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RESEARCH ARTICLE

Many partners, big numbers? Estimating the reach of CGIAR – supported innovations in East and Southern Africa

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Abstract

As resource envelopes to fund research for development activities become tighter, demonstrating value for money is key. This is difficult for various reasons, chief among these being the failure to embed evaluation frameworks in project design. The multiplicity of scaling partners and their interests, and levels of involvement makes it even more complicated to ensure consistent monitoring and evaluation. We demonstrate how to estimate the reach in research for development projects using a population-based computer-assisted telephone interviewing (CATI) survey methodology that is statistically representative at the desired administrative unit level. This approach was applied to the CGIAR Research Initiative – Diversification in East and Southern Africa (Ukama Ustawi) implemented with several scaling partners across 12 countries in Eastern and Southern Africa. The assessment focused on five of the 12 target countries covered in phase one of implementation. The goal of the assessment was to measure the extent of reach and use of agronomic, mechanization, livestock, and nutrition innovations promoted under Ukama Ustawi, and to assess the extent to which the Initiative reached its intended targets. The data comes from 6,445 randomly sampled rural individuals across 27 districts in the five countries. Approximately 1.05 million people were aware of Ukama Ustawi activities, with Kenya and Zambia showing the highest awareness at 16%. Overall, 164,363 people benefited from various innovations promoted by Ukama Ustawi as of September 2024, about 3 years from the beginning of the project. Of these, 135,767 people were direct beneficiaries in areas where specific interventions were implemented. The rest benefited from spillover effects. About 52% of the beneficiaries were female and 56% were youth aged 18–35 years. Innovation use was highest for minimum tillage and post-harvest mechanization in Zimbabwe, followed by agronomic and mechanization options in Malawi. The benefit-reach ratio was highest in Zimbabwe at 61%, followed

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by Malawi at 31%. This means that Ukama Ustawi activities were most effective at converting reach to beneficiaries in Zimbabwe and Malawi, partly because implementation was layered on past similar interventions. While our results are comparable to more traditional case studies, our survey approach is nearly fourfold cheaper, demonstrating cost-effectiveness and efficiency. We discuss project design and implementation issues necessary to facilitate this kind of evaluation in international development projects.

Author summary

It is increasingly important to demonstrate value for money in international research for development projects. This is a daunting task. It is expensive and requires embedding evaluation frameworks in project design. We present a novel population-based, ex-post phone survey methodology that can be used to assess the extent of reach, use, and potential impacts of research for development projects. We used data collected from 6,445 randomly sampled rural individuals across 27 districts in the five countries where the CGIAR Research Initiative – Diversification in East and Southern Africa (Ukama Ustawi) was implemented between 2021 and 2024. We found that about 1 million people were aware of the Ukama Ustawi activities and 164,363 people benefited from using the various promoted innovations as of September 2024. The use of innovations varied across the five main domains considered: agronomy, mechanization, livestock, irrigation and nutrition. The phone-based statistically representative survey approach used here is nearly fourfold cheaper, demonstrating cost efficiency for evaluating project reach and value for money in international research for development.

1. Introduction

Agriculture employs approximately 65% of the population, contributing over 30% of the Gross Domestic Product (GDP) in East and Southern Africa (ESA) [1]. The region, however, faces significant challenges driven in part by climate change, low productivity, soil degradation, input supply disruptions, and input price spikes driven by the aftermath of the COVID-19 pandemic and the Russia-Ukraine crisis [2,3]. Climate change-induced droughts, floods, and extreme weather events have become more frequent and severe, negatively affecting smallholder agriculture, food and nutrition security in the ESA region [4,5]. Poor soil health, limited use of quality organic and inorganic fertilizers, and improved multi-stress tolerant seeds, and reliance on manual-based and rudimentary farming methods exacerbate the challenges for smallholder farmers in the region. This is compounded by limited access to market opportunities, rising labor shortages and rural wages, and credit rationing, which limits smallholder access to financial resources, especially for youths and women [6].

The national research and extension systems (NARES), international research organizations under. the Consultative Group on International Agricultural Research (CGIAR) and several partners have developed numerous innovations to help address the forgoing key challenges faced by smallholder farmers. However, challenges persist in scaling these potent innovations. Large gaps remain between innovations generated by research and what is used by farmers in their own fields [7,8]. The CGIAR Research Initiative on Diversification in East and Southern Africa (ESA), also known as Ukama Ustawi (UU) was designed to bridge this gap. Implemented between 2021 and 2024, UU co-developed and co-designed agricultural innovations through a network of on-farm living labs and implemented participatory action research in farming communities. The goal was to transform agroecological systems and strengthen food, land, and water systems while harnessing the opportunities of digital extension, private sector engagement, and an enabling environment [9]. As part of the end of Initiative outcome one, UU targeted to reach 100,000 farmers with 40% women and 40% youth participation. The Initiative was implemented across 12 countries in Eastern and Southern Africa: Eswatini, Ethiopia, Kenya, Madagascar, Malawi, Mozambique, Rwanda, Uganda, South Africa, Tanzania, Zambia, and Zimbabwe.

As is the case with most research for development projects, there was a need for evidence on the reach and use by smallholders of the innovations promoted and to assess progress towards the end of Initiative targets. To address this gap, we used a cost-effective, population-based mobile-phone survey methodology that could be applied by other CGIAR research for development projects and other international development interventions to assess the extent of reach, awareness and use of promoted innovations. Because we do not systematically track innovation use over time, we mainly focus on reach, awareness and use. We use reach to refer to individuals who interacted with the UU promoted innovations and awareness to having knowledge about a given innovation. Use refers to having implemented the technology. The three terms follow a logical sequence: reach precedes awareness, which comes before use. We also used the data collected to assess progress towards the end of Initiative targets. Building such evidence base on the uptake of the promoted innovations under UU is important to inform scaling, and to draw lessons to inform future research for development projects.

We focused on several innovations for this assessment spanning agronomy, mechanization, nutrition, livestock, and irrigation (S1 Table). Under agronomy, key practices promoted included minimum tillage, crop rotation, intercropping/strip cropping, and mulching (S2 Table). Mechanization technologies included two-wheel tractors (and their ancillary equipment, such as trailers), groundnut shellers, multi-crop threshers, and irrigation equipment. The paper does not include an expanded analysis of irrigation practices/equipment due to the absence of relevant data. Livestock management involved fodder production and the use of mechanization tools such as feed chopper grinders to prepare livestock feed. For the nutrition component, iron-fortified bean and orange-fleshed sweet potatoes (OFSP) varieties were promoted to improve nutrition. The bean and OFSP varieties were distributed through various channels, including school feeding programs, formal market seed systems, and small seed packs. The main delivery mechanisms for agronomy, mechanization and livestock interventions were through on-farm demonstrations, road shows, and fairs done in conjunction with the NARES, regional NGOs, and private sector partners across the various countries.

