Africa RISING East and Southern Africa Project and Iles de Paix (Islands of Peace) Partnership in Karatu District, Tanzania

Technical Report,
01 March 2020–30 September 2020

Submitted to
Iles de Paix (Islands of Peace)

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About Africa RISING

The Africa Research In Sustainable Intensification for the Next Generation (Africa RISING) program comprises three research-in-development projects supported by the United States Agency for International Development (USAID) as part of the US Government's Feed the Future initiative.

Through action research and development partnerships, Africa RISING is creating opportunities for smallholder farm households to move out of hunger and poverty through sustainably intensified farming systems that improve food, nutrition, and income security, particularly for women and children, and conserve or enhance the natural resource base.

The three regional projects are led by the International Institute of Tropical Agriculture (in West Africa and East and Southern Africa) and the International Livestock Research Institute (in the Ethiopian Highlands). The International Food Policy Research Institute leads the program's monitoring, evaluation and impact assessment.

Africa RISING appreciates support from the American people delivered through the USAID Feed the Future initiative. We also thank farmers and local partners at all sites for their contributions to the program and the CGIAR Trust Fund.

About Iles de Paix (Islands of Peace)

Islands of Peace (IDP) is a Belgian NGO created in the 1960s. It is a pluralist association, with no religious, philosophical, ideological, or political ties. Currently IDP works in Benin, Burkina Faso, Peru, Uganda, and Tanzania. IDP also conducts activities in Belgium such as advocacy and development education. The intervention of IDP in Africa's overall objective is to enable people to pursue their own sustainable development process independently and with dignity.
In its countries of operation, Islands of Peace facilitates local, reproducible, and sustainable development led by disadvantaged populations with their representatives and local authorities. Islands of Peace is an NGO specialized in the support for local development. Its interventions target vulnerable rural communities for whom the IDP programs tackle food insecurity.

Contents

Part I: Postharvest activities

Overview

Activity name:	Africa RISING East and Southern Africa Project and Iles de Paix (Islands of Peace) partnership in Karatu District, Tanzania
Activity start date:	01 September 2019
Activity end date:	30 September 2020
Name of prime implementing partner:	International Institute of Tropical Agriculture (IITA)
Major counterpart organization (s):	Iles de Paix (Islands of Peace)
Contact person:	Dr Christopher Mutungi Email: C.Mutungi@cgiar.org
Implementation team:	• Christopher Mutungi (IITA) • Audifas Gaspar (IITA) • Juma Amri (IITA) • Judith Tungu (IITA) • Abass Adebayo (IITA)
Geographic coverage (districts, regions):	Karatu District, Arusha Region, Tanzania
Reporting period:	01 March 2020 – 30 September 2020

Executive summary

Since June 2018, IITA's Africa RISING and Iles de Paix have been collaborating to scale-up postharvest management technologies in Karatu District. The implementation of key activities is spearheaded by Kilimo Endelevu (KE), which is the implementing arm of Iles de Paix, while Africa RISING provides technical support. In 2018/19, the collaboration demonstrated improved postharvest technologies in eight villages (Generation 1), reaching 346 direct beneficiaries (farmers hosting the mother learning demos + members of the respective farmer groups), and another 1039 farmers as indirect beneficiaries. The Generation 1 villages included Buger (Buger ward), Kambi ya Simba (Mulumbulu ward), Chemchem (Rhotia ward), Chagarawe (Daa ward), Rhotia Khainam (Rhotia ward), Bashay (Gyekrum Lambo (Karatu ward), and Slahhamo.

In 2019/20, scaling activities extended to 10 new (Generation 2) villages: Q'orong'aida and Qurus (Qurus ward); Endagem, Qaru, Kinihhe (Endabash ward), Kilimatembo (Rhotia ward); Upper Kitete (Mbulumbulu ward); Ng'aibara (Kansay, ward); and Basodawish and Khusumay (Endamarariek ward). In these new villages, demo sites and learning actions have been spearheaded by lead farmers and community-based postharvest committees whose capacity had been built by KE with technical backing from Africa RISING. In addition, seven spreading villages (not directly targeted by the technology demonstrations but learning from their peers indirectly) have been involved. These include Endanyaweti, Marera, Kilimamoja, Gendaa, Dofa, Tloma, and Endasshangweti. The locations of the primary villages are shown in Figure 1.

