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EDITED BY
Enoch Kikulwe,
Alliance Bioversity International and CIAT, Kenya

REVIEWED BY
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Université Paris 8, France
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Saints Cyril and Methodius University of Skopje, North Macedonia

*CORRESPONDENCE
Robert Kajobe
r.kajobe@muni.ac.ug

†These authors have contributed equally to this work

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Pioneering the use of embedded research translation methodology for potential increased income and livelihoods of smallholder farmers

Robert Kajobe[1*†], Experito Muyanja Kabuga[1†], Ratib Dricile[2†], Victor Wadri[3†], Richard Malingumu[3†] and Peninah Yumbya[4†]

[1]Directorate of Graduate Training, Research and Innovation, Muni University, Arua, Uganda, [2]Faculty of Health Sciences, Muni University, Arua, Uganda, [3]Faculty of Agriculture and Environmental Sciences, Muni University, Arua, Uganda, [4]International Centre for Evaluation and Development, Nairobi, Kenya

Whereas participatory research and development is widely acclaimed, an effective explicit procedure for ensuring end-user participation remains a holy grail. Our study proposes a simple participatory approach by operationalizing the Embedded Research Translation (ERT), developed by LASER PULSE, and demonstrates its application among smallholder vegetable farming communities in the West Nile sub-region of Uganda. The ERT involves integrating research findings directly into practical applications or solutions within specific contexts. It emphasizes collaboration between researchers and stakeholders, ensuring that findings are relevant, actionable, and effectively applied in real-world scenarios. It is built on four pillars: (i) partnerships between researchers and stakeholders (ii) engaging in a process of generating a relevant research (iii) product and (iv) dissemination of findings. Based on these pillars and their underlying principles, an implementation process is recommended, beginning with a start-up stage where researchers actively involve a diverse range of partners and stakeholders. This is followed by a design stage, characterized by participatory discussions, collaborative decision-making, and planning. These steps guide the implementation phase, during which partners remain actively engaged in research. Finally, the partnership collectively disseminates the findings to maximize impact and uptake. In our study, we adapted the method to Ugandan context using a five-stage procedure: In the first stage (understanding the context), researchers rapidly obtain as much information as possible about the relevant aspects of the target cropping system and the broad areas of intervention through literature review, and quantitative baseline surveys. This is followed by the second stage (co validation) in which the information is validated by stakeholders through FGDs and feedback meetings. At the third stage (co-selection of priority areas of interventions), researchers and stakeholders co-select target crops and specific constraints to be addressed. The fourth stage is co-development which involves co-ideation and co-testing of potential technologies. The final stage (dissemination) consists of scaling the co-developed technologies through the partnership and other dissemination channels.

KEYWORDS

co-designing, prioritization, pre-harvest, post-harvest, marketing, dissemination

1 Introduction

1.1 Overview of participatory research and development methods

Research and development interventions in smallholder farming systems have increasingly embraced participatory approaches since the 1980s due to mounting criticism against traditional top-down approaches (Bryceson et al., 1980; Jackson-Smith and Veisi, 2023). Despite their indisputable contribution over the years, top-down research efforts overlook the role of 'science society' interaction in shaping appropriate context specific knowledge (Aeberhard and Rist, 2009). Consequently, they underutilize indigenous knowledge and innovative capacity accumulated by farmers as they interact with peers and their farming system context (Neef and Neubert, 2011). As a result, there is limited cross fertilization of knowledge between researchers and their intended farmers, which reduces appropriateness of the interventions (Sumane et al., 2017). In contrast, participatory methods ground the technology development into the target biophysical and socioeconomic context, and thereby improve their appropriateness and uptake (Coe et al., 2013; Nederlof and Dangbegnon, 2007). Participatory researchers for instance are cognizant of farmers' 'silent veto' over technologies proposed and thus adopt a negotiation rather than prescriptive tone. This enhances local ownership and open feedback about the technologies (Descheemaeker et al., 2019; Nederlof and Dangbegnon, 2007).

