers' decisions are shaped not only by individual attributes but also by social relationships and reference groups (Githinji *et al.*, 2024), informal sources, such as fellow farmers, relatives and neighbours, are treated as substantive components of the knowledge system rather than as residual channels.

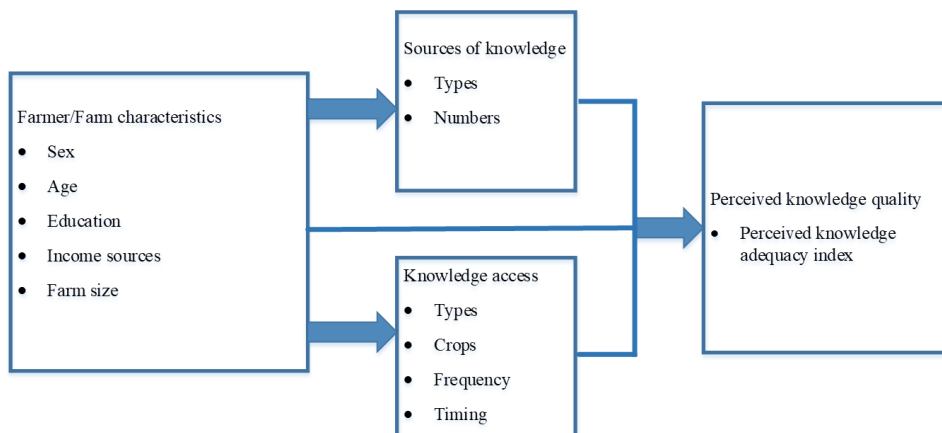


Figure 1: Conceptual Framework: The Variables Hypothesised to Influence Farmers' Perceived Knowledge Quality

Source: Adapted from Mathiesen, 2014

Context of the Study: The Gezira Irrigation Scheme

The Gezira Irrigation Scheme (GS) in Sudan is one of Africa's large-scale irrigation schemes, covering about 880,000 hectares. Established in 1925 to supply cotton to British textile factories and provide income for farmers, it uses gravity irrigation from the Sennar Dam (Osman *et al.*, 2011; Suliman, 2016).

Historically, agricultural knowledge in GS was centrally organised. Knowledge generated by the Agricultural Research Corporation (ARC) was delivered to farmers through Ministry of Agriculture and Forestry inspectors, and farmers were expected to follow these recommendations as part of scheme management.

When Sudan gained independence in the 1950s, management of GS changed to the Sudan Gezira Board (SGB). However, agricultural performance later declined amid inefficient irrigation infrastructure, changing government priorities and contested reform efforts (Goelnitz and Al-Saidi, 2020; Suliman, 2016). The Gezira 2005 Act sought to reduce government responsibilities, decentralise management roles and allow farmers greater freedom in crop choice and scheme administration. It also opened space for private provision of agro-inputs such as credit, machinery and seeds, although formal agricultural knowledge management remained largely under SGB (Goelnitz and Al-Saidi, 2020; Mahgoub *et al.*, 2017).

Implementation of these reforms was difficult. Goelnitz and Al-Saidi (2020) reported weak implementation, limited farmer involvement, unclear reform objectives and governance problems in efforts to transfer responsibilities to farmers. In this context, farmers increasingly had to seek knowledge beyond formal scheme structures, reducing SGB control over the type and quality of knowledge available.

Current evidence on farmers' access to agricultural knowledge within GS remains limited. This study therefore establishes the types of agricultural knowledge accessed, the sources used, farmers' perceived adequacy of that knowledge, and the factors associated with perceived adequacy under reduced government support.

METHODOLOGY

Study Area and Sampling Plan

The study was conducted in seven sites in the Gezira Irrigation Scheme (GS), Gezira State, and central Sudan in 2016, long before the outbreak of the civil war in 2023. GS was selected because it was Sudan's largest irrigation scheme under one management structure. To capture geographical diversity, sites were selected from the northern, southern, eastern and western parts of the scheme (Figure 2). The Gezira Irrigation Scheme is divided into 22 sub-divisions with a total population of 128,000 farmers. Of the scheme's 22 sub-divisions, 7 were selected: 2 from the north, 2 from the south, 1 from the east and 2 from the west. The target population in these sub-divisions was 40,635 farmers. A sample size of 384 was calculated using Mugenda and Mugenda's (2003) formula. Access to respondents was facilitated by the GS agricultural manager and sub-division inspectors.



