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A technology outreach campaign targeting small-scale maize producers in eastern DR Congo

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ABSTRACT

The African Agricultural Leadership Institute conducted an innovative outreach campaign to benefit smallholder maize farmers in the Ruzizi Plain and adjacent highlands in DR Congo. Packages of production inputs for 0.25 ha of maize were prepared, consisting of 6 kg of hybrid maize seed (cv. Haraka and Milima), 20 kg of DAP pre-plant fertilizer, 10 kg of urea topdressing and instructions for farmers. These kits were distributed to 2185 registered farmers prior to the 2023-2024 growing season through a network of pre-established distribution sites. The season saw favorable rains. Average yields were 2736 kg per ha (684 kg per household). At a maize price of $450 per ton, this level of production offers net yields of $900 per hectare and a benefit-cost ratio of $3.72 per dollar invested. Excluded from this analysis are labor and local transportation costs (provided by the farmer) and supervision costs (absorbed by the AALI Youth Brigade program). In total, the awareness campaign covered 546 ha at a cost of program production inputs of $181,030, or about $83 per household. Total maize production amounted to 1,495 tons of maize grain valued at $672,543 (assuming $450 per ton). Coordination and operating costs amounted to approximately $54,188 and, when taken into account, the overall benefit-cost ratio of the campaign is reduced to 2.9:1 ($/$). This outreach approach can be replicated and adjusted to meet local agricultural and socio-economic conditions. One of the strengths of the approach is that it targets an area of 0.25 ha per household, allowing each household to transport production input packaging from local distribution centers to their own farms without additional cost. Production levels have enabled households to achieve food security and produce modest surpluses for sale in a single season.

Keywords: African Agricultural Leadership Institute (AALI), agricultural transformation, Democratic Republic of Congo, extension outreach, food security, International Institute of Tropical Agriculture (IITA), small-scale farming systems

RÉSUMÉ

L'Institut Africain de Leadership Agricole a mené une campagne de vulgarisation innovante auprès des petits producteurs de maïs dans la plaine de la Ruzizi et les hautes terres adjacentes en RD Congo. Des ensembles d'intrants pour la production de 0,25 ha de maïs ont été préparés, comprenant 6 kg de semences hybrides de maïs

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(cv. Haraka et Milima), 20 kg d'engrais DAP pour la pré-plantation, 10 kg d'urée pour le surfaçage et des instructions pour les agriculteurs. Ces kits ont été distribués à 2185 agriculteurs enregistrés avant la saison de culture 2023-2024 via un réseau de sites de distribution préétablis. La saison a bénéficié de pluies favorables. Les rendements moyens ont été de 2736 kg par ha (684 kg par ménage). Au prix de 450 $ la tonne de maïs, ce niveau de production offre des rendements nets de 900 $ par hectare et un ratio bénéfice-coût de 3,72 dollars par dollar investi. Sont exclus de cette analyse les coûts de main-d'œuvre et de transport local (fournis par l'agriculteur) et les coûts de supervision (absorbés par le programme Brigade Jeunesse de l'AALI). Au total, la campagne de sensibilisation a couvert 546 ha pour un coût des intrants de programme de 181 030 $, soit environ 83 $ par ménage. La production totale de maïs s'est élevée à 1 495 tonnes de grain de maïs d'une valeur de 672 543 $ (à raison de 450 $ la tonne). Les coûts de coordination et de fonctionnement s'élevaient à environ 54 188 $ et, en tenant compte de cela, le ratio bénéfice-coût global de la campagne est réduit à 2,9:1 ($/$). Cette approche de sensibilisation peut être reproduite et ajustée pour répondre aux conditions agricoles et socio-économiques locales. L'un des points forts de cette approche est qu'elle cible une superficie de 0,25 ha par ménage, permettant à chaque ménage de transporter les emballages d'intrants de production des centres de distribution locaux à leurs propres fermes sans coût supplémentaire. Les niveaux de production ont permis aux ménages d'atteindre la sécurité alimentaire et de produire des excédents modestes à vendre en une seule saison.