Whereas it is increasingly acclaimed, participatory research remains elusive and comprises various approaches arising from the diverse underlying motivations (Jackson-Smith and Veisi, 2023). Nevertheless, the various approaches appear to converge around key characteristic features such as the extent of farmers' participation in decision making on the research agenda. Since researchers, farmers and other stakeholders have different needs and perspectives, the extent of stakeholder involvement in decision making is a major determinant of how these perspectives and power differences are reconciled (Adamsone-Fiskovica and Grivins, 2021). As such, the relative control over research decisions by farmers and researchers is a major lens for categorization of the various participatory approaches.

In their review, Jackson-Smith and Veisi (2023) reveal a continuum of participatory nature of interventions ranging from conventional top-down projects to fully independent farmer-led research. On one extreme, conventional top-down approaches involve farmers passively majorly to provide land and/or labor to research projects that are fully conceived and designed by researchers. Some consultative projects seek farmers' opinions and preference, but researchers often retain the right to make the final decision. At a higher level of participation and collaborative arrangement, decision making is shared equally between farmers and researchers which is considered a 'cooperation', 'co-learning' or 'co-production'. On the other extreme, with increasing autonomy of farmers, projects can be collegial where farmers consult with scientists to get their input, but retain the final decision-making authority or independent projects where farmers work with only nominal input from researchers. Based on this continuum, we posit that true participatory research should target a collaborative arrangement where both researchers and end users have equal stake in shaping the research trajectory. However, there is limited information about the explicit procedure for incorporating end-user participation especially at project design and agenda setting.

During diagnosis and design, researchers commonly employ various Participatory Rapid Appraisal (PRA) tools such as Focus Group Discussions (FGDs), Key Informant Interview (KII), transect walks, pilot surveys, among others. However, the practical combination of these tools into an impactful workable procedure remains uncertain. This is probably because it is published in gray literature such as project reports or it is generally considered tacit information that practitioners and participatory researchers find obvious. This notwithstanding, inappropriate methodology limits attainment of the intended end-user ownership, wide uptake and sustainability of the interventions (Van Asten et al., 2009), hence, the need for explicit documentation of promising procedures. The research and development fraternity would benefit from sharing a wining process in addition to outcomes given the numerous intricacies associated with participatory research (Adamsone-Fiskovica and Grivins, 2021; Nederlof and Dangbegnon, 2007). Therefore, full development and utilization of participatory research requires open sharing about the process and its complexities, challenges, successes and lessons. In this paper, we share experience on local operationalization of the Embedded Research Translation approach (LASER-PULSE, 2023) to smallholder vegetable production systems in Uganda.

The paper is organized as follows: First we outline the embedded research translation as explained by its developers (LASER PULSE). Then, a description of the case study production system is given, followed by our conceptualization of the procedure and overview of the research methods used in gathering the empirical data along the proposed framework.

1.1.1 Embedded research translation

ERT is an epitome of practical participatory research and development in which the process of 'translating' research outputs into actual development outcomes is 'embedded' within the actual research process. In this approach, research findings are directly integrated into practical applications or solutions within specific contexts. It emphasizes collaboration between researchers and stakeholders, ensuring that findings are relevant, actionable, and effectively applied in real-world scenarios. The ERT rests on four pillars namely; building necessary (i) partnerships between researchers and stakeholders, to engage into a (ii) process of generating relevant research, (iii) product, and (iv) dissemination of findings (Figure 1). Whereas the developers of the ERT do not attempt to classify it along the participation continuum, it is conceivable that this approach lies at the collaborative level of participatory research (Jackson-Smith and Veisi, 2023). It is thus a promising methodology for attainment of the universal aims of participatory research such as intended end-user ownership, wide uptake and sustainability of the interventions.