2. Background

The CGIAR Research Initiative on Diversification in East and Southern Africa built on several previous CGIAR projects in the region, providing long-standing partnerships and continuing program-level long-term research interventions. The main ones include Research in Sustainable Intensification for the Next Generation (Africa RISING), which promoted sustainable intensification through research and development initiatives targeted at increasing crop yields, boosting soil fertility, and incorporating livestock production to boost income and resilience [10]. The second major project was the Sustainable Intensification of Maize-Legume Cropping Systems for Food Security in Eastern and Southern Africa (SIMLESA) focusing on improving maize-legume cropping systems and food security through research and best practice dissemination [6]. The third major precursor to UU was the Sustainable Intensification of Maize-Legume Systems for Eastern Province, Zambia (SIMLEZA) that aimed to improve maize-legume systems in Zambia's Eastern province [11]. Drawing on lessons from these and other related interventions, UU sought to help millions of vulnerable smallholders in the dominant maize-mixed systems to sustainably intensify, diversify, and de-risk agrifood systems. This assessment is restricted to UU activities under the work package "Diversify and sustainably intensify maize-based farming systems".

Under this work package, UU promoted many innovations (technologies, practices, and bundles) designed to improve farming systems' efficiency and sustainability. These included Conservation Agriculture (CA) principles such as minimum tillage, which can be achieved using rippers, direct seeders, dibble sticks, and planting basins. In addition, the project promoted permanent soil cover through mulching to improve soil water retention, add organic matter to the soil, and moderate temperature. Crop diversification was also a key strategy, encouraging farmers to cultivate various crops in space and time to reduce risks associated with low input use, pests, diseases, and market fluctuations. These practices work together to create a more resilient farming system that can better withstand the challenges posed by climate change.

The UU Initiative promoted appropriate-scale smallholder mechanization services to reduce drudgery and improve efficiency in smallholder farming systems in the region. These services were introduced using a service provider (SP) model where a few of the farmers acquired sets of machinery, such as the two-wheel tractor with ancillary equipment, and these farmers would provide services to the other farmers at a fee. The introduction of irrigation systems further supported farmers by facilitating off-season production, while the integration of livestock provided additional revenue streams and provided biomass (animal manure) for soil fertility enhancement. The technologies and practices promoted under UU were based on scientific research and field trials, drawing from different studies [12–15].

3. Methods and approaches

The research used quantitative methods, including primary and secondary data. Primary data were collected using a structured questionnaire, and secondary data (e.g., rural population for study districts) were gathered from national statistics agency websites for the five countries.

3.1. Sampling strategy and data collection methods

3.1.1. Sampling. We used the Cochran sample size formula [16] to determine the required sample size. This formula is considered appropriate in situations with large or infinite populations, and it is given by:

$$n_0 = \frac{[Z^2pq]}{e^2} \tag{1}$$

where n_0 is the minimum ideal sample given a desired level of precision, the desired confidence level, and the estimated proportion of the attribute in the population; Z is the z-score corresponding to the desired confidence level (e.g., 1.96 for 95% confidence); e is the desired level of precision (i.e., the margin of error, 5%); p is the estimated proportion of the population that has the attribute (30%, 0.3), q is 0.7 (1 – p). We calculated the sample for each country, taking the population as the sum of the rural population in the operational districts.

We then allocated the sample across districts using the formula

$$n_d = n \cdot \left(\frac{\sqrt{pop_d}}{\sum_{d=N}^{d=1} \sqrt{pop_d}} \right) \tag{2}$$

where: n_d is the sample size determined for a given district; n is the overall sample size to be allocated, $\sqrt{pop_d}$ is the square root of the population size of a given district; $\sum \sqrt{pop_d}$ is the sum of the square root of the population over all districts (1…N) involved in the allocation. This allocation has precision, estimation, and cost advantages over the equal proportion of population allocation [17].

To estimate the reach of interventions, we used population weights estimated as $w_d = \frac{pop_d}{n_d}$ where: w_d is the calculated population weight for a given district; $p_o p_d$ is population size for all districts involved in the allocation; n_d is the sample size determined for a given district. To get the population weight, we divided the rural district population by the sample interviewed in the district.

3.1.2. Sample size determination. Different sample sizes were determined across the five countries and then distributed to the 27 districts covered in the survey. The sample sizes calculated using infinite and finite populations were about 196 per district, but the sample sizes interviewed were mostly higher. We adjusted the numbers for potential non-response. In all five countries, the target sample size was 6,457, but 99.8% or 6,445 was achieved. This is much higher compared to other computer-assisted personal interviewing or mobile phone surveys reported before [18]. S3 Table shows the sample details including target and achieved and rural population by district. Overall, across all countries, we calculated the statistics of interest with a very small margin of error (less than 5%) and the sample distributions across all five countries are provided in Table 1.

3.2. Data collection

We collaborated with the international data collection firm, GeoPoll, which used Computer-Assisted Telephone Interviewing (CATI) to collect the primary data. CATI is effective in maintaining data quality and consistency, as it allows for immediate validation of responses and ensures that the survey process is standardized across different locations. To ensure clarity and consistency in the data collection process, a comprehensive glossary of all key terms and interventions and a detailed training manual for enumerators were developed with technical support from the International Maize and Wheat Improvement Centre (CIMMYT). This glossary ensured that enumerators understood the specific terminology related to the agricultural interventions being studied. This was necessary to avoid confusion and to ensure that the data collected was accurate and comparable across respondents. The survey tools (questionnaire and glossary) were translated into the major local languages used in the study areas to reduce translation errors. The sampling frames were provided by GeoPoll, which has extensive experience in conducting large-scale surveys across multiple regions. The data from GeoPoll were supplemented by data from CGIAR partners, ensuring a broad-based survey across the 27 target districts in the five countries. Fig 1 shows the location of the survey districts in southern Africa, counties in Kenya or woredas in Ethiopia. Ethical approval was obtained from CIMMYT's Internal Research Ethics Committee ("IREC"). The CIMMYT IREC is registered with the United States Department of Health and Human Services, the Office for Human Research protections under: IORG0010747 - Centro Internacional de Mejoramiento de Maiz y Trigo. IREC is registered under: IRB00012744. In addition, and because the study involved human participants, verbal informed consent was obtained from all participants prior to administering the survey. In the event of a refusal to consent, interviews terminated.

4. Results and discussion

4.1. Awareness and use of UU-promoted innovations

As awareness of a technology precedes its use, this section presents the two together. Results show that partial rather than the full use of CA principles is more prevalent. Minimum tillage remains the most prevalent CA element used by 7%,

Table 1. Sample details by country in intervention districts.

Country	Rural population	Target sample	Actual sample	Percent (%)
Ethiopia	943,471	1,250	1,232	99
Kenya	3,615,974	1,200	1,183	99
Malawi	3,771,217	1,400	1,415	101
Zambia	1,010,890	1,300	1,284	99
Zimbabwe	1,111,190	1,307	1,331	102
Total	**10,457,190**	**6,457**	**6,445**	

Source: National Statistics Agencies.