Figure 2: Map of Gezira Irrigation Scheme Showing the Study Sites

Source: Author's survey 2016

Data Collection

Data were collected using a semi-structured questionnaire developed in English and translated into Arabic. It covered farmers' socio-demographic characteristics, knowledge types and sources, and perceived knowledge adequacy, measured on a four-point scale from very inadequate (1) to very adequate (4). The instrument was reviewed by three experts and peers, then pre-tested with three farmers outside the study sites using cognitive interviewing (Collins, 2003). Eight Arabic-speaking research assistants were recruited before data collection. Prior to actual data collection, the research assistants were trained for two days to ensure understanding of the items in the questionnaire as part of data quality assurance.

Data Analysis

Multiple linear regression was used to identify factors influencing farmers' perceived adequacy of agricultural knowledge. The dependent variable was the perceived knowledge adequacy (PKA) index, computed from ten four-point Likert-type items measuring adequacy of knowledge across different knowledge types. The index was calculated as:

$$\text{perceived knowledge adequacy index} = \frac{\text{total score by the farmers on all 10 items}}{\text{total max. possible score on all 10 items}}$$

The maximum possible score was 40; the index ranged from 0 to 1. The PKA index was entered as the dependent variable in the regression model. Independent variables included sex, age, years in school, farming experience, farm size, number of crops grown, off-farm income, and number of agricultural knowledge sources.

RESULTS

Types of Agricultural Knowledge Accessed in the Gezira Irrigation Scheme

Interaction with respondents revealed that farmers in GS were engaged in the production of various crops, namely cereals (98%), legumes (81%), cotton (44%), vegetable (40%) and oil crops (2%). The farmers reportedly accessed different types of agricultural knowledge on the different crops they were growing. The knowledge accessed ranged from land preparation, seed and fertiliser, credit, pests and diseases, irrigation, weeding, storage, transport, marketing and agricultural insurance (Table 1).

Table 1: Types of agricultural knowledge accessed by farmers on the different crops

Type of knowledge accessed	Percentage of farmers who accessed knowledge about crops				
	Cereals (Wheat, Sorghum) (n=377)	Cotton (n=169)	Legumes, Groundnut, Pigeon Peas, Chickpeas, Faba Beans & Lentils (n=310)	Vegetables (Onion, Tomato, Hot Pepper, Cucumber, Egg Plant, Carrot, Okra & Corchorus) (n=155)	Oil crops (Sunflower & Sesame) (n=7)
Land Preparation	85.9	93.8	28.6	13.8	59.9
Seed and Fertiliser	85.0	92.4	28.8	13.8	59.9
Credit	82.5	91.1	26.8	12.8	54.4
Pests and Diseases	83.5	91.1	28.3	13.5	59.9
Irrigation	84.5	92.9	28.4	13.5	59.9
Weeding	83.7	93.3	28.4	13.3	59.9
Storage	54.9	66.5	21.3	10.1	43.5
Transport	79.1	83.6	27.5	13.3	59.9
Marketing	78.6	83.2	27.2	13.0	54.4
Agricultural Insurance	37.4	61.1	4.2	2.5	16.3

Source: Author's survey 2016

Results from Table 1 indicate that more than 80% of the farmers growing cereals and cotton had access to knowledge on land preparation, seeds and fertilisers, credit, pests and diseases, irrigation, and weeding. In contrast, less than 14% of the farmers growing vegetables accessed the different types of knowledge. About 28% of farmers growing legumes had access to the different types of knowledge, while less than 60% of farmers growing oil crops had accessed knowledge.

For all crops, the proportions of farmers who accessed knowledge on storage and agricultural insurance was generally lower than those who accessed knowledge on other aspects. Interviews revealed that most farmers did not seek knowledge about storage because they perceived their existing practices to be adequate and therefore did not have to search for new knowledge. Similarly, farmers reportedly did not seek for knowledge on agricultural insurance because insurance companies provided inadequate compensation for damages incurred during agricultural production.