The developers outline underlying principles to guide implementation and suggest a step-wise implementation, explaining how each of the four principles are addressed in each phase. The steps include Start up, Design, Planning, Implementation and Impact (Figure 2). In the start-up stage, researchers proactively involve diverse partners and stakeholders, ensuring that they embed research translation from the beginning. The design stage is actually implemented together as equals, with participatory discussion and collaborative decision making and similarly planning is done

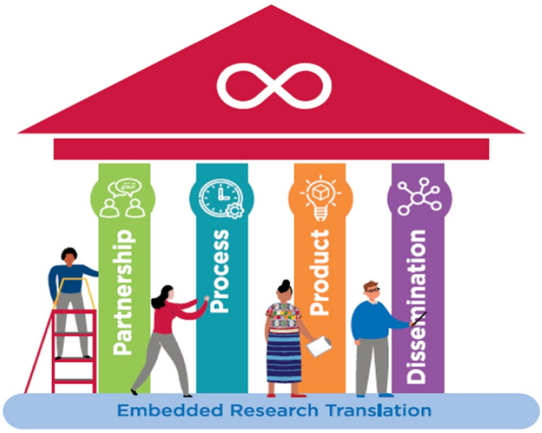

FIGURE 1
Pillars of the ERT (LASER PULSE).

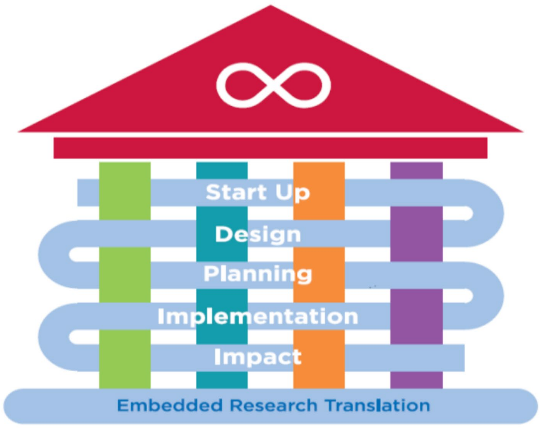

FIGURE 2
Stages of ERT (LASER PULSE).

TABLE 1 Principles of embedded research translation (ERT).

Pillar	Principle
Cross-cutting principles	I. Embed research translation across all phases of the research project, from startup and design through implementation and impact. II. Co-produce research to addresses a development challenge.
Partnership	III. Engage in equitable partnership between practitioners and researchers. IV. Proactively engage relevant stakeholders to increase research uptake and impact.
Process	V. Establish partnership structure, roles, and procedures. VI. Agree upon expectations and project goals among partners.
Product	VII. Ensure evidence is accessible, valued, and understood by practitioners. VIII. Co-design translation products for specific audience or end-users.
Dissemination	IX. Plan for dissemination and impact from the beginning. X. Embrace an iterative approach to research design, implementation, and dissemination.

collectively. This informs the implementation phase which should engage partners and stakeholder throughout the research. Finally, the partnership ultimately disseminates collectively for impact and uptake. A number of associated 'how to' tools are accessible at the LASER PULSE website (Research Translation Tools and Templates - LASER PULSE). We adapted this approach with stakeholders in horticulture subsector in Uganda and thus provide our pioneering experience of its usability with small holder systems. Particularly, the paper dwells on collaborative priority setting and intervention design.

1.1.2 Principles of ERT

The developers of ERT suggested two cross-cutting principles and specific principles to each pillar as presented (Table 1).

2 Suggested conceptual operationalization of ERT

The ERT provides a compelling case for embedding translation into the research process and early engagement of end-users in the agenda setting. However, in an attempt to address each pillar at each stage, the original ERT process assumes a narrative structure that does not provide a clear actionable procedure. Our adaptation contributes to operationalisation and usability of the ERT by suggesting a unique practical and reproducible procedure.

For this procedure, a minimum of three partners including the research organization(s), the intended end user (e.g., farmers or vendors) and an enabling partner such as extension structure or agro-input dealer are required. This minimum partnership of three is in line with the partnership described by Adamsone-Fiskovica and Grivins (2021) which consisted of farmers, advisors and researchers. The procedure comprises, five stages (Figure 3). Compared to the start-up stage of the typical ERT, we propose a simple stage one (understanding the context) during which researchers rapidly obtain as much information as possible about the relevant aspects of the target cropping system and the broad areas of intervention through literature review, quantitative baseline surveys and other feasible rapid appraisal tools. This is followed by the second stage (co-validation) in which the rapid understanding is subjected to validation by the stakeholders through participatory tools such as FGDS, nominal discussions, and feedback meetings aiming at developing consensus among the partners. This leads to the third stage (co-selection of priority areas of interventions) in which the stakeholders co-select target commodities and specific constraints to be addressed. The fourth stage is co-development which involves co-testing of potential technologies through participatory experimentation that leads to refined integration of indigenous and external knowledge. In principle, our co-selection and co-development stages are comparable to the design and implementation phases of the ERT developed by LASER PULSE. The fifth and final stage (dissemination) consists of scaling the co-developed technologies through the partnership and other dissemination channels with the target participants in the lead.

