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Incentives promoting scaling of improved seed varieties in Uganda

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Abstract

This paper aims to explore the current incentives driving the scaling out of improved cassava seed varieties in Uganda. This highlights a critical gap in the limited use of incentives in scaling out transformational technologies for vegetatively propagated crops such as cassava. The farmers involved in such technologies often realise economic benefits only after a significant period, typically through the sale of cuttings. These benefits are neither immediate nor visible, making them less effective in motivating adoption to scale. The aim of this study was to examine the types of incentives that promote the scaling out of research innovations within the cassava seed system in three selected districts of, Kiryandongo, Kamuli, and Serere in Uganda. Data were collected via a mixed-methods approach that included survey interviews, key informant interviews, and focus group discussions. A total of 170 respondents participated. The data were analysed using STATA18, Analysis of Variance (ANOVA) technique was used. The results revealed that nonfinancial incentives such as field tours and training provided by research institutions were significant and contributed to the scaling of improved cassava seed varieties. These incentives were statistically significant at the $p < 0.01$ and $p < 0.1$ levels, respectively, in both the intervention and the non-intervention areas. Knowledge-based incentives are limited to less educated and rural communities, potentially limiting the effectiveness of such incentives. There is need to establish and invest in robust financial-incentive frameworks that support and sustain scaling pathways for research innovations within the cassava seed system.

Keywords Cassava seed systems, Incentives, Transformation

1 Introduction

The real scaling of agricultural innovations, particularly in seed systems, is driven by two critical factors such as access to knowledge and targeted investment. These elements are critical for expanding the reach of agricultural technologies and ensuring their long-term impact [1]. The resulting framework, the PRactice-Oriented Multilevel perspective on Innovation and Scaling (PROMIS), can inform researchers and policymakers on the complex changing aspects involved in scaling research innovations in seed systems [2].

In Uganda, technological innovations in the cassava seed system play a vital role in the agricultural sector [3], yet advances in this area face unique challenges, especially due to

the nature of cassava as a vegetatively propagated crop [4]. These challenges include the bulkiness and perishability of planting materials [5], possibly to meet market characteristics which are influenced by limited formal market structures, high distribution costs, which necessitate tailored incentive mechanisms and supportive policies to enable scaling out [6]. However, the Agricultural Innovation Systems (AIS) framework highlights multistakeholder collaboration and context-specific solutions to some of these challenges [7].

Therefore, this study investigates the types and practices of incentives that foster the scaling out of cassava seed innovations. It explores how these incentives influence farmer participation in scaling out with transformational approach to cause wide spread of technologies, in both intervention and without intervention areas within the cassava seed system. For example, a number of interventions can be deployed to demonstrate how possible to access improved materials without much cost and distance. Interventions that motivate farmers require broader and more inclusive approaches such as Quality Declared Seed (QDS) systems and Local Seed Business (LSB) enterprises, which are typically managed by farmers themselves through seed exchange. While these approaches have remained relevant and effective within communities, they are often less financially rewarding. According to McGuire [8] as a result, financing has been negatively affected, partly due to the limitations of traditional seed systems. Which are associated with lower yields and, in some cases, the spread of diseases. Key incentives must recognize access to improved varieties, where there is increased knowledge exchange, and integration into value chains that reward quality and resilience. The only challenge they have not benefited farmers financially fully. Yet the complexity of the cassava seed system, it is compounded by rising input costs and weak market infrastructure both in intervention and without intervention areas. There are no better structures to cause transformation scaling which call for strategic interventions with inclusive financing models (Richard Lamboll, Practical lessons on scaling up smallholder-inclusive and sustainable cassava value chains in Africa [9]), especially with quality declared seed (QDS) [10]. And better implications have been linked to strengthened public–private partnerships for access to planting material and long-term delivery of quality seed [11]. Also, articulating national policy frameworks to support the adoption and unbiassed involvement of all actors in terms of investment levels is a necessity [12].