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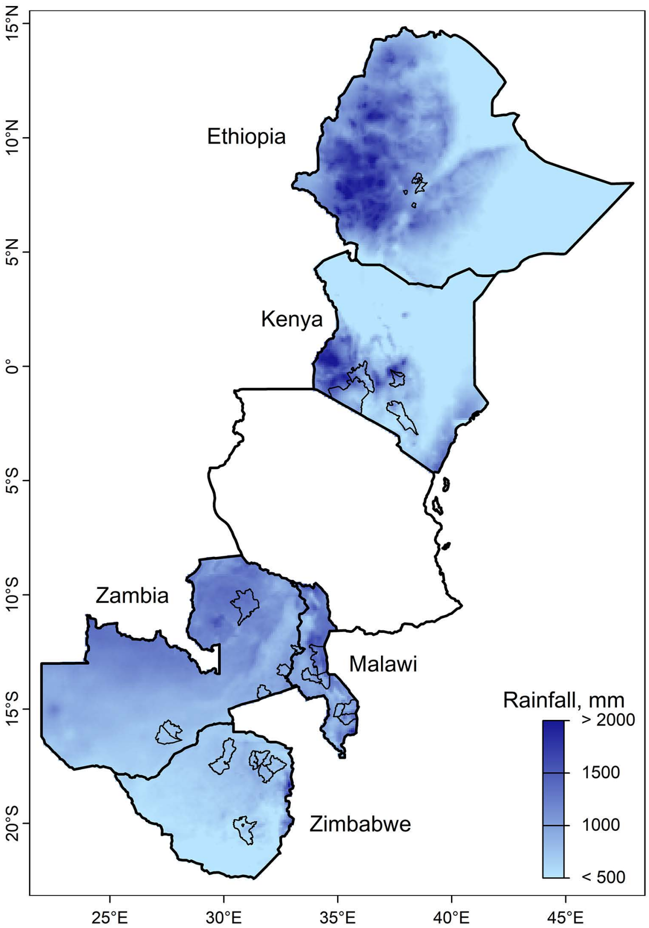

Fig 1. Location of survey districts in Ethiopia, Kenya, Malawi, Zambia and Zimbabwe. Notes: The map was plotted in R using the terra and geodata packages [19–21]. The base layers are NOT proprietary data. They are licensed under the GNU General Public License (GPL) and are fully compatible with Creative Commons 4.0. Rainfall data are from the Climate Hazards Group InfraRed Precipitation with Station Data (CHIRPS) [22], again publicly available on https://www.chc.ucsb.edu/data/chirps. The basemap shapefile used to plot the data was obtained from Natural Earth (https://www.naturalearthdata.com), which provides public-domain boundary files compatible with the CC BY 4.0 license. Source: Climate Hazards Group InfraRed Precipitation with Station Data (CHIRPS).

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23%, 46%, 41% and 90% of the sample in Ethiopia, Kenya, Malawi, Zambia and Zimbabwe, respectively (Fig 2). In contrast, the full CA package was used by 4%, 16%, 26%, 11% and 39% of the sample in Ethiopia, Kenya, Malawi, Zambia and Zimbabwe, respectively. Zimbabwe had the highest awareness and usage rates of minimum tillage and post-harvest mechanization technologies, followed closely by Malawi (Fig 2). Kenya had the highest number of people (43%) using livestock practices, followed by Zimbabwe (14%). Despite the high levels of awareness, we found large gaps between awareness and use of technologies, and this is in line with similar studies that found that farmers often lack access to extension services, information, training, and credit, limiting their ability to invest in sustainable intensification technologies and good agronomic practices [8,13,23,24]. For instance, 61% of the population in the study sites in Zimbabwe was aware of two-wheel tractors, but only 10% used them. Similarly, awareness of post-harvest technologies was high in Zambia at 65% and Malawi at 72%, but usage was low at 21% and 19%, respectively. Thus, knowledge and awareness do not equal use mainly because of resource constraints and other factors such as culture, tradition etc., necessitating incentives to encourage use [2,25].

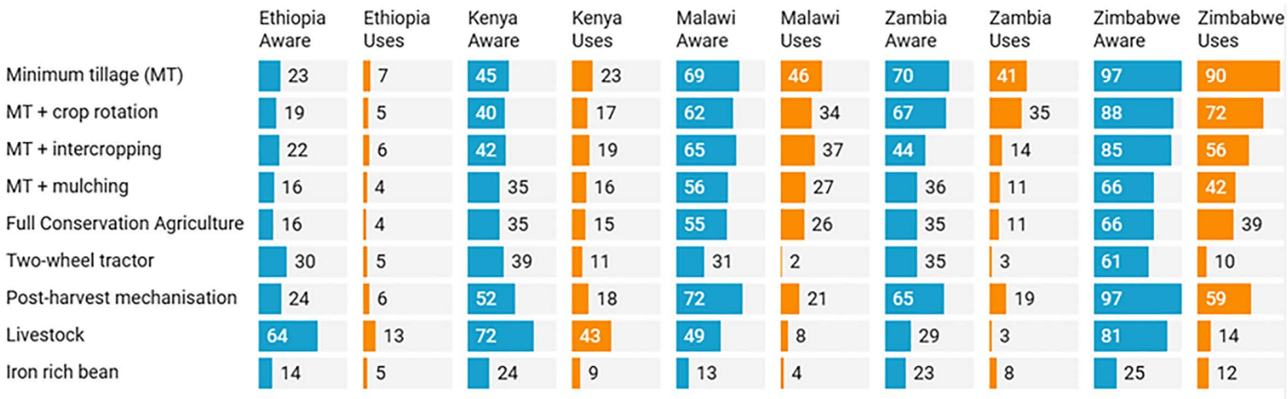

Fig 2. Sample percentage awareness and use of promoted interventions in different target countries. Source: Study survey data (2024).

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Stakeholders, including governments, NGOs, and the private sector, have invested in CA and promoted it, contributing to the high awareness of CA in Malawi and Zimbabwe [7,13]. This is in line with Tufa *et al.* [8], who found high awareness of minimum tillage and crop residue retention in Malawi and Zimbabwe. The higher use of minimum tillage in Zimbabwe is due to the nationwide roll-out of the Pfumvudza program in the 2020/2021 season, which is largely promoting planting basin-based CA. Overall, these findings suggest that while projects create awareness of specific technologies, farmers face intellectual or material bottlenecks to use the promoted technologies. This calls for targeted, market-smart incentives to nudge adoption. For example, providing timely rainfall forecasts and time-limited subsidies were found effective in nudging adoption in Zambia [26]. However, if poorly implemented, incentives can distort adoption and lead to dependency. For example, providing free hand-outs to encourage technology uptake during the project life may seem to increase adoption. However, such adoption is temporal and dissipates immediately after the free hand-outs are stopped, and this explains the variable CA adoption rates in most countries in southern Africa [27].