3 Testing our Ert process on vegetable production in Uganda

Vegetables are major crops produced in all districts of Uganda (Dijkxhoorn et al., 2019), and play important role in food security, employment and income generation among smallholder farmers in the country. Ugandan famers produce a variety of vegetables including tomatoes, cabbages, carrots, green pepper and indigenous vegetable, majorly at smallholder level. However, majority of the horticultural produce (90%) is consumed locally and suffers from post-harvest losses as revealed by global trends. FAO (2015) estimated the global annual loss and waste to be 40–50% of fruits and vegetables but figures as high as 70% are sometimes reported in West Nile.

3.1 Study area

The study was conducted in the Northwestern part of Uganda, also referred to as West Nile sub region, located about 475 kilometers by road northwest of Kampala the nation's capital. It was specifically conducted in five rural districts namely Arua, Koboko, Terego, Yumbe and Zombo. The region comprises a diverse ethnic composition and neighbors two international borders, i.e., South Sudan to the north and the Democratic Republic of Congo (DRC) to the west. The area features varying elevations from 600 meters above sea level close to the Nile to 1,600 masl at the border with DRC, occurring over a relatively short distance (Monaghan et al., 2012). Rainfall is unimodal with 800–1,404 mm per year and average temperature is above 26°C.

Rain-fed subsistence agriculture is the primary source of rural livelihood in West Nile (Kansiime et al., 2018) with a predominantly cassava-based system. However, a wide range of crops are grown owing to the varying elevations that result in varying sub agro-ecologies. The high-altitude zones, including Zombo and part of Arua district predominantly grow perennial crops namely arabica coffee, banana and fruit trees while mid-altitude areas (Koboko, Terogo, Yumbe and Part of Arua) majorly produce cassava, and Sorghum. Low land areas close to River Nile majorly produce dry land crops such as Sesame, Sorghum and feature moderate densities of Livestock. Vegetable production cuts across the entire mid to high altitude areas and is predominantly at smallholder rain-fed scale, dominated by women. With exception of a few farmers close to permanent streams, vegetable production is largely seasonal targeting the rainy season.

3.2 Detailed methods along our adapted ERT

Our study was majorly conceptual and constructivist, leveraging insights from a USAID funded project 'Development of innovative horticulture technologies for improved income and livelihood among small scale women farmers in Uganda,' that was implemented in the area. The project targeted to address important pre-harvest, post-harvest and marketing constraints to four priority vegetables. Selection of priority crops, key constraints to be addressed and a few sets of options to be tested were all decided collaboratively with farmers. This section first elaborates detailed generic methods for implementation of our conceptual adapted ERT procedure. For illustration, we discuss some results and findings and how they were incorporated within the successive stages of the horticulture project.