Funding institutions should support seed system scaling by aligning investments with incentives like skills-focused training, guided by transformational scaling principles and informed by key innovation stage assessments. It's argued that scaling improved cassava varieties is a multidimensional process, not merely a technological upgrade [13]. In doing do so there need to enhances agricultural productivity and contributes to poverty reduction and food security [14]. Agricultural value chains are strengthened for research and innovation to be promoted. And the use of improved planting materials should be expanded with creation of incentive frameworks to support farmers' participation in modern markets [15]. This signifies that the adoption of improved cassava varieties is not merely a technological shift but also a socioeconomic transformation driven by capacity building, institutional support, and community-level engagement with known financing models for transformation [16]. This paper explains how promoting a mix of incentive practices are key in scaling out of improved varieties with transformation of the seed system. because through transformational perimeter like insight and boundary

it's easy to identify where incentives and incentive practices can be promoted along the path ways to cause change or positive scaling out in the seed system. Through this multidimensional analysis. This paper adopts a transformational scaling lens to assess how these interventions (inclusive models, strengthen public private partnership, articulate public policy) contribute to Uganda's broader agricultural transformation.

2 Materials and methods

2.1 Study area

The study was conducted in the districts of Kiryandongo, Serere and Kamuli, all in Uganda. These districts are located in midwestern ecological zones in the Bunyoro region, eastern zones in the Busoga region and north eastern zones in the Teso region. Kiryandongo is located at 1″ 14′ 20.0″ N and an elevation of 1160 m, whereas Kamuli is located at 0.94722000 and longitude of 33.11972000 and an elevation of 1,100 m. Serere district is located at 1°30′00.0″N, 33°33′00.0″E, and an elevation of 1,085 m (Fig. 1).

2.2 Sampling criteria and selection

A purposive sampling approach was used to evaluate the impact of the Cassava: Adding Value for Africa Phase II (CAVA II) project, which aimed to promote improved cassava varieties through the development of Cassava Seed Entrepreneurs (CSEs) across five African countries Uganda, Nigeria, Ghana, Tanzania, and Malawi. In Uganda, the project was implemented by the Africa Innovations Institute (AFRII) [17], and according to [18]. It led to increased access to quality cassava seed and a significant rise in yields, from 16.1 t/ha in 2014 to 33.8 t/ha in 2016 in beneficiary fields.

For the present study, key sub counties with a strong history of cassava cultivation were selected in each district, and at least 1 village within each parish was chosen through a multistage random sampling method, distinguishing between areas with NARO-led cassava multiplication trials and those with no intervention (control). A total of 120 households were randomly selected, 60 from intervention areas and 60 from non-intervention areas to ensure a comparison between the treated and untreated. Data collection also

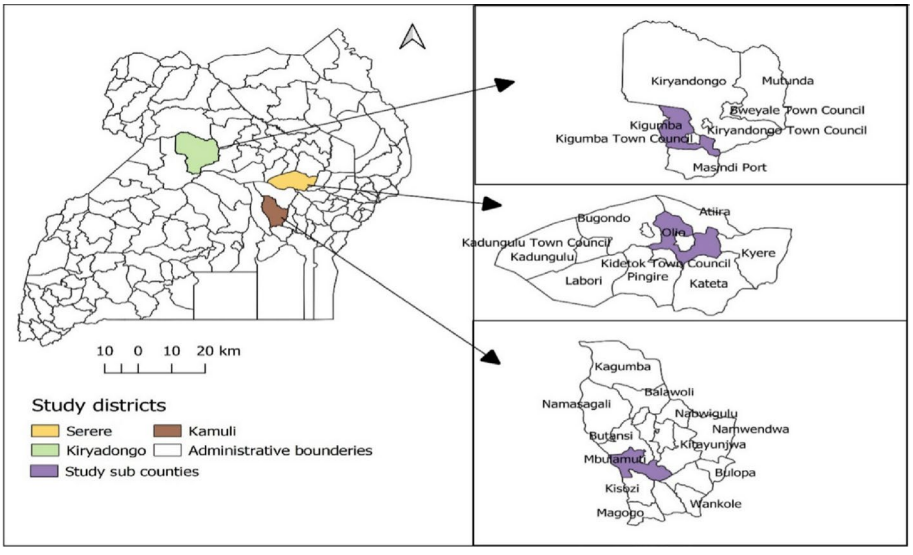

Fig. 1 Map of Uganda showing study areas of districts of Kiryandongo, Kamuli and Serere

included 21 key informant interviews (KIIs) with highly knowledgeable respondents and six Focus Group Discussions (FGDs) involving 8–12 participants each.