In this reporting period, activities were hampered by the COVID-19 outbreak. However, the following activities continued: training and installation of demos in new sites led by lead farmers, initiatives to link farmers to technology suppliers and enhance business skills, and farmer support through mobile phone messaging on postharvest and nutrition issues. As a result, 699 new farmers in 17 new villages benefited from training and involvement in site demos, and 616 farmers (from 18 villages) were registered to receive postharvest and nutrition knowledge support through mobile phone messaging. Capacity development of KE field staff on postharvest management continued reached a milestone with the publication of one co-authored research article in the Journal of Stored Products Protection - https://doi.org/10.1016/j.jspr.2020.101723

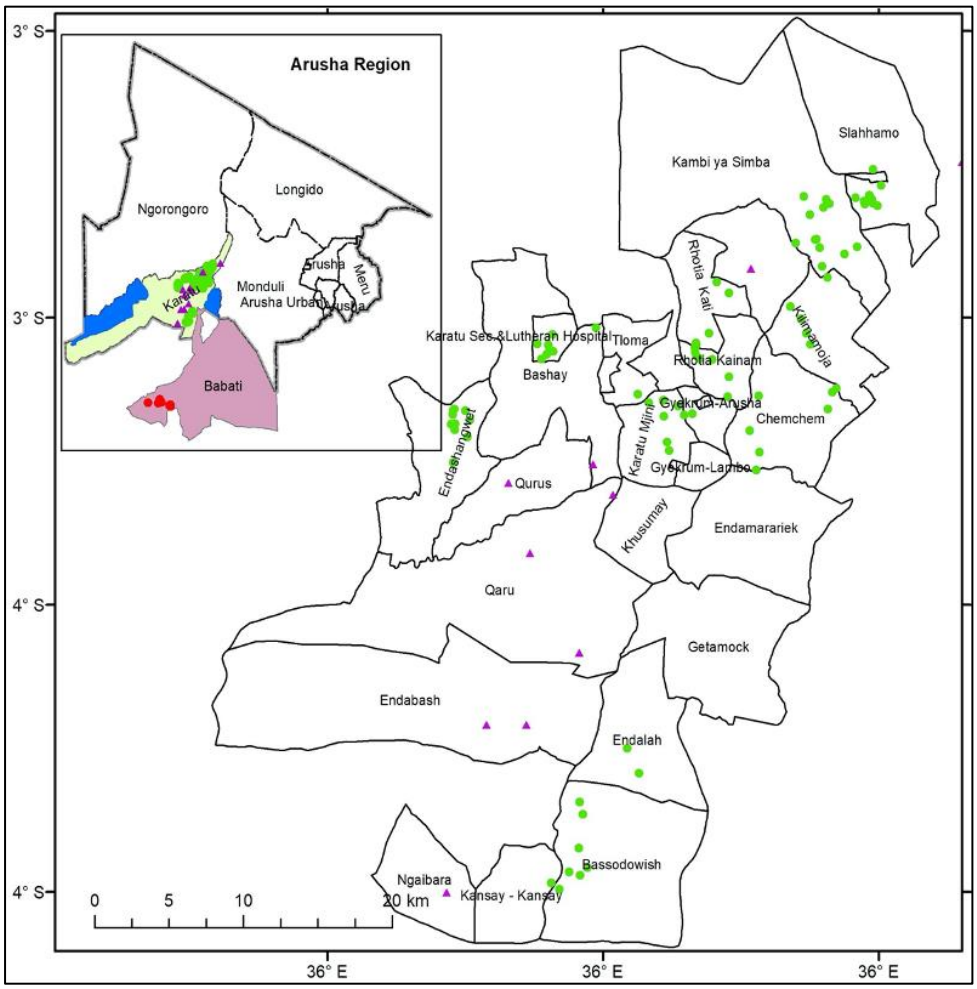

Figure 1. Postharvest activity sites showing Generation 1 (2018/19) villages—demonstration sites marked by the green symbol, and Generation 2 villages (2019/20) are marked by the purple triangle.