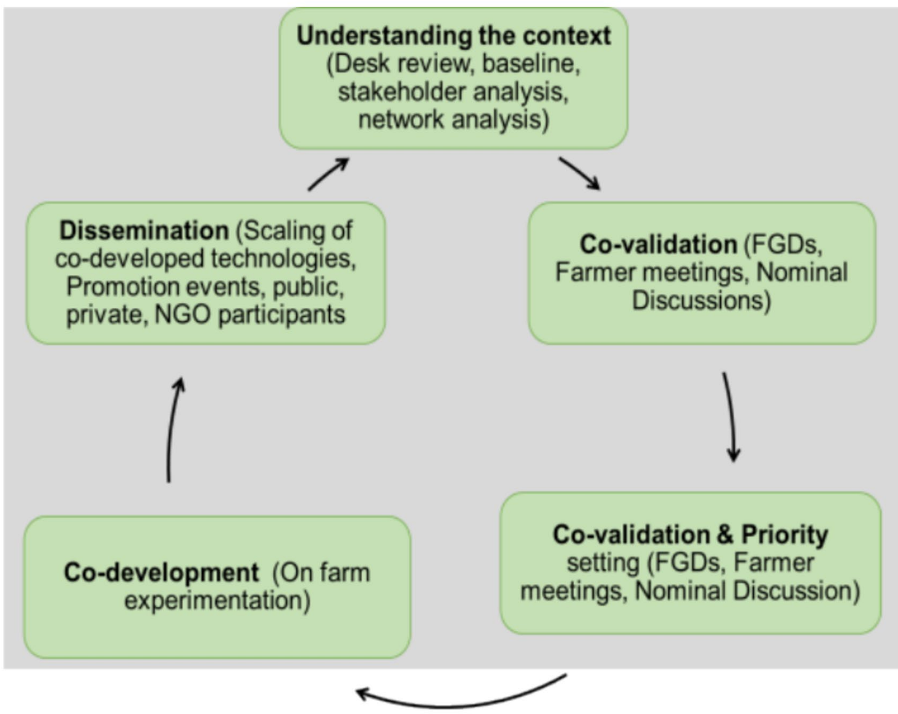

FIGURE 3
Adapted ERT process.

3.2.1 Step one: understanding the context

In this project, stage one (understanding the context) sought to study the socioeconomic context, major vegetable crops grown and the key production constraints. We obtained general understanding about the status of vegetable production through literature review, field observation, local expert information and baseline survey ($n = 607$). We pre-determined to work on four priority vegetable crops in the study area and addressed important constraints broadly classified as pre harvest, post-harvest and farmer organization. Insights from literature review, rapid field observations and expert opinion informed the development of baseline survey methodology and tools. The baseline analysis ultimately informed our researcher-based tentative target crops based on the most frequently reported crops.

3.2.2 Step two: co-validation

This stage consisted of feed-back meetings with selected farmers across the project sites conducted in the target sub counties. For each meeting, participants were convened from two major vegetable growing parishes and hosted at one of the members' farms. This venue was preferrable to public spaces such as administrative premises since it would reduce intruders. It improved the practicality of the discussion since participants sometimes referred to the crops on the farm to describe production constraints. In one case however, the selected parishes were too distant for farmers to convene in one place, therefore two meetings were conducted but the ensuing results were similar. Mobilization of the participants was done by the area extension officer of the private partner in consultation with the local leaders at parish and village level to ensure that all invitees were vegetable farmers. There were slight variations in the turn up for the meetings but it was generally 20–30 farmers facilitated by a team of researchers and the private sector agro-dealer/extension officers. In the meetings, farmers were introduced to the project citing examples of broad problem of preharvest and post-harvest loss and the need to intervene on key horticulture commodities. This was followed by an explanation of the ERT approach and the strong need for farmer partnership for joint decision making and owning of the entire research intervention. This was premised on the tenets of embedded research translation, which show a partnership between researchers, practitioners and the end users. With this clear understanding, the farmers suggested four priority vegetables based on consensus. After the four crops were suggested, the facilitators shared the original lists of potential crops based on frequency and farmers explained any differences in the list.

3.2.3 Step three: co-selection of priority intervention areas

Having reached an agreement on priority crops, the farmers were facilitated to discuss the major production constraints which the project should address on each crop. Furthermore, they were asked to hypothesize a few potential agronomic, post-harvest and marketing management options to be co-tested based on their farming experience and their own imaginations. This way, we involved farmers in hypothesis development and identification of potential treatments to be tried. Farmer involvement in hypothesis setting is inadequate in many participatory research studies which limits the ability to harness farmer's innovative potential in such collaborations.

3.2.4 Step four: co-development

The co-development phase involves co-creating appropriate locally tested technologies originating from hypotheses made by different stakeholders. Appropriateness has varying meaning to different stakeholders. For example, optimum nutrient use efficiency and positive environmental impact might be desirable to the researcher while profitability, affordability and convenience might be additional measures of appropriateness to a farmer. In this stage, stakeholders share emerging evidence and allow multiple interpretation before reaching a negotiated common position.