Mots clés : Institut Africain de Leadership Agricole (AALI), transformation agricole, République Démocratique du Congo, vulgarisation, sécurité alimentaire, Institut International d'Agriculture Tropicale (IITA), systèmes agricoles à petite échelle

Introduction

The Democratic Republic of the Congo (DRC) has the largest number of food insecure people in the world, where over 26 million people experience acute food insecurity (IPC, 2023). This situation results from a combination of factors including widespread poverty, conflict and displacement as well as low agricultural production, high food prices and a lack of basic infrastructure. The country continues to experience a domestic maize crisis because demand far exceeds production. The current annual maize deficit is about 2.8 million MT, a shortage that was addressed through importation from surplus producing countries. But Zambia, a major supplier in the past, recently halted exports in order to cope with its own domestic shortages. As a consequence, the cost of maize flour skyrocketed. A recent Government communication stated "The causes of this situation include the shortfall in local production in line with demand, restrictions on Zambian exports and high import costs, as well as the deterioration of climatic conditions, which affects agricultural production in the sub-region". As a result of this situation, DRC placed priority upon its increased capacity to produce maize and other staple crops.

Maize must evolve from a subsistence crop receiving little or no external inputs into a commercially produced and traded crop. Its current yield of only 0.8 t/ha in 2022 (CAPUICD, 2022) can readily be improved to 3.0 tons under proper management (TAAT, 2021). Despite these poor yields, it occupies a predominant role in the farming systems and diets of millions of Congolese. It is a very versatile crop as it is used for domestic consumption in addition to its industrial use by flour mills, breweries, confectioneries and animal feed manufacturers. Increasing maize yields in DRC's savanna and highland areas is critical to the country's agricultural transformation due to its high yield potential, diverse uses, and ease of transportation, processing and marketing, but productivity is constrained by the lack of proven agricultural extension and local development models (Ragasa *et al*., 2013; Ragasa and Ulimwengu, 2017).

The Agricultural Transformation Agenda in the Democratic Republic of Congo (ATA-DRC) seeks to modernize the country's agriculture and overcome its chronic food production deficits (Woomer *et al*., 2023). The Government appointed the International Institute of Tropical Agriculture (IITA) to lead this Agenda in early 2022 (IITA and AALI, 2022). While it has a nationwide mandate, its first phase commenced in five carefully selected areas, including South Kivu Province (see Bagula *et al*., 2021), with a focus upon maize, beans, soybeans, cassava, rice, banana, and aquaculture. Through its national counterparts, ATA-DRC provides seeds and other production inputs, good agricultural practices and value addition strategies. IITA works closely with Bio Agro Business (BAB) appointed as a national counterpart by the Ministry of Agriculture. Initial attention was focused upon realizing the potential of large state farms in different parts of the country, but has now shifted to also working with smallholder farmers to directly address the concerns of poverty and food insecurity. This paper describes a pioneering effort to conduct a technology outreach campaign among small-scale maize producers in South Kivu Province of DRC, and examines how similar efforts may be replicated and expanded in the future.

Materials and Methods

The design of technology transfer packages requires an interactive approach (Barnett *et al*., 2020; Woomer *et al*., 2023). An outreach campaign was designed that consisted of six stages. Stage 1: Existing producer groups are identified in collaboration with extension officers, local authorities, and civil society leaders; recruitment rallies are held and preliminary information is compiled, including information on those with reliable access to smart phones. Stage 2: Smallholders acceptable to the outreach campaign are identified and contacted, and clustered into groups led by a local coordinator. Stage 3: Prototype production input packages are used to train participants on modernized production approaches and serves as the location of a future farmers' field day. Stage 4: An input package with proven ability to raise farm production to a targeted level is designed, mass produced and distributed to participants. Stage 5: Farmers install the production input packages and follow management instructions and local coordinators report their results via smart phone applications. Farmers benefit from ongoing monitoring and local advice from AALI teams and experienced community facilitators involved in the campaign. Stage 6: Farmers harvest their crops at grain maturity and each group is assigned a collection point and schedule where they may shell and bag their grain, and market their surpluses. A sub-sample of these farmers is surveyed by monitors and asked how the outreach campaign may be improved in the future.