Sources of Agricultural Knowledge

Farmers reported that they accessed agricultural knowledge from multiple sources including GS staff, fellow farmers, relatives and neighbours, Agricultural Research Corporation (ARC) researchers, and private companies (Table 2). From Table 2, it is evident that fellow farmers, neighbours and relatives were the most common sources of knowledge except for irrigation for all crops and all aspects of cotton. GS staff were the most common source of knowledge on irrigation and cotton production. The limited role of GS staff as a source of knowledge on production of cereals and legumes is mainly attributed to the government's policy change in 2005; this reduced financial support to the scheme and removed restrictions on the types of crops grown.

Farmers reported that the knowledge they received from fellow farmers was largely through unstructured and unplanned meetings in various places such as markets and mosques. This was normally done on an individual basis as the farmers were reportedly not organised in functional farmer groups. They reported that the GS management allocated land to individual farmers and offered advisory services on individual basis. However, farmers reported that the GS staff did not regularly provide agricultural knowledge as frequently as farmers would have wished.

Table 2: Types and sources of knowledge accessed by farmers for different crops (n = 381)

Crops	Sources of Knowledge	Type of knowledge accessed by farmers %									
		Land Preparation	Seed and Fertiliser	Credit	Pest and Diseases	Irrigation	Weeding	Storage	Transport	Marketing	Agricultural Insurance
Cotton (n=169)	GS Staff	65.2	68.1	63.3	75.1	76.4	64.0	40.4	46.2	55.7	42.6
	Farmers, relatives and neighbours	26.2	20.1	20.7	10.1	15.3	26.2	24.8	36.7	16.0	1.1
	ARC researchers	1.8	3.6	1.1	1.1	1.1	0.7	0.7	0.7	0.7	0.7
	Private companies	0.7	0.7	5.9	4.7	0.0	2.5	0.7	0.0	10.8	16.7
	Total	93.8	92.4	91.1	91.1	92.9	93.3	66.5	83.6	83.2	61.1
Cereals (n=377)	GS staff	28.7	34.5	28.4	39.1	55.5	34.0	15.7	17.7	22.9	17.7
	Farmers, relatives and neighbours	56.2	46.6	46.2	30.9	28.4	26.1	37.8	60.9	28.5	3.4
	ARC researchers	0.7	1.2	0.3	0.3	0.5	0.1	0.1	0.1	0.1	0.1
	Private companies	0.3	2.7	7.6	13.1	0.1	13.4	1.3	0.4	27.1	16.2
	Total	85.9	85.0	82.5	83.5	84.5	83.7	54.9	79.1	78.6	37.4
Legumes (n=310)	GS Staff	2.9	3.3	1.1	6.0	15.6	5.0	0.9	1.4	0.5	0.6
	Farmers, relatives and neighbours	25.2	23.2	24.9	14.3	12.4	16.2	20.0	26.2	17.5	2.5
	ARC researchers	0.4	0.5	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
	Private companies	0.1	1.7	0.7	8.0	0.1	7.1	0.4	0.0	9.2	1.1
	Total	28.6	28.8	26.8	28.3	28.4	28.4	21.3	27.5	27.2	4.2
Vegetables (n=155)	GS Staff	1.2	1.5	0.2	2.5	6.9	1.7	0.0	0.2	0.0	0.2
	Farmers, relatives and neighbours	12.3	11.1	12.3	7.4	6.4	8.4	10.1	12.8	9.3	1.7
	ARC researchers	0.2	0.2	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
	Private companies	0.0	1.0	0.2	3.7	0.0	3.2	0.2	0.2	3.7	0.5
	Total	13.8	13.8	12.8	13.5	13.5	13.3	10.3	13.3	13.0	2.5

Crops	Sources of Knowledge	Type of knowledge accessed by farmers %									
		Land Preparation	Seed and Fertiliser	Credit	Pest and Diseases	Irrigation	Weeding	Storage	Transport	Marketing	Agricultural Insurance
Oil crops (n=7)	GS Staff	16.3	16.3	5.4	16.3	38.1	16.3	5.4	16.3	5.4	5.4
	Farmers, relatives and neighbours	43.5	43.5	49.0	21.8	21.8	21.8	38.1	43.5	27.2	5.4
	ARC researchers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Private companies	0.0	0.0	0.0	21.8	0.0	21.8	0.0	0.0	21.8	5.4
	Total	59.9	59.9	54.4	59.9	59.9	59.9	43.5	59.9	54.4	16.3

Source: Author's survey 2016

Farmers' Perceptions on the Quality of Agricultural Knowledge Accessed

Farmers' perceptions about the adequacy of the knowledge accessed were used as a measure of its perceived quality. On average, over 50% of the farmers perceived the quality of all types of knowledge accessed to be either adequate or very adequate, with the exception of knowledge on storage and agricultural insurance (Table 3).