For the 2019/2020 partnership period between Africa RISING and Iles de Paix, KE developed a strategic plan to expand the scaling of postharvest technologies to reach more farmers in the original villages and in the new action villages. The scaling strategy included specific actions to be implemented by KE with technical backstopping from Africa RISING, to achieve the targets shown in Figure 2. The commitment areas are summarized in Table 1, together with the achievements made. The activities that received attention during the present reporting period are marked in blue. For the purpose of this report, these have been grouped and described in sections B1–B3 as follows:

1. **Section B1:** Africa RISING Support Areas 1 & 6: Estimating nutritional gains of improved postharvest handling and storage practices of maize and common beans; a compositional interpretation.
2. **Section B2:** KE Action 6/Africa RISING Support Area 5: Formulation and delivery of actionable postharvest tips that support decision making of farmers for scaling via mobile phone messaging.
3. **Section B3:** KE Actions 3, 4, & 5: Installation of demonstrations in new villages and initiatives to link farmers to technologies.

Table 1. Commitment areas by partners and progress

Activity	Status
KE Actions as laid out in KE scaling strategy	
Action 1: KE-led identification, training, and deployment of champion farmers as agents of scaling.	Accomplished in previous reporting period (September 2019–February 2020)
Action 2: KE-led facilitation of the formation of postharvest management subcommittees to steer scaling in the villages.	Accomplished in previous reporting period (September 2019–February 2020)
Action 3: KE-led installation of demonstrations in new villages for farmers to learn the technologies.	Continued in the present reporting period
Action 4: KE-led initiatives to link farmers to technology manufacturers/suppliers.	Continued in the present reporting period
Action 5: KE-led initiatives to enhance business skills of farmers in action villages.	Continued in the present reporting period
Action 6: KE-led and AR-supported *e*-extension initiative to enhance scaling.	Continued in the present reporting period
Africa RISING support areas	
Area 1: Refining technologies and offering technical support in training of champion farmers.	Continued in the present period
Area 2: Preparation and reproduction of training materials.	Accomplished in previous reporting period (September 2019–February 2020)
Area 3: Preparation of protocols for installation of demos and guidelines for monitoring and collection of scaling data in new action villages.	Accomplished in previous reporting period (September 2019–February 2020)
Area 4: Attendance to follow-up actions and formulation of questions for Iles de Paix's M&E annual survey.	Suspended due to COVID-19
Area 5: Formulate and deliver actionable postharvest tips that support decision making of farmers for scaling via mobile phone messaging	Accomplished in the present reporting period
Area 6: Identification of postharvest challenges within local farmer contexts and recommendation of best practices to address them.	Continued in the present reporting period