A production input package of hybrid seed and fertilizer provided registered farmers with the inputs required to produce maize on 0.25 ha (2500 meter^2 or 0.62 acre). This area is expected to provide about 750 kg of maize grain. Simple farming guidelines were developed describing how to prepare land, mark boundaries, apply preplant fertilizer (DAP at 80 kg ha^{-1}), plant hybrid maize seeds (at 44,444 plants ha^{-1}), control weeds, apply urea topdressing (at 40 kg ha^{-1}) and respond to pests and disease (particularly Fall Armyworm, see TAAT 2021). Note that there were two different types of hybrid seed, Haraka (WH 101), a fast maturing, drought tolerant line, and Milima (WH 605), a long-duration, large-statured line, both obtained from Western Seed Company (Kenya) via a distribution office established in Goma, North Kivu. Finally, farmers were advised and assisted to harvest and shell their maize, including providing them with some woven polythene bags to contain part of their harvest. The data was collected not only from the farmer' fields but also from the five demonstration fields located across the study area used for training earlier.

This campaign was conducted in the Ruzizi Plain of South Kivu Province and in highland areas to the north (e.g. Nyangezi and Walungu). The Ruzizi Plain lies at the bottom of the West African Rift, between 2°42' and 3°24' S as a northern extension of Lake Tanganyika (Ilunga *et al*., 1982). This area provided 87% of study's beneficiaries across nine key sites; Kamanyola, Katogota, Luvungi, Bwegera, Luberizi, Sange, Runingu, Kiliba and Kawizi (see Figure 1). The Ruzizi Plain lies along the Ruzizi River, with 80,000 ha of arable land in DR Congo with Burundi to the East (De Failly, 2000). The average altitude is 800 m and annual rainfall is around 1,600 mm. The rainy season lasts 9 months from September through May. The soil is predominantly a sandy-loam or clayey-sand (Rushigira *et al*., 2023).

An excel spreadsheet utility was constructed and tested based upon the design of this campaign and the anticipated need for future outreach. The resulting Campaign Design and Analysis Utility consists of a front end where queries on the outreach design are entered (e.g. number of farms, area per farm) and a parameter entry section where the amount and price of production input technologies are entered (e.g. seed, fertilizer and pesticide rates and cost). Users are then queried concerning the optional campaign design, particularly the participant unit costs related to coordination, farmer training, monitoring and local transportation. Finally, users enter the average yields and commodity price and then calculations are performed. The outputs include the amount and costs of production inputs and the associated campaign management costs, total operations costs, and the coverage (ha), total production (kg) and value of the resulting farmer production, and a summary of economic returns (total, net and benefit-to-cost ratio). The utility offers color coded cells to assist user entries, and a backend offering a campaign summary and economic analysis. The utility's routines and calculations were then inspected for errors and various scenarios run.   In addition to the Excel spreadsheet utility, field and farmer data were collected through the ODK "Fast Field" application, and summary statistical analyses were conducted using SPSS software. Growth parameters were measured as a function of the number of days of emergence, while yield parameters concerned ear length, number of rows per ear, 100-seed weight, number of ears per plant and the average yield obtained for each of the two varieties.

Results

The African Agricultural Leadership Institute conducted an innovative outreach campaign among smallholder maize producers in the Ruzizi Plain and adjacent highlands. This was performed by the AALI Youth Brigade in conjunction with the DRC Agricultural Transformation Agenda. Production input packages intended for 0.25 ha were distributed to registered farmers in South Kivu in advance of the 2023-2024 growing season through a network of prearranged distribution sites.