Table 3: Farmers' perception on adequacy of agricultural knowledge (n=381)

Agricultural Knowledge type	Farmers' rating of the quality of knowledge (%)			
	Very inadequate	Inadequate	Adequate	Very adequate
Land Preparation	7.6	23.6	37.3	31.5
Seed and Fertiliser	7.9	24.7	37.8	29.7
Credit	16.8	26.2	30.4	26.5
Pest and Diseases	10.0	34.4	35.2	20.5
Irrigation	12.3	22.0	36.5	29.1
Weeding	9.4	29.1	36.2	25.2
Storage	26.8	23.4	22.3	27.6
Transport	12.1	21.8	36.5	29.7
Marketing	13.1	25.2	35.2	26.5
Insurance	55.4	16.5	14.2	13.9

Source: Author's survey 2016

Determinants of Farmers' Perceptions on Adequacy of Agricultural Knowledge

Multiple linear regression was used to identify factors associated with farmers' perceived adequacy of agricultural knowledge. The model explained 29% of the variation in the adequacy index, adjusted $R^2 = 0.287$, and was statistically significant, $F(8,324) = 3.897$, $p < 0.001$. Collinearity diagnostics indicated no serious multicollinearity, with all variance inflation factors below 10 and tolerance values above 0.1 (Table 4). Four predictors were statistically significant. The number of crops grown and number of knowledge sources were positively associated with perceived adequacy. A one-unit increase in the number of crops grown was associated with a 27% increase in the adequacy index, while an additional knowledge source was associated with a 9% increase. In contrast, years in school and off-farm income were negatively associated with perceived adequacy. Each additional year of schooling was associated with a 12% decline in the index, while off-farm income was associated with a 32% decline.

The results indicate that farmers' perceptions about the adequacy of agricultural knowledge accessed were influenced by their education level (years in school), engagement in off-farm income activities, number of crops grown and number of sources from which knowledge is accessed. Specifically, the number of crops grown and the number of sources from which farmers accessed

knowledge had a positive and statistically significant influence on the perception of the adequacy of knowledge. Conversely, farmers' education level and possession of off-farm income had a negative and statistically significant influence on the perception of the adequacy of knowledge.

The number of crops grown and the number of knowledge sources were positively associated with perceived adequacy. In contrast, years in school and off-farm income were negatively associated with perceived adequacy. Specifically, one additional crop was associated with a 27% increase in the adequacy index and one additional knowledge source with a 9% increase, whereas an additional year of schooling and off-farm income were associated with declines of 12% and 32%, respectively.

Table 4: Determinants of Farmers' Perceptions about Adequacy of Agricultural Knowledge (n=381)

Predictor variables	Standardised B	Std. Error	T-value	P-value	Collinearity Statistics	
					Tolerance	VIF
Sex (1= Male, 0= Female)	0.042	0.135	0.768	0.443	0.963	1.039
Age (years)	0.020	0.002	0.237	0.812	0.397	2.518
Years in school	-0.118	0.003	-2.342	0.023	0.748	1.337
Experience farming (years)	0.094	0.001	1.104	0.271	0.392	2.551
Off-farm income (1=Yes, 0=No)	-0.315	0.025	-2.523	0.018	0.941	1.063
Farm size (acres)	-0.012	0.001	-0.224	0.823	0.957	1.045
Number of crops grown	0.269	0.007	2.637	0.008	0.880	1.136
Number of sources of agric. knowledge (sum across crops)	0.088	0.012	2.378	0.018	0.899	1.113
Constant	0.438	0.166	2.637	0.009		

Adjusted R-square= 0.287, Significant at $P < 0.05$, $P < 0.01$

Source: Author's survey 2016

DISCUSSION

The relatively high proportion of farmers accessing production-related knowledge on cotton and cereals can be explained by the historical role of these crops in the Gezira Scheme and by the continuing presence of their formal advisory structures. Farmers also have accumulated experience that can be shared informally. By contrast, fewer farmers accessed knowledge on legumes and vegetables, despite legumes also being part of the traditional crop rotation. This may reflect the lower priority historically given to legumes and the limited institutional support for vegetables, which were not central to the original production system. The higher access to knowledge among oil-crop farmers may be related to market incentives from vegetable-oil industries; these encourage farmers to seek information on production quality and quantity requirements.