4.2. Number of people using promoted technologies in the UU intervention sites

4.2.1. Use of minimum tillage practices. Regarding minimum tillage elements, Zimbabwe had the highest use rates, with 55% of the study population having used ripping, 32% direct seeding, 30% basins, and 10% dibble stick (Fig 3). In Malawi, 23% of the population used basins, 18% used the dibble stick, 13% used ripping, and only 2% used the direct seeder. Ripping was the most used minimum tillage practice in Zambia and Kenya, used by 24% and 12%, respectively. Thus, minimum tillage use rates outside intensive promotional areas, although rising, remain low in Malawi, Zambia and Zimbabwe [7]. Except for ripping used by 12% in Kenya and Ethiopia, Kenya had the least number (less than 5%) of users for the other specific minimum tillage practices. This finding is similar to Marenya *et al.* [28] who found low adoption rates of minimum tillage in Ethiopia and Kenya due to resource availability, market access and social capital.

4.2.2. Use of intercropping practices. Traditional intercropping was widely used across the region, with Malawi exhibiting the highest prevalence at 69% (Fig 4). Use rates for specialized intercropping techniques in Ethiopia were estimated at 17% for two-row strip cropping, 10% for cereal-legume *Gliricidia* intercropping systems and four-row strip cropping at 5%. Zambia had the least number of people using all the intercropping techniques (i.e., less than 3%). In Zimbabwe, two- and four-row strip cropping systems were used by 7% and 5%, respectively, whereas traditional intercropping was used by 40% of people. These variations highlight the staggered uptake of various sustainable intensification practices, with newer options still least adopted. The low uptake and use of strip cropping corresponds to findings that farmers are less accustomed to these practices, and strip cropping requires more labor than traditional

	Dibble stick users	Dibble stick % of pop	Direct seeder users	Direct seeder % of pop	Ripping users	Ripping % of pop	Basins users	Basins % of pop
Ethiopia	10,042	1	7,724	1	29,421	3	6,211	1
Kenya	92,389	2	146,560	3	610,476	12	139,855	3
Malawi	742,872	18	91,807	2	536,476	13	930,144	23
Zambia	18,515	1	14,641	1	327,439	24	59,356	4
Zimbabwe	114,882	10	375,453	32	641,954	55	354,020	30
Total	978,700	8	636,185	5	2,145,766	17	1,489,586	12

Fig 3. Population-based number and percentage of people using minimum tillage practices in the target countries. Notes: "% of pop" stands for percentage of population. Source: Study survey data (2024).

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	Traditional intercropping users	Traditional intercropping % of pop	2-row strip cropping users	2-row strip cropping % of pop	4-row strip croppping users	4-row strip croppping % of pop	Cereal-legume & gliricidia intercopping users	Cereal-legume & gliricidia intercopping % of pop
Ethiopia	202,559	21	156,935	17	43,611	5	93,100	10
Kenya	2,124,271	43	256,392	5	113,312	2	45,612	1
Malawi	2,814,575	69	214,178	5	176,520	4	190,851	5
Zambia	290,460	21	23,525	2	33,689	2	3,800	0
Zimbabwe	466,098	40	82,278	7	62,546	5	29,867	3
Total	5,897,963	47	733,308	6	429,678	3	363,230	3

Fig 4. Population-based number and percentage of people using intercropping and strip cropping practices in the intervention countries. Notes: "% of pop" stands for percentage of population. Source: Study survey data (2024).

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intercropping even if it confers higher financial returns [13]. However, appropriate mechanization offers options to address the high labor requirements associated with strip cropping, possibly leading to increased use in future.

4.2.3. Use of livestock interventions. The use of fodder production-specific practices was minimal (<12%) across countries, with few exceptions. For instance, feed chopper grinders were used by 10.9% of the population in Kenya, 4.5% in Zimbabwe, and 2.5% in Ethiopia (Fig 5). Approximately 5% of the population in the study areas was engaged in producing *Brachiaria ssp.* fodder grass. Even though fewer people produced fodder crops, Kenya had the highest number of producers of velvet beans (*Mucuna ssp.*) and *Bracharia* ssp. at 1.3% and 5%, respectively, while Ethiopia had the highest number of lablab producers (2.1%). There are two possible reasons for the minimal production of fodder crops. First, many people may be unaware of the additional benefits of fodder crops, such as their ability to suppress weeds and enhance soil fertility. Second, there is limited access to seed for fodder crops, as was found by Chakoma [29]. In addition, the uptake of livestock activities requires high upfront financial investments in land, labor, seed, knowledge and skills. This could also explain the low use rates for fodder production interventions.

4.2.4. Use of post-harvest practices. Multi-crop threshers were most used in Malawi at 14% and Kenya (12%), reflecting their potential suitability for diverse cropping systems common (Fig 6). In contrast, Zimbabwe saw greater use of groundnut roasters and shellers, with 14% and 11% of farmers, respectively, using these technologies. These findings confirm the assertion that high cost, local unavailability, and limited knowledge and awareness about improved postharvest technologies limited their uptake and use [30]. The regional variation in uptake highlights the need for

	Mucuna producers	Mucuna production % of pop	Lablab producers	Lablab production % of pop	Bracharia producers	Bracharia production % of pop	Fodder chopper users	Fodder chopper % of pop
Ethiopia	3,014	0.3	19,772	2.1	6,624	0.7	23,941	2.5
Kenya	65,661	1.3	48,025	1	245,623	5	535,202	10.9
Malawi	16,686	0.4	4,407	0.1	25,271	0.6	32,275	0.8
Zambia	4,890	0.4	463	0	1,630	0.1	13,515	1
Zimbabwe	12,847	1.1	7,060	0.6	7,909	0.7	53,090	4.5
Total	103,098	0.8	79,727	0.6	287,057	2.3	658,023	5.3

Fig 5. Population-based number and percentage of people using livestock production practices in the intervention countries. Notes: "% of pop" stands for percentage of population. Source: Study survey data (2024).

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	G/nut sheller users	G/nut sheller % of pop	Multicrop thresher users	Multicrop thresher % of pop	G/nut roaster users	G/nut roaster % of pop
Ethiopia	12,718	1	49,156	5	0	0
Kenya	47,362	1	571,438	12	37,412	1
Malawi	319,459	8	571,129	14	57,222	1
Zambia	64,969	5	52,952	4	15,165	1
Zimbabwe	165,859	14	74,553	6	131,078	11
Total	610,367	5	1,319,228	11	240,877	2

Fig 6. Population-based number and percentage of people using post-harvest practices in the intervention countries. Notes: "G/nut" stands for groundnut and "% of pop" is for population percentage. Source: Study survey data (2024).

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context-specific interventions to promote the adoption of appropriate technologies in different agroecological zones [31]. It is also noteworthy that much of the reported uptake is autonomous, not necessarily connected to UU activities.