Growth and harvest parameters for the two hybrids appear in Table 1. Haraka (WH 101) is considered a "climate-smart" maize variety with faster emergence, shorter ears and smaller grains, but substantially lower yield (Table 1). The earliest emergence times recorded for the varieties were 5 and 7 days, respectively (data not presented). In terms of ear length, Milima was the longer variety, with an average of 20 cm, while Haraka was the shorter, with an average of 18 cm. In terms of the number of grain rows per ear, the two varieties showed no difference with 14 each. In relation to the 100 seed weight, Haraka was lower (35.2 g) than Milima (40.3 g) with a 9% Coefficient of Variation. Both varieties showed potential to produce two cobs per plant. Across the three intervention areas where the Ruzizi Outreach Campaigm was conducted (Plaine de la Ruzizi, Nyangezi and Walungu), the Milima variety outperformed Haraka in terms of yield (Figure 2).

This pilot outreach campaign serviced 2185 farm households covering 546 ha at a Program production input cost of $181,030, or about $83 per household (Table 2). Total maize production was 1,495 tons of grain worth $672,543 (assumes $450 per ton). Coordination and operations costs were about $54,188 and when taken into account, the campaign's overall benefit-to-cost ratio is approximately 2.9:1 ($/$). These results were generated using the Campaign Design and Analysis Utility. Note that the MS Excel utility is compact, requiring only 252 cells (9 columns x 28 rows) and 25 user entries, and occupies only 16 KB.