Across crops, knowledge on storage and agricultural insurance was least accessed. Similar gaps in post-harvest and risk-management knowledge have been reported elsewhere in sub-Saharan

Africa (Abass *et al.*, 2014; Affognon *et al.*, 2015; Qange *et al.*, 2024). Limited access to storage knowledge may increase post-harvest losses, particularly for perishable crops. Likewise, limited insurance knowledge may reduce farmers' ability to manage risks related to climate variability, pests, and production losses.

The prominence of GS staff as a source of knowledge on cotton and irrigation reflects the original mandate of the scheme. However, after reduced government support and the relaxation of restrictions on crop choice, farmers increasingly relied on informal sources, especially fellow farmers, relatives, and neighbours. This shift is consistent with recent evidence that farmers' social networks and reference groups influence agricultural decisions and information use (Appiah *et al.*, 2025; Githinji *et al.*, 2024; Izuchukwu *et al.*, 2023). Informal exchange can extend access when formal services decline, but it may also increase variation in the quality, consistency, and accuracy of the information received.

Farmers perceived knowledge on storage and agricultural insurance as relatively inadequate. This suggests that these knowledge areas may be less likely to be used, because farmers tend to apply information they regard as salient, credible, and useful (Lemos *et al.*, 2012; Ho *et al.*, 2023). The finding is consistent with previous evidence that agricultural knowledge systems in sub-Saharan Africa often emphasise production more than post-harvest handling and risk management (Affognon *et al.*, 2015; Mutungi *et al.*, 2023).

The positive association between the number of crops grown and perceived knowledge adequacy may indicate that crop diversification exposes farmers to more sources and learning opportunities. Similarly, access to more knowledge sources may allow farmers to compare, verify, and adapt information, a pattern also reported in recent studies of smallholder information access (Shitaye *et al.*, 2024; Wale and Mkuna, 2023). However, multiple sources may also produce conflicting advice, indicating the need for co-ordination and quality control.

Education and off-farm income were negatively associated with perceived adequacy. More educated farmers may be more critical of available knowledge because they can compare information across sources and identify gaps. Farmers with off-farm income may have less time or motivation to seek agricultural knowledge because their livelihoods are less dependent on farming (Pfeiffer *et al.*, 2009). These findings suggest that improving access alone is insufficient; knowledge must also be relevant, credible, and adapted to farmers' changing production systems and livelihood strategies.

CONCLUSIONS AND RECOMMENDATIONS

Farmers in the Gezira Irrigation Scheme accessed knowledge on land preparation, seed and fertiliser, credit, weeding, pest and disease management, irrigation, storage, transport, marketing, and insurance. However, crop diversification after reduced government support exceeded the capacity of formal scheme staff to meet farmers' knowledge needs. For crops other than cotton, farmers relied heavily on informal sources, especially fellow farmers, relatives, and neighbours.

Most knowledge was perceived as adequate, except knowledge on storage and agricultural insurance. Perceived adequacy was higher among farmers growing more crops and using more knowledge sources, and lower among more educated farmers and those with off-farm income. The study therefore recommends strengthening farmer-to-farmer knowledge exchange through organised groups and appropriate information and communication technologies (ICTs), while expanding knowledge provision on post-harvest handling and agricultural risk management.

ACKNOWLEDGEMENTS

We acknowledge the Gezira Irrigation Scheme Management for their support in data collection. The corresponding author appreciates the efforts and support from Irene Tamubula and Narisi Mubangizi in the analysis and editing. We are also grateful to Gezira Scheme farmers who participated in this study.

COMPETING INTEREST STATEMENTS

The authors declare that they have no competing interests

FUNDING

Intra-ACP funded this study through the SHARE Project by providing tuition fees, stipend, medical insurance and air ticket support. RUFORUM sponsored research finalisation through the Carnegie Foundation of New York “Research Finalization Project Grant No. RU/2016/INTRAACP/RG/024”.

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