3.2.5 Step five: dissemination

The iterative nature of the design allows dissemination at any point along the process if new knowledge has emerged. It involves multiple communication channels including interactive methods such as participatory on farm demonstrations, learning exchanges among farmers, workshops and exhibitions. These are supported by wide reaching mass media methods like radio campaigns, television and print materials such as newspapers, newsletters, brochures and fliers. Some audiences, especially the youth can be reached through ICT supported channels like websites and social media.

3.3 Illustrative findings and discussion

3.3.1 Socioeconomic attributes of participating horticulture farmers

The socioeconomic characteristics of farmers across study areas are presented in table one. The age of household heads varied from 18 to 83 with a mean of 43 years. Related to this, the farming experience of the household heads varied between 1 to 60 years with a mean of 18 years. These two indicators showed that the horticulture sub sector in the region employed farmers of various age groups including the youth, adults and some elderly members. This observation aligns with earlier research by Bamwesigye et al. (2020) who stated that agriculture in general is a major source of employment to the population in Uganda. The average level of education in the study was about 7 years of formal education which corresponds to completion of primary school according to Ugandan standard. This is also in line with various studies in other parts of the country including (Nantima et al., 2015; Sell and Minot, 2018).

A farming household consisted of four active members (aged 15–64) on average which could be a good source of family labor for agricultural production (AKPAN et al., 2023; George Rapsomanikis, 2015). The average land holding was1.44 ha (0.04–12). This average land size can support successful a vegetable enterprise comprised of high value crops that can make economic sense even when produced on small scale. Farming was the main source of income for nearly all (> 95%) the households and very few (29%) had alternative sources. With limited alternative sources and strong dependence on farming, it is likely that capital is a major constraint to the vegetable production.

Households accessed produce markets within 3.7 km while farm input markets were more distant at an average of 6.5 km. This indicates that produce markets are averagely nearer probably because the horticultural products grown are also consumed locally within the farming community and nearby dense settlements. Such proximal markets are likely to favor intensification of vegetable production. However, input markets are more distant probably because input shops prefer larger town centers. This is likely to discourage input use and intensification since the transport costs associated with access to input shops ultimately increase the cost of the inputs.

3.3.2 Major vegetable crops grown in the study area

The findings revealed tomato (54%), cowpea leaves (Osubi) (47%), okra (46%) and cabbage (38%) as the four most frequently grown vegetables (figure one) and thus as researchers we presumed, they would be the priority target crops but the co-validation phase proved otherwise. As noted by Dijkxhoorn and colleagues (Dijkxhoorn et al., 2019), vegetable production details are not well captured by the Uganda Bureau of Statistics (UBOS). Nevertheless, tomato, onion and Cabbage are some of the most frequently grown vegetables in Uganda based on production area and exports (e.g., Akello et al., 2023; Food and Agriculture Organization of the United Nations, 2023). On the other hand, cowpea leaves and okra, do not appear as important at national level as observed in this regional study. Their relatively higher frequency here is probably because they are key components of the local diet (Authors' observation; Figure 4).

3.3.3 Co-validated priority crops

During feedback meetings, four major observations were made: First, the list of priority crops was considerably different from what the researcher's criterion of frequencies revealed. Unlike what researchers had identified based on quantitative results of baseline, the order of priority by farmers was tomato, followed by cabbage, onion and another site-dependent crop. Secondly, unlike researchers who considered relative frequency, farmers' priority setting criteria had a mixture of the relative economic importance as well as perceived susceptibility of the crop to production constraints. For example, cabbages attracted higher profit than cowpea leaves and the latter were predominantly grown for home consumption. This explained why farmers prioritized cabbage over cowpea leaves. Similarly, onions fetched better income than cowpea and okra and thus prioritized.

These two observations of farmer's prioritizing behavior provide a strong justification for the co validation stage of all indirect knowledge obtained about a production system and context during the stage of 'understanding the context'. Furthermore, the difference in prioritizing criteria exemplifies the widely reported differences in perspective of different stakeholders in participatory research (Aeberhard and Rist, 2009; Nederlof and Dangbegnon, 2007). The third observation at co validation was the similarity of the first three priority crops (Table 2) and site-specificity of the fourth. This implies that whereas it is inevitable to generalize interventions, provision for site specificity allows local refinement of the research agenda and increases ownership. Lastly, we also noted that our initial externally developed quantitative approach was insufficient. First, the questionnaire was not exhaustive to capture one of the farmer's priorities the eggplant. In addition, the quantitative ranking would relegate watermelon (9% frequency) which turned out to be prioritized in one of the sites (Table 3).