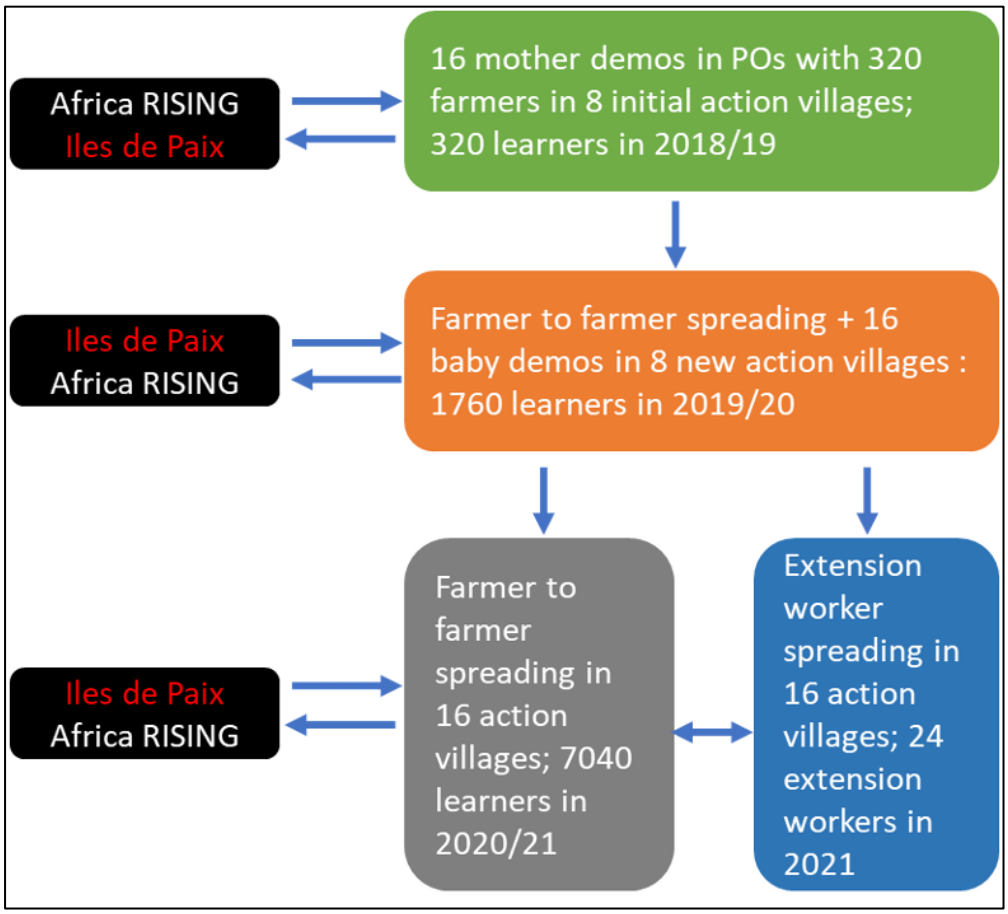

Figure 2. AR-IoP model and targets for scaling postharvest technologies in Karatu.

Africa RISING Support Areas 1 & 6: Estimating nutritional gains of improved postharvest handling and storage of maize and common beans; a compositional interpretation

The nutritional complementarity of maize and beans was empirically demonstrated in earlier work (Hulse 1991). Beans are a prime source of protein, minerals, and the B-complex group of vitamins, while maize is primarily a source of calories. However, the large quantities of maize and maize products consumed in diets make it an important source of protein and minerals. In terms of protein, maize is deficient in lysine and tryptophan but has fair amounts of sulphur amino acids (methionine and cystine), which are limiting in beans. Accordingly, maize and beans complement each other to meet the recommended amino acid balance if consumed in a ratio of 2:1 as suggested by Broughton et al. (2003).

Considering this complementarity, the preservation of sufficient quantities of maize and beans between harvests is important for the nutritional security of households. Nutritional value loss is an integral component of food loss (Affognon et al. 2015). The physical postharvest losses of maize can reach 20–30% in Tanzania (Abass et al. 2014). For beans, dry weight loss of 10–40% was measured in Karatu (Mutungi et al. 2020). Whole grains lost when cobs or pods are not completely collected or are scattered or sorted out result in a direct loss of nutrients as well. Attack by pests diminishes the nutrients contained in the parts eaten up by the pests in different

ways. Hence, beyond the physical grain damage and weight loss, pest attacks can have consequences, which could potentially lead to serious nutritional deficiencies if key nutrients become considerably diminished.

We aimed to estimate the nutritional value loss in farmers maize and common beans stocks during the postharvest season. The relationships between physical quality and nutrient content were examined and applied to estimate the nutritional gains of improved handling and storage practices. Such knowledge would help to provide crucial evidence and guidance for justifying engagement of communities and the public on progressive food loss reduction investments.

Methods

Data sources

Data comprised the physical quality of grain and nutritional value measurements of samples taken from the trials installed in eight villages (Buger, Chemchem, Kambi ya Simba, Khainam Rhotia, Gyekrum Lambo, Bashay, Slahhamo, and Changarawe) during the 2018/2019 season to demonstrate improved postharvest handling and storage practices for maize and beans. The postharvest season in Karatu extends from July and continues through to April. The grain stocks held by most households decline significantly from February, hence there is a shortage in the two months between March and May. We distinguished the improved practices as a set of operations comprising timely harvesting, drying the de-husked cobs or bean haulms on mats in readiness for threshing, further drying the threshed grain on mats, moisture verification, cleaning of the grain (winnowing/sieving/sorting) before bagging, and finally storage in air-tight containers. Farmers in Karatu received training on these practices.

Determination of physical quality

A physical appraisal of grain damage was performed using the “count and weigh” method, which involves sorting samples into wholesome grains and those with various forms of defects: insect damage, mold damage, rotten/diseased/discolored grains, rodent damage, mechanical injury, and shriveled grain. The total damage is then adjusted by further determining the quantity of the damaged grain that is totally non-consumable for the estimation of losses. The method uses trained technicians who are conversant with the acceptance/rejection criteria of consumers, and therefore closely mimics consumer behavior, decisions, and actions at the point of use of the grain. The physical damage and losses data were expressed as percentages on a weight basis (Mutungi et al. 2019).