2.2.1 Face-to-face survey

A semi structured questionnaire was developed with the approval of supervisors, doctorial committee and departmental committee for quality purpose. It was then uploaded into Kobo collection software for the face-to-face survey with the farmers. The questionnaire consisted of both closed- and open-ended questions to capture demographic information, perceptions and experiences related to scaling out improved cassava seed variety. The questions were designed to be clear, concise and culturally relevant [19, 20].

To enhance the effectiveness of the semi-structured questionnaire, the instrument was pretested on a small group outside the study area. This was done to assess the clarity, relevance, and comprehensibility of questions related to both the intervention and non-intervention areas [21]. Based on feedback from the pre-tests, revisions were made to improve the wording and flow of the questions, ensuring they were easily understood by participants. Further refinements were made in consultation with the research supervisors to align the tool with the local socioeconomic context and the cassava seed system.

Each question to the famer was read aloud by the research assistant for the farmer to consent to the interviews, and telephone number and GPS locations were captured in the Kobo collection software. The data collected were edited, validated and cleaned before being downloaded into STATA 18 computer software for further analysis.

2.3 Key informants interview tool

The Key Informants Interviews (KII) tool checklist was designed for interviews with 21 key stakeholders, including seed entrepreneurs, agricultural officers and International Potato Centre (IITA), National Agricultural Research Organisation (NARO), Makerere University, and Chain Uganda. The tool included open-ended questions intended to explore the participants' knowledge, experiences and opinions on the determinants of scaling out improved cassava seed varieties in Uganda.

The KII checklist was based on the study's key research questions, which were designed to probe topics such as improved cassava seed use, sources and availability, adaptation, and barriers to scaling out. The literature on cassava seed systems, particularly studies involving scaling out (adoption and uptake), was used to guide the development of these questions.

The KII checklist was piloted and tested, and selected cassava seed multipliers and key informants were interviewed to identify ambiguities in the questions. Feedback was used to refine the guide to the research survey for clarity and effectiveness. Adjustments were made to the phrasing of questions to ensure that they elicited detailed and relevant responses.

2.4 Focus group discussion tool

The Focus Group Discussion (FGD) tool checklist was designed to facilitate group discussions among 8–12 participants from each district and for both project intervention and non-intervention areas. The tool was structured around a series of thematic questions designed to stimulate discussion and allow participants to share their collective experiences.

The FGD checklist was developed by reviewing consistent, relevant and in-depth qualitative data needed for the study. The questions were open-ended and structured to encourage discussion sessions, with some prompts to guide the facilitator in managing the group dynamics.

To ensure that the FGD checklist was appropriate for the participants' literacy and cultural context, it was pretested with 30 households from a similar background of villages of intervention and non-intervention in areas with improved cassava variety seeds but outside the study area. On the basis of feedback, the facilitators were trained to adapt the questions as needed during the discussion, ensuring that all voices were heard [22]. The tool was revised to eliminate jargon or complex terms that could confuse participants.

2.5 Data analysis

Data was imported from kobo collect, organized, and analysed using STATA18. Descriptive statistics were calculated, including frequencies, percentages, means, standard deviations, and the minimum and maximum values. Furthermore, a one-way ANOVA was performed to determine whether there were any significant differences in the use of clean planting materials across different seed system landscapes, as influenced by the expansion of cassava research interventions. Data from focus group discussions and key informant interviews were analysed using qualitative methods. The responses were transcribed, coded, and organized into themes to identify recurring patterns and insights related to the study objective. A thematic analysis approach was employed to interpret participants' perspectives, allowing for a deeper understanding of contextual factors influencing the use of clean planting materials across different seed system landscapes.