3.4 Co-selection

Tomato was the top priority crop across sites. The major pre-harvest constraints on tomatoes included pest and diseases particularly whitefly, leaf miner, fruit ball worm, late blight, damping off during the nursery stage and some notorious weeds. Farmers also identified soil fertility and soil and water related constraints such as drought, soil erosion and water logging in some areas during rainy seasons. Beyond production, farmers also expressed concern about inauthentic agro inputs, limited capital and inadequate advisory services on vegetable production as well as post harvest constraints of poor transportation and lack of appropriate packaging during transportation. Similarly, cabbage faced challenges of pests and diseases particularly the cabbage web worm, variegated grasshopper, bacterial wilt and damping off. In addition, farmers raised a problem of inferior varieties and poor seed quality together with occurrence of weather-related challenges of drought and hailstone. Other constraints mentioned about cabbage included high labor and input costs together with inadequate knowledge on agronomic operation, majorly land preparation. The major constraints noted about onion production were pests including crickets, grabs, grasshoppers and earthworms. Although earthworms are conventionally considered beneficial, farmers raised a peculiar allegation about their parasitic nature which needs scientific investigation. In addition to pests, farmers highlighted poor seed quality and drought among pre-harvest constraints. The

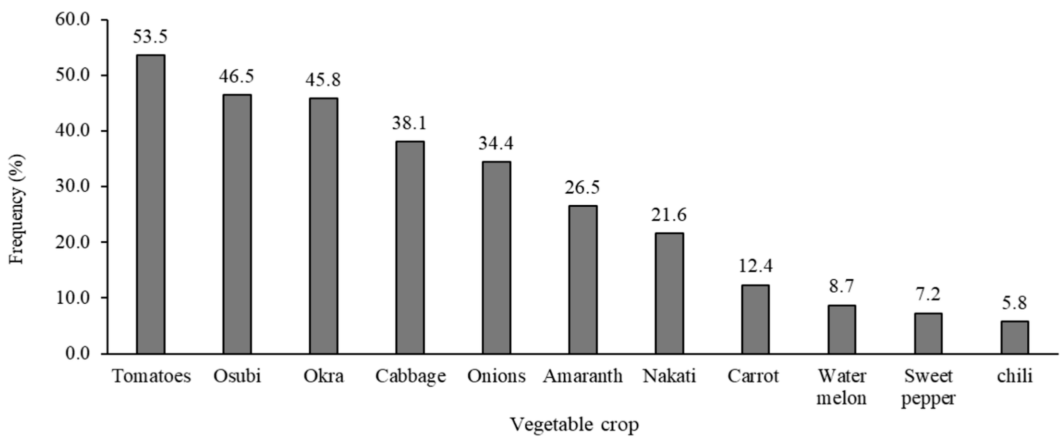

FIGURE 4
Major vegetable crops grown in the study area (average for districts).

TABLE 2 Socioeconomic attributes of the respondents.

Variables	*N*	Mean (range)
Age of household head (yrs)	503	42.5 (18–83)
Education level of household head (yrs)	463	7.3 (0–16)
Farming experience of household head (yrs)	594	18.1 (1–60)
Active members of the household	596	4.0 (1–15)
Land (acres)	587	1.44 (0.04–12)
Market distance (km)	592	3.7 (0–32)
Distance to agro-input shop (km)	594	6.5 (0–50)
Categorical variables	*N*	%
Gender of household head (Dummy, 1 = Male)	596	83.9
Marital status of household head (Dummy, 1 = Married)	596	81.2
Possession of alternative income source (Dummy, 1 = yes)	596	28.7
Major source of income of household head	596	
Farming	570	95.6
Salary employment	12	2.0
Off farm self-employment	12	2.0
Pension	2	0.4

TABLE 3 Final co-prioritized target crops.