Determination of nutritional content

The standard AOAC methods (AOAC 2000) were used. Whole subsamples (ca. 500 g) were sieved to remove the foreign matter, insects, and other debris. They were then milled into a fine flour using a laboratory mill and analyzed for moisture content (Method 925.10), crude protein (Method 920.87), crude fat (Method 920.86), crude ash (Method 923.03), and total carbohydrate by the difference. Mineral content was determined using flame atomic absorption spectrophotometry. The energy values were calculated using the standard formula as follows: maize: kcal/100 g = (4.03 * carbohydrate g/100 g) + (8.37 * fat g/100 g) + (2.73 * protein g/100 g); beans: kcal/100 g = (4.07 * carbohydrate g/100 g) + (8.37 * fat g/100 g) + (3.47 * protein g/100 g) as also applied by the USDA food database https://fdc.nal.usda.gov/.

Results

Physical quality

Table 2 shows the different kinds of defects determined on maize and common bean at different stages of the postharvest season with and without improved practices. On the far-right column, the improved practices for the mitigation of the defects are given. The results are shown in Figure 3. Insect damage (ID) was the predominant damage under ordinary practices and increased from harvest to the late postharvest stage. Other kinds of damage—rotten, diseased, and discolored grains (RDD); mechanically damaged grain (MD); and shriveled grain (SG)—were low but significant when viewed collectively (range in maize: 4.2–24%; beans 2–13.8%). Practice influenced significantly ($P < 0.001$) the physical quality of maize and contributed 38% and 24% of the observed variability in physical quality of maize and beans, respectively. The postharvest stage also significantly influenced the physical quality and contributed 30% of the variability observed in maize and 22% of the variability observed in beans. The interaction between practice and postharvest stage was significant for ID in both commodities as well as for RDD in maize.

Table 2. Grain defects associated with postharvest losses in maize and common beans, causes, and interventions (improved practices) implemented for control.

Defect type	Cause	Maize	Beans	Intervention practice
Mechanical damage (MD)	Poor shelling/threshing methods			Optimal grain moisture, thresher calibration, careful use of methods
	Rodents (rats, mice) and other gouging pests			Rodent traps; air-tight storage
Insect damage (ID)	Maize weevils, grain borers, bean bruchids			Air-tight storage
Rotten/diseased/discolored grain (RDD)	Mold growth			Drying on tarpaulin, moisture verification
	Fermentation/germination/biochemical activity/heat damage			Proper drying on tarpaulin, verification of grain moisture
	Bacteria, fungi, and other agents of disease/decay			Cob/pod separation sorting