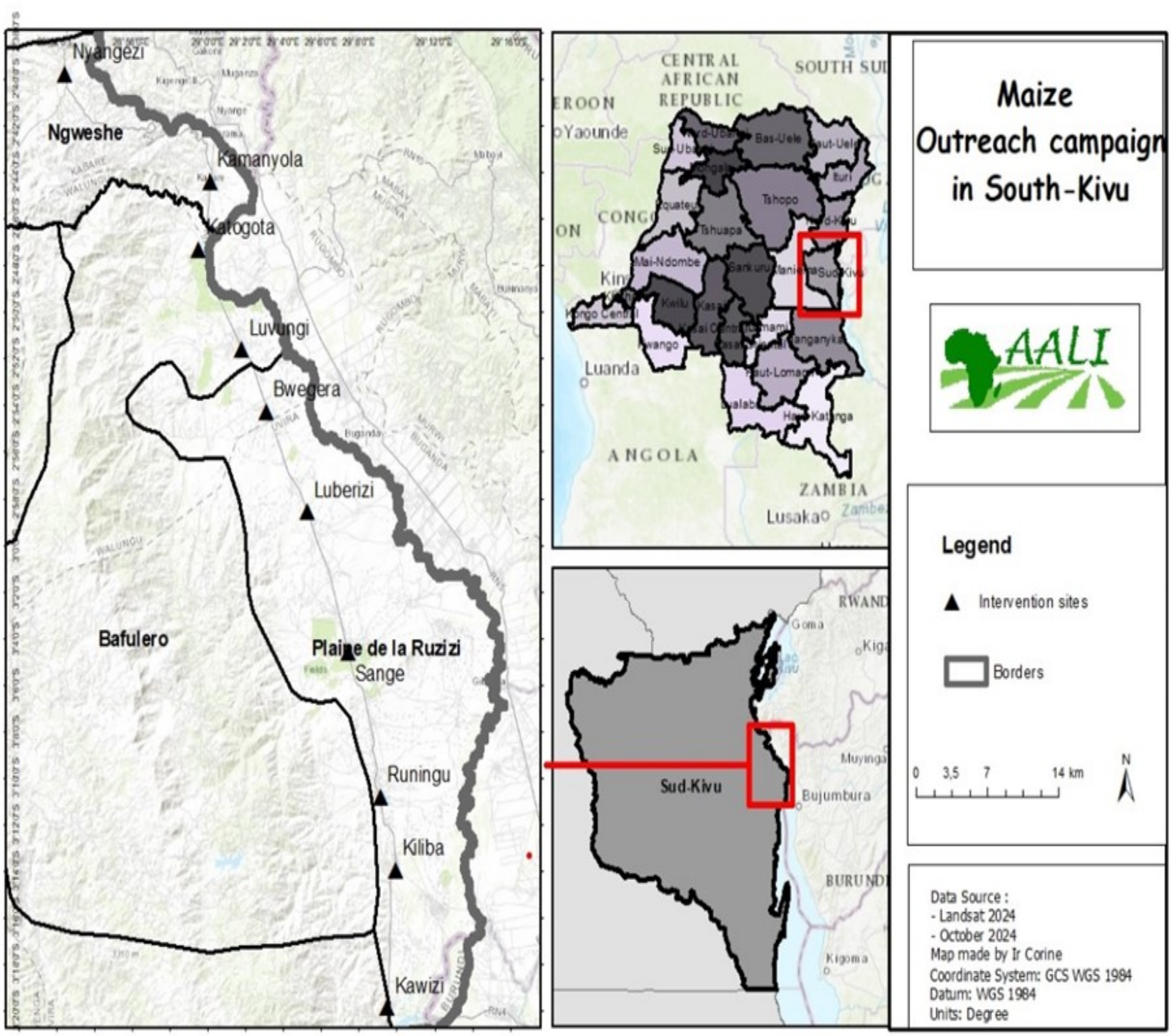

Figure 1. Geographical area covered by the Ruzizi Outreach Campaign

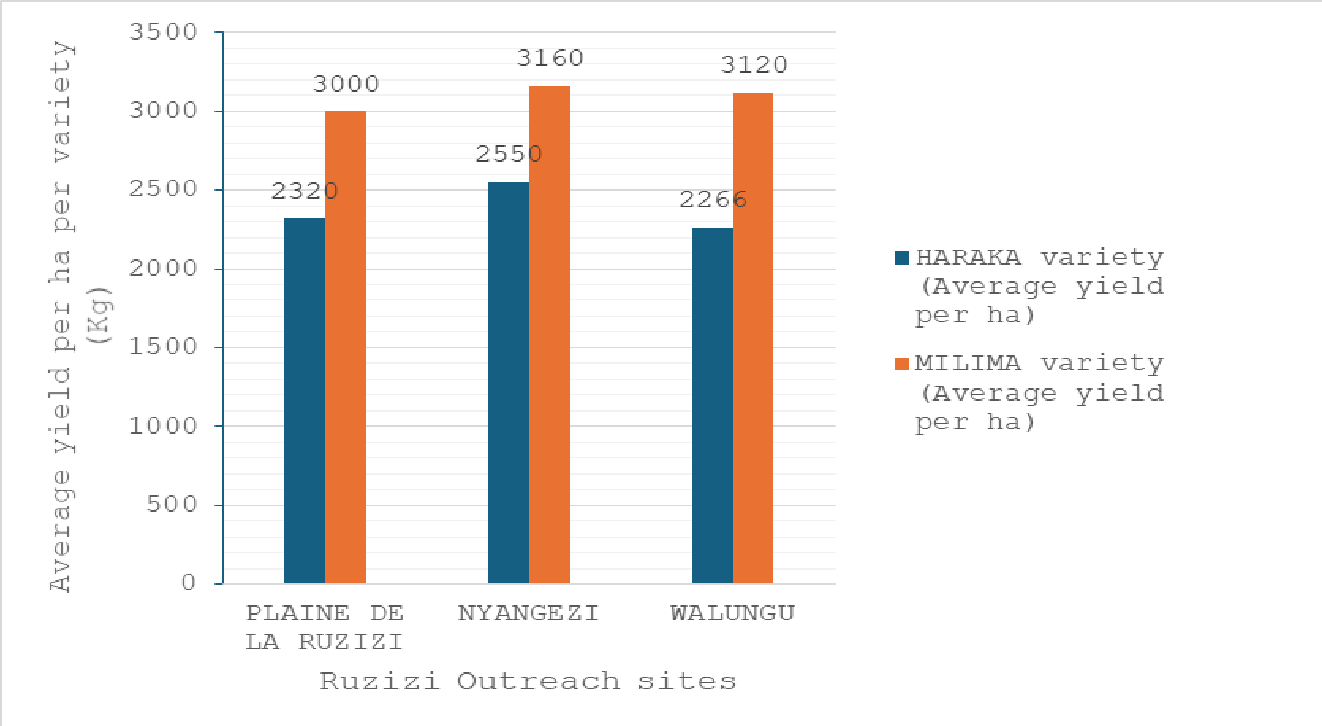

Figure 2. Average yield of the two maize hybrids in the different outreach areas

Table 1. Growth and yield parameters of the two maize hybrids.

Maize hybrid	Emergence (days)	Ear length (cm)	100 seed weight (g)	Grain yield (kg ha-1)[a]
Haraka (WH 101)	6	18	35.2	2378 ± 151
Milima (WH 605)	9	20	40.3	3093 ± 83

[a] Grain yield ± Standard Deviation

Table 2. Summary of the Maize Outreach Campaign conducted by the AALI Youth Brigade in South Kivu during the 2023 -2024 "A Season"

Number of farms	2,185
Average yield (kg/ha)	2,736
Farm Investment ($/ha)	$331
Farmer's benefit: cost ($/$)	3.72
Total coverage (ha)	546
Production input costs ($)	$181,030
Coordination costs ($)	$54,188
Total costs ($)	$235,218
Total yield (t grain)	1,495
Overall grain value ($)	$672,543
Net return ($)	$437,325
Campaign benefit: cost ($/$)	2.86
Input: Coordination cost ratio	3.34

Table 3. A Campaign Design and Analysis Utility used to describe and predict outreach project impacts developed as a result of the study. Note the color coding of initializing inputs (green), calculations (red) and useful outputs (blue).

Scenario	Updated AALI Maize Outreach 2024			crop	maize	Location	South Kivu, Season A	