District	Sub county	The four prioritized target crops			
		First priority	Second	Third	Fourth
Arua	Vura	Tomato	Cabbage	Onion	Cowpea
Koboko	Kuluba	Tomato	Cabbage	Onion	Okra
Terego	Bileafe	Tomato	Cabbage	Onion	Watermelon
	Omugo	Tomato	Cabbage	Onion	Eggplant
Yumbe	Kei	Tomato	Cabbage	Onion	Okra
	Odravu	Tomato	Cabbage	Onion	Eggplant
Zombo	Warr	Tomato	Cabbage	Onion	Eggplant
	Paidha T/C	Tomato	Cabbage	Onion	Eggplant

major post-harvest constraints included market access and storage while other challenges included inadequate knowledge on site selection and limited capital.

Among the site-specific crops, eggplant was the commonest, selected in four out of the eight sub counties. The major production constraints were diseases (majorly damping off, soil born wilts and soft rot), inadequate knowledge on nursery bed management and variety selection, drought and poor flower retention during rainy seasons. They also noted limited access to inputs such as seed and pesticides as well as poor storage. The second site specific crop was okra as suggested in two sub counties. The key pre-harvest challenges noted about okra were soil fertility, inadequate knowledge on good agronomy as well as limited access to seed and other inputs. The major post production constraint was limited capacity to determine maturity.

The last two priority crops, watermelon and cowpea leaves were suggested in one sub county. Watermelon was mostly constrained by pests, particularly fruit flies, poor quality seed and one post-harvest challenge of poor taste, i.e., 'too watery and not sweet'. Though farmers did not attempt to link soil fertility to the taste, the low sugar content is likely related to potassium deficiency (Arah et al., 2015; Marques, 2016). On the other hand, cowpeas were majorly affected by late planting, and soil fertility which according to farmers was exacerbated by too much rain. Other constraints included drought and minor foliar pests that cause leaf curling in some cases.

3.4.1 Co-development

In this study, the co-development phase followed three major approaches namely, on farm training, demonstration plots and experiments. The training and demonstrations were considered for interventions that are generally accepted as effective elsewhere but are not widely adopted in the target community. In the training approach, farmers received planned practical training on an agreed farm and were encouraged to try on their own farms. Demonstrations were used for technologies that researchers and agro-dealers were sure of their effectiveness but were not commonly agreeable to the farmers. Due to the multiple crops demonstrated on one plot, we adopted a true demonstration rather than a trial approach of comparing farmer practice and technical option (Adamsone-Fiskovica and Grivins, 2021). Farmers were encouraged to try whatever was learnt on the training and demonstration points. Learning and evidence collection was done through participatory monitoring, evaluation and learning on experiments, demonstration sites, adopter and no-adopter farms.

3.4.2 Dissemination

Dissemination approaches can use multiple individuals, group, mass communication and ICT supported channels but our dissemination arsenal particularly comprises field days, expos, learning exchanges, demonstration, publications, newsletters, video documentaries, documentaries and websites.

4 Conclusion

The Embedded Research Technology provides a simple framework for technology co development. In this study we operationalize its usability by suggesting practical step-by step procedures for its implementation in multi-enterprise projects that need collaborative agenda setting and technology co-production. The suggested procedures comprise five iterative stages that start with understanding the context by the external change agents, followed by co-validation of this understanding with the target community, co-selection of priorities and co-testing of the options to develop a research product for dissemination. This process is highly iterative, and some stages can be merged or skipped based on nature of the project and time. This conceptual cycle is helpful in guiding the embedded research process in smallholder farmer setting.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical approval was not required for the study involving humans in accordance with the local legislation and institutional requirements. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their informed consent to participate in this study.

Author contributions

RK: Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Project administration, Resources, Writing – original draft, Writing – review & editing. EK: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. RD: Data curation, Investigation, Project administration, Writing – original draft, Writing – review & editing. VW: Data curation, Formal analysis, Investigation, Methodology, Writing – review & editing. RM: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing. PY: Conceptualization, Investigation, Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing.

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Conflict of interest

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Generative AI statement

The authors declare that no Generative AI was used in the creation of this manuscript.

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