Shriveled grains (SG)	Poor grain filling			Cob selection/sorting

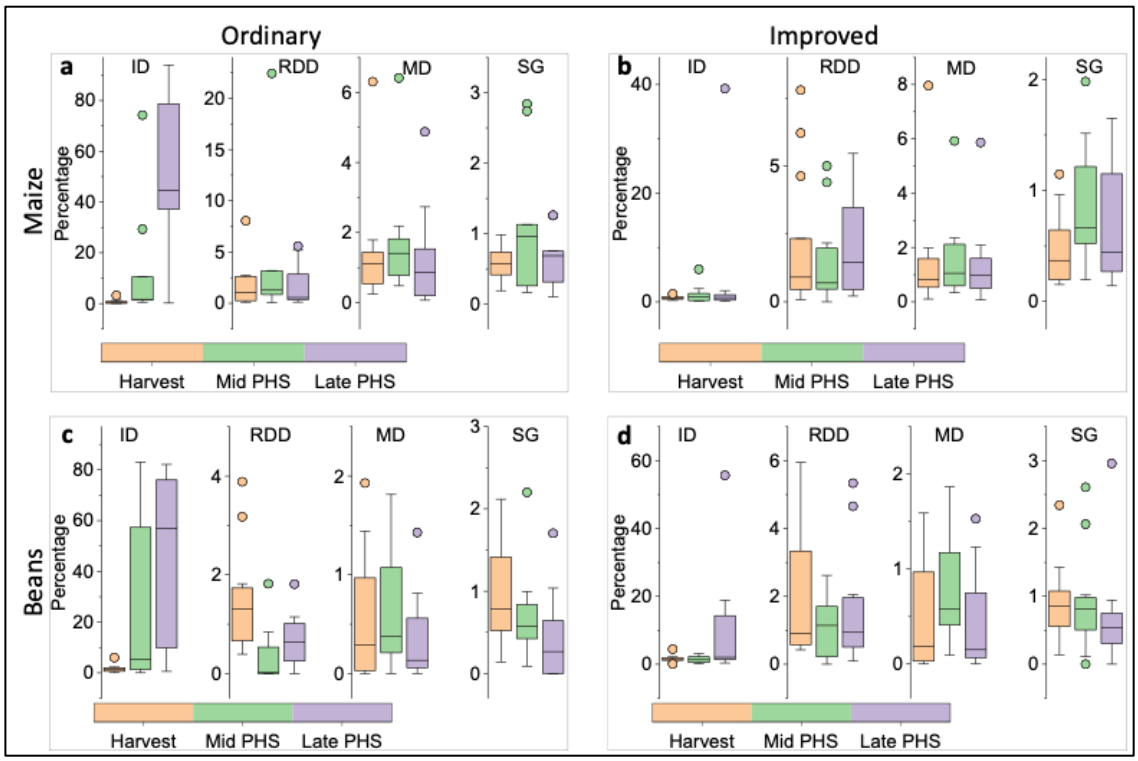

Figure 3. Levels of insect damaged (ID), rotten/diseased/discolored (RDD), mechanically damaged (MD), and shrivelled grain (SG) at harvest stage, mid postharvest stage (mid PHS) and late postharvest stage (late PHS) under ordinary and improved practices.

Nutritional quality

Both practice and stage in postharvest season significantly influenced the nutritional quality of maize and beans. Practice was responsible for 18% of the observed variability in the nutritional quality of maize, while postharvest stage was responsible for 76%. Similar observations were made regarding the nutritional quality of beans; practice was responsible for 17% of observed variability, whereas postharvest stage was responsible for 69%. The effect of stage in the postharvest season was, therefore, stronger in both commodities. All the measured nutritional parameters except crude fiber changed during the postharvest season. With maize (Fig. 4a), protein, ash, and fat contents increased by 6–7%, 12%, and 2–17%, respectively. The highest content was measured at the mid-stage. Fiber and carbohydrates decreased progressively by 9–12% and 2.3%, respectively. Likewise, protein, fat, and ash content in the beans (Fig. 4b) increased by magnitudes of 7% (protein), 16% (fat), and 19% (ash), and reached the highest levels in the late stage. The fiber content did not change significantly, whereas the available carbohydrates decreased by 3% in the late stage. In both maize and beans, the calorie content did not change. The majority of the mineral elements increased particularly at the late postharvest stage. In maize, significant increases were observed for Fe (17–206%), Zn (19–25%), Mn (39–143%), Ca (35–152%), Mg (4–76%), and K (18–28%). In beans, increases occurred for Fe (24–34%), Zn (8–29%), Mn (44–53%), Ca (16–22%), Mg (72–86%), K (75–76%), and Na (102–152%).

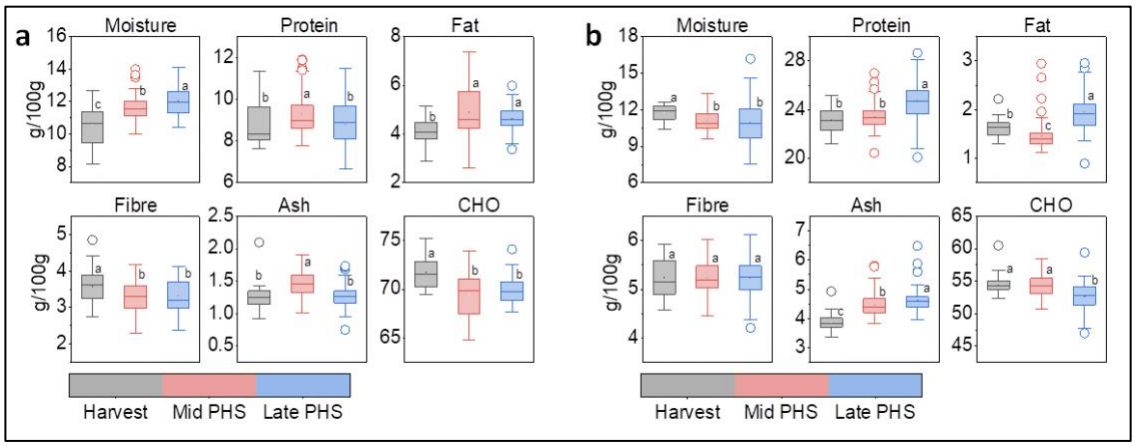

Figure 4. Actual proximate compositions of maize (a) and common beans (b) at harvest stage, mid postharvest stage (mid PHS) and late postharvest stage (late PHS) under ordinary and improved practices. CHO = carbohydrates. Letters on the boxplots represent the results of post-hoc analysis. For each parameter, on the separate commodities, same letters mark compositions that are not significantly different at 0.05 probability level.