4.2.5. Awareness of Ukama Ustawi activities. The levels of awareness of the UU project interventions ranged from 5 to 16% across the study areas in the five countries (Fig 7). Intervention districts in Zambia and Kenya had the highest levels of awareness at about 16%. Intervention districts in Ethiopia had the least awareness at 5% of the study population. In Malawi and Zimbabwe, about 5.7% and 8.2% of the people were aware of UU interventions. The differences in the

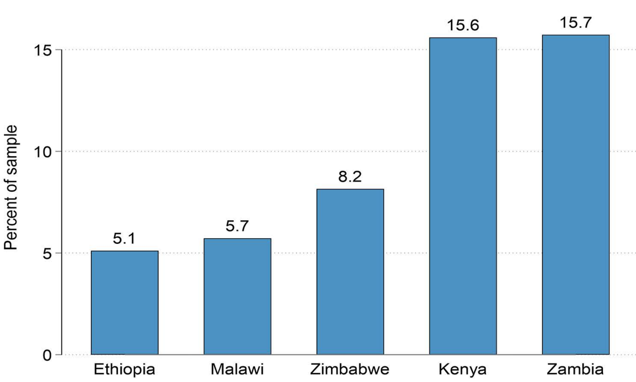

Fig 7. Levels of awareness (percentage of sample) of Ukama Ustawi activities by country. Source: Study survey data (2024).

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levels of awareness can be explained by how long UU interventions had been implemented in each geographic location and the intensity of promotion. For example, most UU activities started in 2021 in Kenya and Zambia, translating into the highest awareness. In contrast, UU activities only started in Ethiopia towards the end of 2023, which could explain the country's low awareness levels alongside divergent socio-political contexts.

We found no particular pattern of awareness by gender and youth across countries (Figs 8 and 9). More men than women were aware of project interventions in Ethiopia and Kenya. In contrast, more women than men were aware of project interventions in Malawi, Zambia, and Zimbabwe (Fig 8). When disaggregated by age, more youths (aged 18–35) were

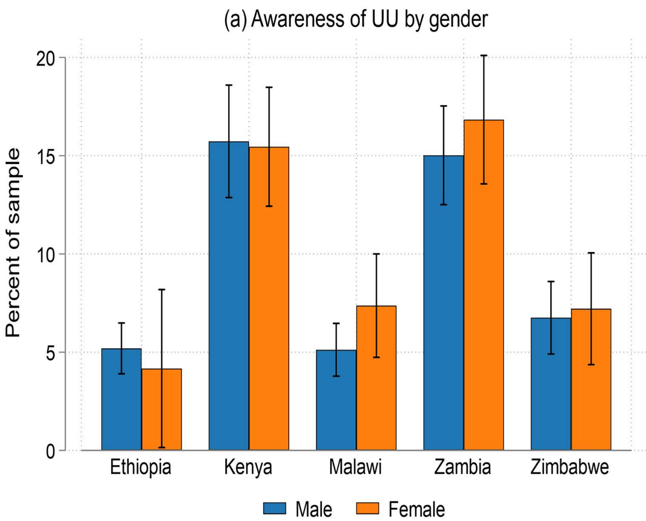

Fig 8. Levels of awareness (%, sample) of Ukama Ustawi activities by gender in the intervention countries. Source: Study survey data (2024).

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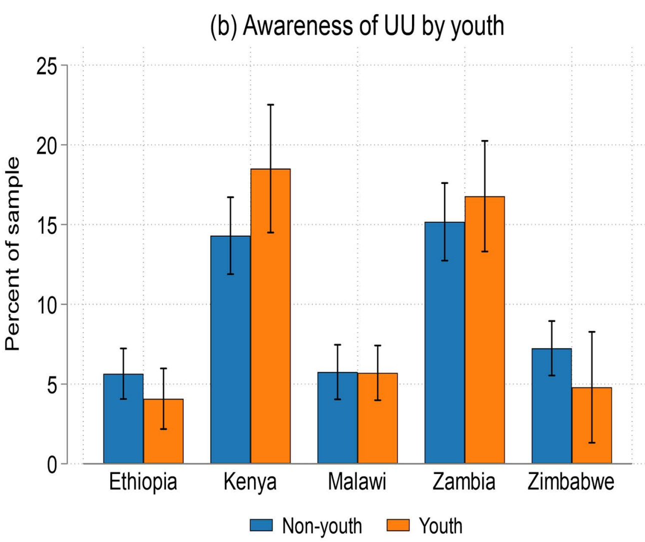

Fig 9. Levels of awareness (%, sample) of Ukama Ustawi activities by youth in the intervention countries. Source: Study survey data (2024).

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aware of project interventions than non-youths in Kenya and Zambia (Fig 9). In contrast, more non-youths were aware of project interventions in Zimbabwe and Ethiopia than youths. Without testing for significance, there is little difference in awareness of UU among youths and non-youths in Malawi.

4.3. How people interacted with Ukama Ustawi

More than a quarter (28%) of the population interacted with UU project interventions through training facilitated by different implementation partners (Fig 10). Other important avenues of interaction with UU included agronomy activities (22%), exchange visits (16%), nutrition and livestock, each at 14%, and mechanization activities at 5%. These avenues represent hosting/attending agronomy, mechanization, nutrition, and livestock demonstrations, and field days. At the country level, training was the most common pathway through which farmers interacted with the project in Kenya (50%) and Zambia (29%). Agronomy demonstrations were most popular in Zimbabwe (32%) and Malawi (31%), whereas nutrition demonstrations were most popular in Zambia (21%). In Ethiopia, about 40% of the population interacted with the project during exchange visits and 25% through livestock activities. Except for Ethiopia where exchange visits and livestock activities were the main ways farmers interacted with UU, training and agronomy interventions were the top two ways farmers interacted with UU in all the other four countries.

4.4. The extent of reach of UU activities

The project activities reached approximately 1.05 million people across the targeted countries. When disaggregated by country, Kenya reached the highest number and share of people, with 565,000 people (Figs 11 and 12), representing nearly half of the total number of people reached by the project. The high number of people reached in Kenya is potentially due to the diversity of interventions in the country. In comparison, the numbers of people reached are lower in other