3 Results and discussion

Table 1 below presents a comparison of key sociodemographic characteristics between the project intervention and non-intervention areas. A small proportion of armers had no formal education (5.8% in the intervention area and 4.4% in the control area), whereas tertiary and university education levels were more prevalent in both districts. Specifically, 3.8% of the farmers in the project intervention areas reported tertiary education,

Table 1 Demographic characteristics of the study

Variable	Intervention area	Without intervention area	Significance
	Mean	Mean	
Level of education			
No formal education (1 = Yes, 0 = No)	0.058	0.044	
Primary (1 = Yes, 0 = No)	0.885	0.897	
Tertiary (1 = Yes, 0 = No)	0.038	0.015	
University (1 = Yes, 0 = No)	0.019	0.044	
Household size	7.923	6.662	*
Age of the household head	45.269	52.544	
Income from cassava sales (UGX)	1,620,096	905,294	
Type of household			
Female headed (1 = Yes, 0 = No)	0.250	0.162	
Male headed (1 = Yes, 0 = No)	0.750	0.838	
Received training			
No (1 = Yes, 0 = No)	0.923	0.926	
Yes (1 = Yes, 0 = No)	0.077	0.074	

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

whereas 1.5% reported in control areas. On the other hand, 4.4% of the farmers in the control areas had a university education, compared with 1.9% in the intervention areas.

Household size was significantly different ($p < 10\%$), with the intervention area households being larger (mean = 7.92) than those in non-intervention areas (mean = 6.66). Improved cassava varieties may not need definitive labour, depending on their cassava traits and farming methods. The age of the household head differed significantly across the groups, with household heads in the intervention areas being younger (mean = 45.3 years) than their non-intervention counterparts (mean = 52.5 years).

3.1 Incentives promoting scaling up of research innovations in cassava seed systems

3.1.1 Incentives practices

Table 2 blow shows the key incentives that facilitate scaling of research innovation in cassava seed system among farmers. The results indicate that 34.8% identified training by model farmers as an incentive, while 47.8% pointed to training at research institutions. A slightly higher proportion (approximately 52.2%) associated incentives with demonstration plots, whereas about 17.4% accessed information through radio, and 13% regarded field tours as motivating factors.

These findings suggest that practical, field-based approaches such as demonstration plots and institutional training play a more influential role in encouraging participation compared to other channels. This highlights the importance of strengthening incentives that encourage hands-on learning opportunities and formal training systems, while also improving the reach and effectiveness of mass communication and experiential learning methods to ensure broader and more inclusive access to information.

3.2 Certified cassava seed production by district

3.2.1 Seed production levels

The production levels of certified cassava seed appear to play a significant role in motivating farmers to participate in the scaling of the seed system. In the Fig. 2 below, higher production levels of certified cassava seed act as a strong incentive for farmer participation in scaling seed systems.

Market incentives vary across districts, reflecting differences in productivity and returns. For instance, Kiryandongo, which records the highest annual production (3,840 bags of cassava cuttings), also offers the highest average price per bag (35,000 UGX), followed by Kamuli with moderate production (1,230 bags) and a price of 25,000 UGX. In contrast, Serere, with the lowest production level (490 bags), offers the lowest price (15,000 UGX).

These variations suggest that higher production levels are associated with better market returns, thereby providing stronger economic incentives for farmers to engage in

Table 2 Showing incentives promoting scaling out research innovations in cassava seed system

Incentives	Percentage (%) (N = 120)
Support training by Model farmers (1 = Yes, 0 = No)	0.348
Training at Research institution (1 = Yes, 0 = No)	0.478
Demonstration plots (1 = Yes, 0 = No)	0.522
Radio program (1 = Yes, 0 = No)	0.174
Field tours (1 = Yes, 0 = No)	0.130