Number of farms	2185	Area per farm	0.25	ha/farm	Recover all campaign costs? (0=no, 1 =yes)			1
Service:farm ratio	240	Attrition	0.00	farm/farm	Transport required per farm (km)			12
Parameter	---------------- per ha -------------------			---------------- per BRIDEP Maize campaign -------------------				
Production inputs	rate (kg/ha)	price ($/kg)	cost ($/ha)	farms	ha/farm	ha/campaign	quantity (kg)	input cost ($)
hybrid maize seed	24	2.7	64.8	2185	0.25	546.25	13,110	35,397
preplant fertilizer	80	1.5	120	2185	0.25	546.25	43,700	65,550
topdress fertilizer	40	1.5	60	2185	0.25	546.25	21,850	32,775
pesticides/herbicides	4	17	68	2185	0.25	546.25	2,185	37,145
processing/bagging	55	0.34	19	2185	0.25	546.25	29,891	10,163
other inputs	0	0	0	2185	0.25	546.25	0	0
input total cost			331					181,030
Outreach campaign				units			unit cost ($)	operation cost
coordination				2,185			5	10,925
service center				9			1200	10,925
farmer training				2,185			10	21,850
monitoring				2,185			8	17,480
transportation				26,220			0.15	3,933
outreach cost								54,188
Total Costs								235,218
Yield & Returns	yield kg/ha	price $/kg	$/ha	farms	ha/farm	ha/campaign	quantity (kg)	return
average maize yield	2736	0.45	1,231	2185	0.25	546.25	1,494,540	672,543
return			900					437,325
benefit:cost ratio			3.72					2.86
Color code	enter initializing variable		allow for calculation		key performance output			