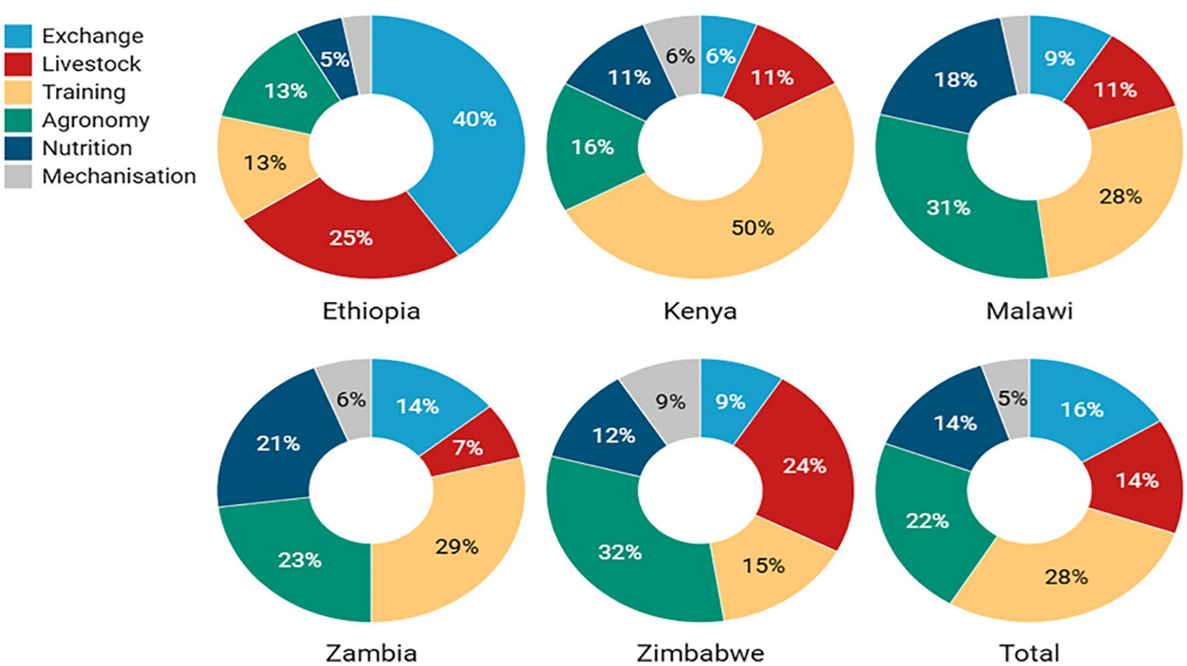

Fig 10. Various ways in which people interacted with Ukama Ustawi in project sites in the intervention countries. Source: Study survey data (2024).

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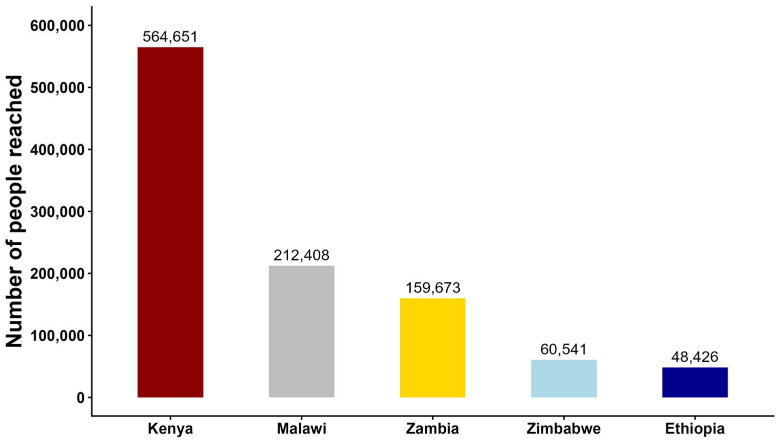

Fig 11. Number of people reached by Ukama Ustawi. Source: Study survey data (2024).

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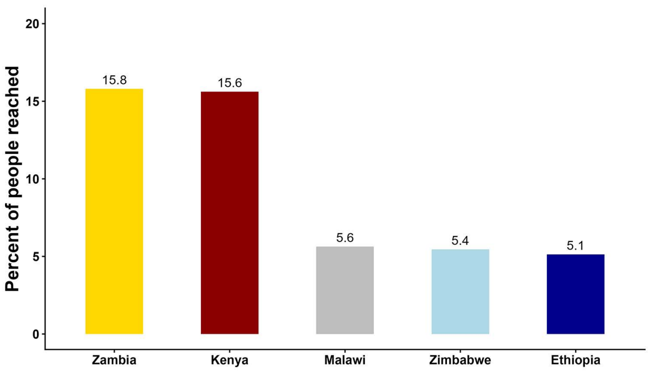

Fig 12. Share of the rural population reached. Source: Study survey data (2024).

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countries. In Malawi, the UU reached 212,000 people, while 160,000 people were reached Zambia. UU reached 61,000 people in Zimbabwe and 48,000 in Ethiopia.

4.5. Number of beneficiaries of Ukama Ustawi innovations

Across the project sites in the five project countries, 164,363 people benefited from UU using various innovations the Initiative promoted as of September 2024 (Fig 13). Among these, 135,767 people, or 82%, were direct beneficiaries, meaning they were in districts where specific interventions were implemented and were users of unique interventions (i.e., without spillovers). It's worth mentioning that youth and women also participated in project activities, with 86,008 females (accounting for 52% of the participants) using various innovations (S5 Table and S6 Table). Additionally, 92,847 youths (both men and women), representing 56% of the participants, were using UU innovations. These results highlight the project's commitment to promoting gender equity and youth empowerment. In terms of its targets, UU exceeded the end of Initiative outcome one target of 100,000 farmers by 36% when we consider the reach without spillovers and 64% with spillovers. The Initiative also exceed its targeted participation of 40% women and 40% youth by 12 – 16%.

The project had the highest engagements in Malawi, where 49,812 people were using different innovations (Table 2). These results are in contrast with [8], who found higher adoption of CA in Zambia and Zimbabwe than in Malawi but