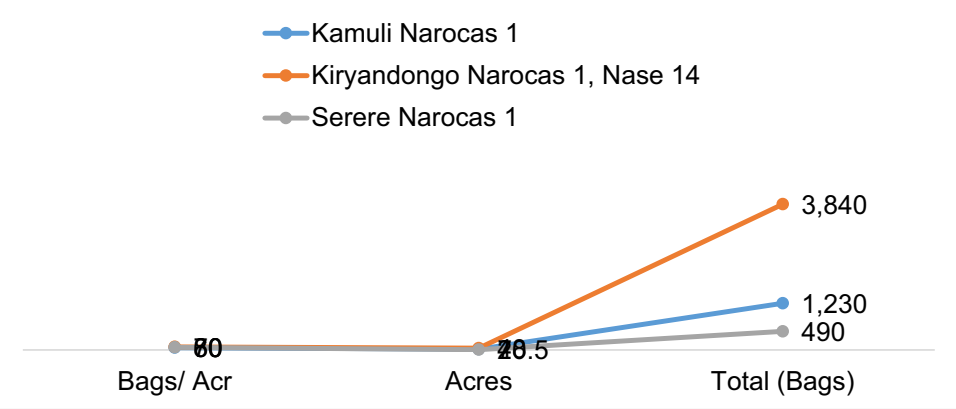

Figure.2 Annual certified cassava seed production by district in bags per acre

Table 3 Distribution of incentive practices

Incentives practices	Intervention	Non-intervention	Significance
Support training by model farmers (1 = Yes, 0 = No)	0.273 (0.467)	0.455(0.522)	
Training at Research institutions (1 = Yes, 0 = No)	0.217(0.421)	0.636(0.505)	*0.1
Radio programs (1 = Yes, 0 = No)	0.545(0.522)	0.459(0.512)	
Demonstration plots (1 = Yes, 0 = No)	0.471(0.237)	0.189(0.104)	
Field tours (1 = Yes, 0 = No)	0.182(0.405)	0.091(0.302)	**0.05

Standard errors in parentheses, (***$p < 0.01$, **$p < 0.05$, *$p < 0.1$)

certified seed production. This demonstrates that improving productivity and market linkages can encourage greater farmer participation in scaling cassava seed systems.

However, the persistent challenge in agricultural research and development is determining how to convert incentives into real technology adoption among local farmers. Resource constrained smallholders face many obstacles, especially their limited access to timely, relevant, and research-based innovations. These difficulties are further compounded by weak linkages among research institutions, extension services, farmers, and input providers [23]. Despite this, farmers have shown the capacity to adapt and reorganize incentive structures to suit their needs. This suggests the presence of a well-developed seed market, likely supported by strong infrastructure, effective market connections, there is higher advantages to make income from improved varieties [24]. The yield attracts farmers economic incentives especially high yields and prices encourages farmers hence scaling seed production, as seen in Kiryandongo, followed by Kamuli with 1230 bags, and Serere district, producing just 490 bags annually [25].

3.2.2 Distribution of incentive practices

Table 3 shows the distribution of incentives across interventions and without interventions across selected districts.

The incentives that were statistically significant included field tours ($p < 0.05$) and training at research institutions ($p < 0.1$) across intervention areas and without intervention areas. These are nonmonetary incentives aimed at encouraging behaviour change, learning, or adoption of innovations.

Field tours were appreciated by 13% of the farmers as key elements of nonfinancial incentives, indicating that while practical exposure is beneficial, logistical and access barriers may limit their overall impact [26]. Among the approaches evaluated, field

tours were statistically significant at $^{**}p < 0.01$ in influencing farmers' adoption of new practices. These forms of support play crucial roles in promoting innovation uptake by encouraging learning, fostering behavioural change, and building farmer confidence. Farmers' preferences regarding support methods varied significantly. On the other hand, only 17% of the farmers considered radio programs to be useful sources of agricultural knowledge. Despite its accessibility, radio lacks the interactive component essential for effective learning.

Training at Research Institutions approximately 34.8% of farmers recognized training from model farmers as a key incentive, highlighting the value of peer-to-peer learning, which thrives on shared experiences and trust within communities. In comparison, 47.8% of the respondents cited training at research institutions as highly beneficial. This suggests a strong appreciation for formal, science-driven learning, especially when such training introduces advanced techniques and practices [27].