Discussion and Conclusion

AALI's outreach campaigns are based upon organizing a large number of smallholders to modernize, mechanize and market their production. In the case of maize, this involves the production and distribution of combined input packages containing hybrid seed, preplant and topdressed fertilizers and management instructions. Outreach campaign organizers anticipated yields of about 3 tons per ha, equivalent to 750 kg per 0.25 ha and roughly equal to the annual food needs of a 7-member smallholder household. Average yields were 2736 kg per ha (or 684 kg per household). At a maize price of $450 per ton, this level of production offers partial net returns of $900 per ha and a benefit-to-cost ratio of $3.72 per dollar invested. Not included in this analysis were labor and local transportation costs (provided by the farmer) and coordination and monitoring costs (absorbed by the Youth Brigade program).

An economic analysis of the youth-led outreach campaign appears in Table 3. While the utility allows for the results of this technology outreach campaign and its technology package to be readily analyzed, and future outreach approaches to be designed, the utility itself is rather simplistic. It allows for economic analysis of a crop production technology package, but only one such package at a time that does not allow for sensitivity analysis of different technical options. Nor does it consider statistical variation to assign probabilities to utility outputs.

The utility systematically under-estimates production costs. Costs missing from the analysis are land access and preparation (Mondo *et al*., 2020), labour costs for crop management and other less-direct opportunity costs such as depreciation of farm equipment. It assumes that participating farmers bear these costs and as such it only provides partial economic analysis. It provides a framework for calculating technology promotion costs, but assumes this cost is the same for all outreach beneficiaries. It can, however, be used to calculate the breakeven costs for technology promotion and adoption at both the farmer and project level (e.g. when net return = 0 and benefit-to-cost = 1), and this is in itself an important aspect too seldom considered in technology outreach operations. Its greatest worth is perhaps in its simplicity, allowing outreach partners to better test and understand outreach campaign purpose and design.

The outreach approach described in this paper can be replicated and adjusted to meet local agricultural and socio-economic conditions. One strength of the approach is that it targets an area of 0.25 ha per household, allowing each household to transport the production input packages from distribution centers to their own farms without additional costs. Production levels allowed households to achieve food security and produce modest surpluses for sale over only one season, while the Ruzizi Plain receives bimodal rainfall, permitting two rainfed growing seasons per year.

Hodder and Migwalla (2023) identified six key levers required to "ignite" agricultural transformation, as it was earlier envisaged by the African Development Bank (AfDB, 2016; Mukasa *et al*., 2017) and others (see Badiane *et al*., 2021). These levers include broadened policy support, improved access to capital assets, overcoming infrastructure gaps and supply chain issues, improving productivity of small-scale farmers and adapting to climate change. It is built upon an agricultural transformation agenda recognized at the highest levels of government (IITA and AALI 2022) and in compliance with the Dakar 2 Feed Africa strategy (Woomer *et al*., 2024). It creates demand for hybrid maize and accompanying production inputs that are otherwise slow to enter the market in eastern Congo, and developed understanding around their cost and value. It distributed production input packages in a way that relies upon local farmers and their organizations to engage in last-mile delivery. It introduced modernized maize production as both a food security lifeline and a marketable commodity, and encouraged farmers to market their surpluses and invest in proven technologies the following season. The production input packages that were distributed resulted in expected yield improvement without placing excessive expectations upon the households and their communities (Barrett *et al*., 2020). Finally, it relied upon climate-smart crop varieties and their accompanying production management practices that account for both drought and extreme weather events (Bagula *et al*., 2016; Simtowe *et al*., 2019; Bagula *et al*., 2021; Nyairo *et al*., 2021), although that final facet requires greater emphasis within future interventions (Woomer *et al*., 2024). For a relatively small project involving thousands of farmers and modest production input levels, this approach executed an ambitious, robust design and brought large benefits to local communities that often experience maize shortfalls. This approach should be replicated across DR Congo as part of its effort to establish food self-sufficiency.

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Statement of No-Conflict of Interest

The Authors declare no conflict of interest in the paper.

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