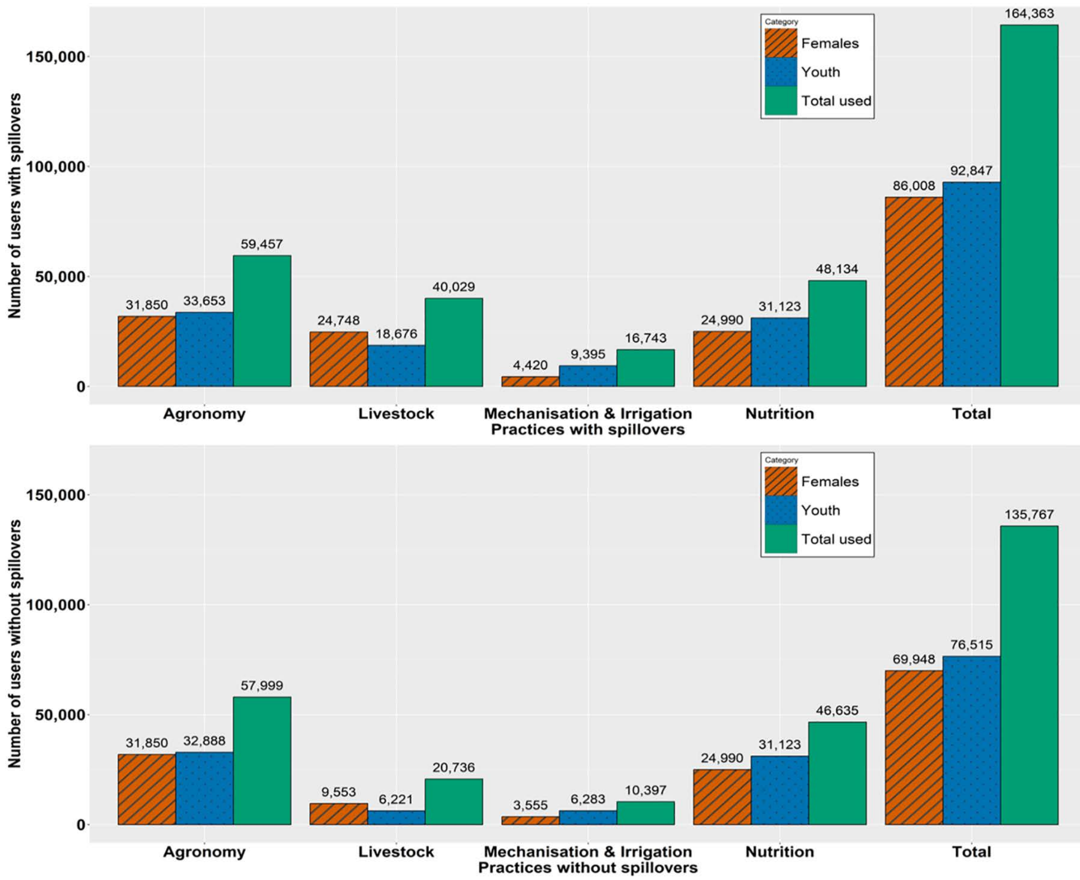

Fig 13. Number of beneficiaries using various Ukama Ustawi innovations overall (top panel) and without spillovers (bottom panel). Source: Study survey data (2024).

https://doi.org/10.1371/journal.pstr.0000230.g013

Table 2. Number of beneficiaries using various Ukama Ustawi innovations by country.

Used without spillovers					Used with spillovers			
Country	**Total used**	**SE**	**[95% conf. interval]**		**Total used**	**SE**	**[95% conf. interval]**	
Ethiopia	1,571	1,111	(607)	3,749	7,413	3,798	(32)	14,858
Kenya	37,470	17,886	2,407	72,533	37,470	17,886	2,407	72,533
Malawi	49,812	16,712	17,051	82,573	66,014	22,395	22,113	109,915
Zambia	14,578	5,380	4,030	25,126	16,208	6,068	4,312	28,104
Zimbabwe	32,336	8,673	15,333	49,339	37,258	9,771	18,103	56,413
Total	135,767	49,763	38,214	233,320	164,363	59,918	46,902	281,824

Note: Spillovers refer to the indirect effects or secondary impacts that extend beyond the intended target group or area; disaggregation by technology across countries was not feasible due to low numbers for some technologies.

Source: Study survey data (2024).

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aligned with Pangapanga Phiri *et al.* [32] who found higher adoption in the Nkhotakota district, where interventions were ongoing even before UU started. In addition, these differences could be explained by differences in sampling approaches. Tufa *et al.* [8] used a random sample of areas where CA had been promoted in the last ten years from the time of their study. The sampling in this study is similar to that of Pangapanga Phiri *et al.* [32], who used a more granular approach and sampled from specific project sites.

Kenya is ranked second with 37,470 people using UU innovations, partly attributed to the diversity of interventions promoted in the country. Zimbabwe ranked third, closer to Kenya, with 32,336 people who used UU innovations. One possible reason for the high numbers in Zimbabwe is that all the project's interventions were actively promoted by other players as well. In contrast, Ethiopia had the lowest number of people using the project innovations (7,413). This lower result in Ethiopia is attributed to a few key factors, notably the late start of the project in the country and the fewer innovations that were initially introduced. Overall, there were possible challenges faced in different regions as shown by the distribution of people using different project innovations (See S4 Table and S7 Table in the supplementary information).

An alternative way to interpret these results is to use the benefit-reach ratio, which is the quotient of the number of beneficiaries relative to those reached by the project. This is based on overall beneficiaries with spill overs (Table 2) and reach (Fig 11). The benefit-reach ratio was highest in Zimbabwe at 61%, followed by Malawi at 31%, Ethiopia at 15%, Zambia at 10%, and Kenya at 7%. This means that UU activities were more effective at converting reach to beneficiaries in Zimbabwe, Malawi, Ethiopia, and Zambia than in Kenya, even when, in an absolute sense, more people were reached in Kenya. The results in Zimbabwe could also be reflective of the effects of the Pfumvudza program that has been rolled out nationwide since 2021.

4.6. Bundles of innovations used

As bundling of technologies is becoming increasingly popular for enhancing synergies and benefits, and for making CA cropping systems more feasible [8,33], we report these results in Fig 14. The figure provides a detailed overview of the distribution of people using different combinations of agricultural practices, shedding light on the varying preferences and uptake patterns. The agronomy and nutrition bundle was the most widely used by over 40,000 people or 24% of the total

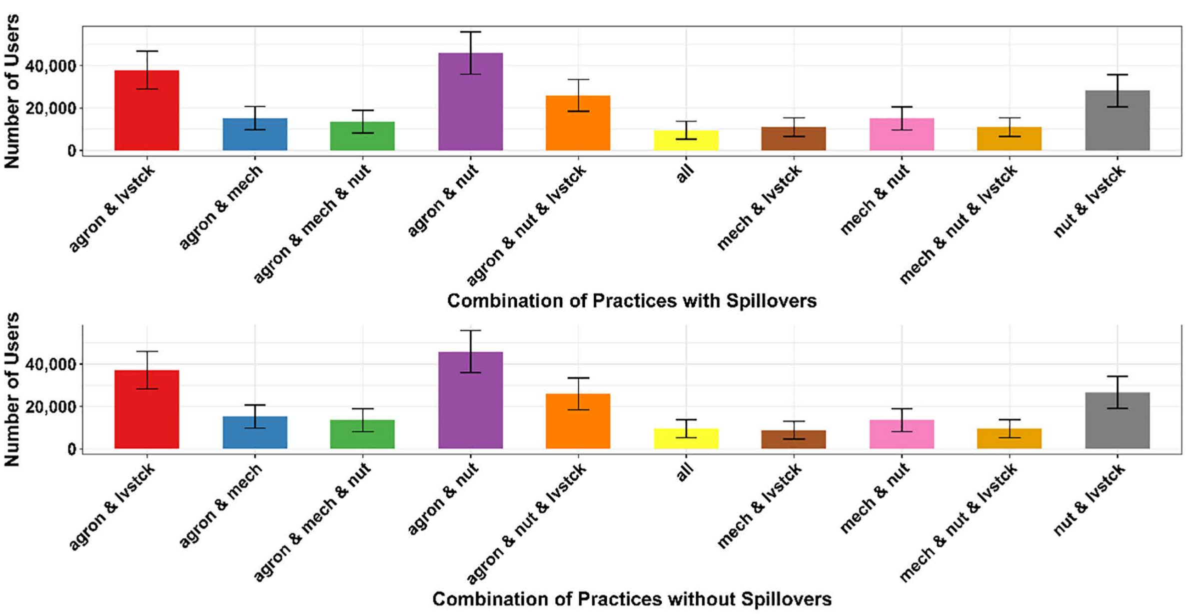

Fig 14. Number of people using various Ukama Ustawi innovations bundles. Notes: agron & lvstck - agronomy and livestock; agron & lvstck & nut-agronomy and livestock and nutrition; agron & mech – agronomy and mechanization; agron & mech & nut – agronomy and mechanization and nutrition; all – all main broad innovations; mech & nut – mechanization and nutrition; mech & nut & lvstck– mechanization and nutrition and livestock; nut & lvstck - nutrition and livestock; The error bars represent standard error of mean. Source: Study survey data (2024).