Training includes teaching through model farmers, conducting sessions at research institutions, setting up demonstration plots, using radio programs for awareness, and organizing field tours. According to [28], such strategies highlight the importance of knowledge and information dissemination in promoting agricultural innovation if a concept is well supported.

Support for training also enhances farmers' sense of ownership, promotes sustainability, and reduces transaction costs in the adoption of new technologies. However, [29] pointed to a gap between complex theoretical innovation models and practical tools for decision-making in research for development. Bridging this gap requires transformative leadership, as noted by the [30]. To avoid the observed limited presence of institutional arrangements with universities for follow-up on training and monitoring of variety innovations to reduce hindrances to the scale-up process. Encouraging public–private partnerships (PPPs) and introducing accountability tools such as Joint Sector Reviews (JSRs), as proposed by Foundation [31], can foster collaborative planning and resource allocation.

In terms of the effectiveness of nonmonetary incentives, comparative analysis across intervention districts and non-intervention districts revealed substantial differences in the impact of nonmonetary incentives.

Such incentives are especially vital in low-resource areas where access to formal education or extension services is limited [32]. Moreover, they are often more sustainable and scalable than direct financial subsidies are, as they build intrinsic motivation and reduce long-term reliance on external support [33, 34]. The statistical findings revealed that field tours had a significant impact ($p < 0.05$), whereas research institution training was also notable ($p < 0.1$). These learning experiences effectively bridge the gap between research and practice by offering farmers hands on exposure and science-backed knowledge.

The fact that these methods proved impactful even in districts without active interventions demonstrates their borrowed strength “or applicability and potential for upscaling. These findings align with recommendations from [35] and [36], who advocate for increased returns on public science investments through effective innovation dissemination. Strengthening networks of seed enterprises (SEs) and supporting associations can connect early-generation seed producers with smaller-scale farmers, enhancing overall system resilience.

Table 4 Proportion of cassava growers using clean planting material in the areas

Respondent type	Use of improved certified cassava varieties		
	No	**Yes**	**Total**
Core		18	18
		(16.36)	(15.00)
Informal	10	45	55
	(100)	(40.91)	(45.83)
Spill over		47	47
		(42.73)	(39.17)
Total	10	110	120

Source: Field data

A statistically significant difference ($p < 0.000$) in the adoption rates of improved cassava seeds across different groups, such as intervention and non-intervention farmers, was observed for those using clean planting materials. This finding demonstrates that scaling out is strongly influenced by individual or contextual characteristics. Personalized or tailored strategies are therefore essential. Programs must account for factors such as access to training, extension support, and the specific needs of marginalized groups such as youth, women, and disadvantaged communities.

3.3 Proportion of cassava growers using clean planting material

3.3.1 Use of improved certified cassava varieties

Table 4 below, presents the distribution of cassava growers using improved certified planting materials across different farmer categories.

Table 4 reveals overall, 110 out of 120 farmers s reported using improved varieties, while only 10 indicated non-use. Adoption was highest among spill over farmers (47; 39.17%), followed by informal farmers (45; 40.91%), and core farmers (18; 15.00%). All non-users were recorded within the informal group. These results indicate a high overall uptake of improved cassava planting materials, with variations observed across farmer categories.

To aid scaling out, policy recommendations are essential for effective dissemination of agricultural technologies, incentive structures should focus on support mechanisms to stabilize farmer's incomes, skills, and exposure to market conditions to enhance competitiveness and direct payments linked to adoption, such as compensation for demonstration plots or seed multiplication activities within the contract support for seed-multiplication by farmers and local farmers/farms. Such incentives must also address social equity, ensuring that benefits reach vulnerable farming households.

While some incentives, such as government subsidies for clean cassava planting materials are clear cut, others are more specific such as distribution of planting materials by Operation Wealth Creation (OWC), National Agriculture Advisory Services (NAADS), reflecting the cultural and economic systems in which the seed system operates [37]. These less obvious incentives are equally important for sustainable adoption.

Nonmonetary incentives such as training, field tours, and peer learning play crucial roles in enhancing technology adoption in agriculture, particularly in low-resource settings. These approaches are sustainable, scalable, and effective across different intervention contexts. Market-based incentives also drive increased production, particularly where infrastructure and awareness are strong, as seen in Kiryandongo. However,

disparities in adoption persist owing to unequal access to training, weak institutional support, and limited private sector involvement.

According to [38] addressing these gaps through targeted and inclusive policies can enhance farmer education and strengthen public–private collaborations, both of which are essential for sustainable transformation [39]. emphasizing a combination of structured and context-specific incentives, policymakers and stakeholders can foster an enabling environment that empowers farmers, improves livelihoods, and accelerates the scaling of agricultural innovations, particularly within seed systems such as cassava.

In conclusion, the scaling of improved cassava seed varieties in Uganda is strongly influenced by a combination of nonmonetary, institutional, and market-based incentives. The practical learning approaches such as demonstration plots, field tours, peer-to-peer learning through model farmers, and training at research institutions significantly enhance farmers' willingness to adopt and multiply improved cassava seed varieties. These incentives strengthen farmers' knowledge, confidence, and exposure to innovation while promoting sustainable behavioural change. Market opportunities, including higher yields, better prices, and reliable seed demand, further motivate farmers to participate in certified seed production, particularly in productive districts such as Kiryandongo. However, adoption remains uneven because of limited access to extension services, weak institutional linkages, and inadequate support for vulnerable farming groups. The findings therefore highlight the need for inclusive policies, stronger public–private partnerships, improved research-extension-farmer networks. As targeted support systems that enhance access to information, training, and markets. Strengthening these incentives can create an enabling environment for sustainable scaling of improved cassava seed systems. Including, Improved farmer livelihoods, and increased agricultural productivity in Uganda.

4 Recommendations

Nonfinancial elements, as incentives key for upscaling, include field tours and training support.

Financial investment, especially for NAROCAS1, which has been sold online and performs well across borders of Uganda to Malawi, Kenya, and Rwanda, can substantially increase farmers' earnings, similar to other types of seed systems or crops, especially when e-commerce is involved and pivotal in connecting farmers to broader markets, leading to income growth and enhanced market visibility.

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Author contributions

Co-Authors All others contributed to the papers and jointly supervised the work.

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Data availability
The datasets generated during and/or analysed during the current study are not publicly available due that PhD study is still ongoing but are available from the corresponding author on reasonable request. Therefore, data will be made available on request.

Declarations

Ethics approval and consent to participate
The study protocol, including the questionnaire and research procedures, was reviewed and approved by the Doctoral Committee and the Department of extension and innovation studies at Makerere University in accordance with the University's postgraduate guidelines and regulations. All participants provided informed consent prior to participation, and the study was conducted in accordance with relevant ethical principles for research involving human participants as respondents.

Consent for publication
This manuscript does not contain any individual person's data in any form (including images, audio, or identifiable quotes). The datasets generated during and/or analysed during the current study are not publicly available due that PhD study is still ongoing but are available from the corresponding author on reasonable request. Therefore, data will be made available on request.

Informed consent
Informed Consent of verbally read to the participant and, was obtained from all participants involved in the study prior to participation. Participants were informed about the purpose of the study and questions read loudly, confidentiality, and their right to withdraw at any time without consequence. The questionnaire was interpreted to local languages as per the location of the participants and interviews. The statement of consent to participate was as follows conducting this research and PhD study as a student of Makerere University college of Agriculture, Department of Extension & Innovation studies. Your participation is completely voluntary. You have the right not to participate. However, if you decide to participate, your information and identity will be kept confidential and your name and identification will never be affiliated with the answers you provide. Do you consent to the interview 1 Yes. 2 No.

Human or animal rights
This study it did not involve any intervention or sensitive personal data, and was conducted in accordance with institutional and national ethical guidelines where concept, proposal and questionnaire were presented and approved by the supervisors, doctorial committee and passed by the departmental committee as recommended by Makerere University Graduate Handbook.

Competing interest
The authors declare no competing interests.

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