https://doi.org/10.1371/journal.pstr.0000230.g014

beneficiaries (Fig 14). In second place was the agronomy and livestock bundle used by around 38,000 people (23%). Similar results hold even if we consider the results with and without spillovers. The least common bundle was the integration of all four technologies: agronomy, mechanization, nutrition, and livestock. This combination was used by only 10,000 people (6%). The distribution of users for these various combinations underscores the importance of understanding farmers' specific needs and resource availability when designing and promoting integrated agricultural interventions. In addition, despite the likely multiplicative benefits of technology bundles, we found that the uptake of bundles remains low. This calls for more efforts by development practitioners and national governments to promote the use of innovation bundles for smallholder farmers to realize the enhanced benefits of bundling technologies.

In summary, the results in this paper demonstrate that the sampling approaches influence adoption numbers, in line with Ngoma *et al*. [34]. As such, what is important is the goal to estimate representative statistics that allow for inferences to larger geographical areas. We demonstrate a conscious attempt to guarantee representativeness within the examined districts by drawing a random sample from the intervention districts using a population-weighted sampling technique. This strategy seeks to improve the precision of the estimates and the generalizability of findings within the administrative units.

5. Conclusion

As funding for research for development continues to dwindle, it is increasingly critical to demonstrate value for money. This is crucial to inform scaling efforts and to achieve greater impact. Doing so is difficult for various reasons. We present an approach to address the lack of baseline data when estimating the reach, awareness and use of innovations in research for development projects. This approach uses a population-based computer-assisted telephone interviewing (CATI) survey methodology that is statistically representative at the desired administrative unit level. This approach was applied to the CGIAR Research Initiative – Diversification in East and Southern Africa (Ukama Ustawi) implemented with several scaling partners across 12 countries in Eastern and Southern Africa. However, for this assessment, we focused on only five countries: Ethiopia, Kenya, Malawi, Zambia, and Zimbabwe. The goal of the assessment was to measure and estimate the reach, awareness, and use of agronomy, mechanization and irrigation, livestock, and nutrient-dense crop interventions. We also assessed the extent to which the Initiative reached its target of 100,000 farmers with 40% women and 40% youth participation under outcome one. We used quantitative primary data collected through CATI from a random sample of 6,445 rural people across 27 districts in five project intervention countries.

Overall, we found that the UU Initiative made significant progress in promoting agricultural innovations across Ethiopia, Kenya, Malawi, Zambia, and Zimbabwe, although with varying degrees of success. Out of approximately 12.5 million rural people in the project target areas, about 1.05 million (8.4%) were aware of UU activities, with Kenya and Zambia showing the highest awareness levels at around 16% each. The Initiative reached 164,363 people across the intervention districts, with 135,767 people being direct beneficiaries in areas where specific interventions were implemented. The rest benefited from spillover effects. Notably, the project demonstrated strong inclusion, with 52% of beneficiaries being female and 56% being youth aged 18–35 years. There are variations by country. These results demonstrate that UU exceeded the end of Initiative outcome one target of 100,000 farmers by 36% when we considered the reach without spillovers and 64% with spillovers. The Initiative also exceeded its targeted participation of 40% women and 40% youth by 12 – 16%. At country level, the benefit-reach ratio was highest in Zimbabwe at 61%, followed by Malawi at 31%, Ethiopia at 15%, Zambia at 10% and Kenya at 7%. This means that UU activities were most effective at converting reach to beneficiaries in Zimbabwe, Malawi, Ethiopia, and Zambia than in Kenya, even when in absolute sense, more people were reached in Kenya. This also highlights the importance of other players in the operational areas who promoted similar technologies closely aligned to UU during the intervention period.

We found that technology uptake patterns varied considerably across countries. Zimbabwe and Malawi demonstrated the highest awareness and usage rates of conservation agriculture (CA) practices, particularly minimum tillage technologies. The use of partial rather full CA was more prevalent. The highest benefit-reach ratio in Malawi and Zimbabwe can be attributed to sustained investments in CA promotion by various stakeholders, including non-governmental organizations (NGOs), and importantly, national governments, e.g., the Pfumvudza/Intwasa Governmental program that promotes CA in Zimbabwe. The study also revealed that the use of innovation bundles is low, with the agronomy and nutrition combinations being the most widely used, followed by the agronomy and livestock bundle option.

We found a persistent gap between awareness and use of technological innovations, a common challenge in agricultural development projects. This suggests the need for more targeted approaches in project design and implementation, particularly in addressing barriers to adoption and scaling. To enhance the inclusivity of research for development interventions like UU, evaluation frameworks must be embedded right from project inception, and traditionally underrepresented groups must be deliberately targeted.

The success of the UU Initiative, particularly in countries like Malawi and Zimbabwe, provides valuable lessons on the need to build on from previous projects. This approach is a practical guide to future agricultural development programs and projects in East and Southern Africa. The additional costs of nudging people to adopt technologies are lower in places where target innovations have been promoted before. Leveraging these advantages requires intentional efforts to build synergies and harmony to minimize conflicts, duplication, and competition among development practitioners. National governments have a big role in actualizing a harmonized approach to development facilitation by guiding where interventions are needed most in the countries. Development practitioners, too, need to improve in identifying ongoing projects and finding ways to build synergies for greater impact. The methodology used in this study can be easily replicated and applied in different settings. One potential improvement to be considered in future surveys of this nature would be to use cluster randomized sampling approaches and computing sampling weights at different clusters.

Supporting information

S1 Table. Project intervention areas implemented in each study country.
(DOCX)

S2 Table. Specific agronomic, mechanization, irrigation, livestock, and nutrition interventions promoted by the project.
(DOCX)

S3 Table. Sample size for each district by country.
(DOCX)

S4 Table. Estimated UU reach by technology domain, disaggregated by youth and females, including spillover effects.
(DOCX)

S5 Table. Estimated UU reach by technology domain, disaggregated by youth and females, excluding spillover effects.
(DOCX)

S6 Table. Estimated UU reach by technology domain including spillovers, with standard errors and 95% confidence intervals.
(DOCX)

S7 Table. Estimated UU reach by technology domain excluding spillovers, with standard errors and 95% confidence intervals.
(DOCX)

S1 Data. Dataset used to reproduce the main results.
(DTA)

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