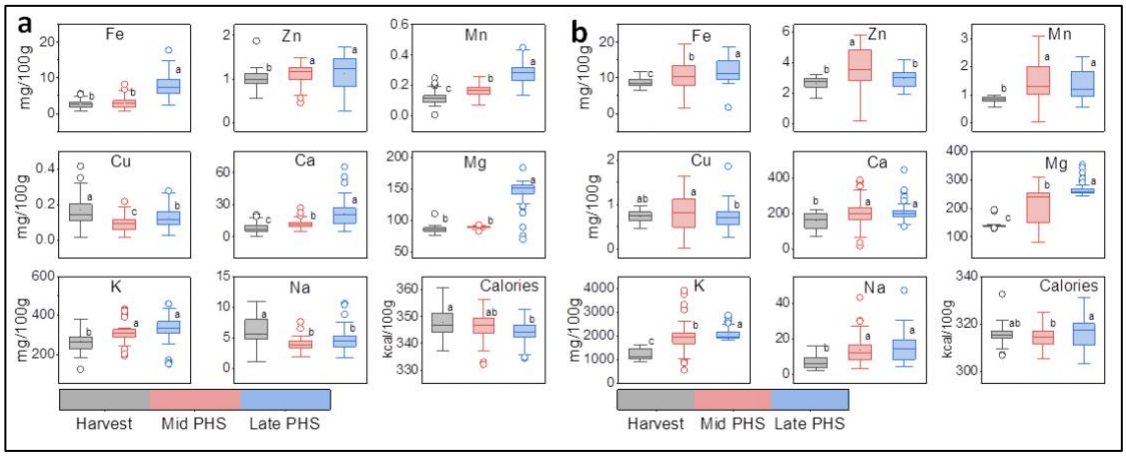

Figure 5. Actual minerals and calories content of maize (a) and common beans (b) at different stages of the postharvest season. Letters on the boxplots represent the results of post-hoc analysis. For each parameter, on the separate commodities, same letters mark compositions that are not significantly different at 0.05 probability level.

Improved practices or ordinary practices had significant effects mainly on minerals. A comparison of the actual nutrient contents under ordinary and improved practices are shown in **Error! Reference source not found.**. The maize handled and stored under improved practices had higher protein (+7.8%) and Fe (+11.1%) content in the mid-postharvest stage but not in the late postharvest stage. On the contrary, under improved practices, higher levels of Cu (+13%), Ca (+38%), and Na (+22%) were measured at the late postharvest stage while lower levels of ash (8.4%), Fe (–25%), and Mn (–11.2%) were determined. With beans, the improved practices resulted in marked gains on Na (+38%), Fe (+23%), Zn (+7%), Mn (+31%), and Cu (+36%) in the mid-, but no gains in the late postharvest stage. Thus, for common beans, ordinary practices resulted in higher levels of all the nutrients except Na. Interaction between practice and postharvest stage was significant and contributed about 11% of the observed variation in the nutritional value of maize ($P = 0.024$, $F_{(26;\ 338)} = 2.521$; $\eta_p^2 = 0.11$) and 19% of the variation in the

nutritional value of beans (P = < 0.000, $F_{(24;\ 356)}$ = 3.036, η_p^2 = 0.19). These effects were mainly on mineral contents. In Figure 6, the mean nutrient contents of maize and beans under improved and ordinary practices are visualized, and the gains or losses marked. Common beans under improved practices had lower contents of the measured nutrients, particularly at the late postharvest stage. This is probably the effect of enrichments from insect infestations because, generally, insects are rich in minerals, protein, and fat (Rumpold et al. 2013). The only significant gains relate to protein, Fe, Zn, and Cu in maize under improved practices during the mid-stage, which can also be explained by developing hidden (pre-emergent) forms of insects (larvae) in the grains. The accumulation of the same micro minerals (Fe, Zn, Mn, and Cu) was likewise observed with the beans in the mid-postharvest stage.

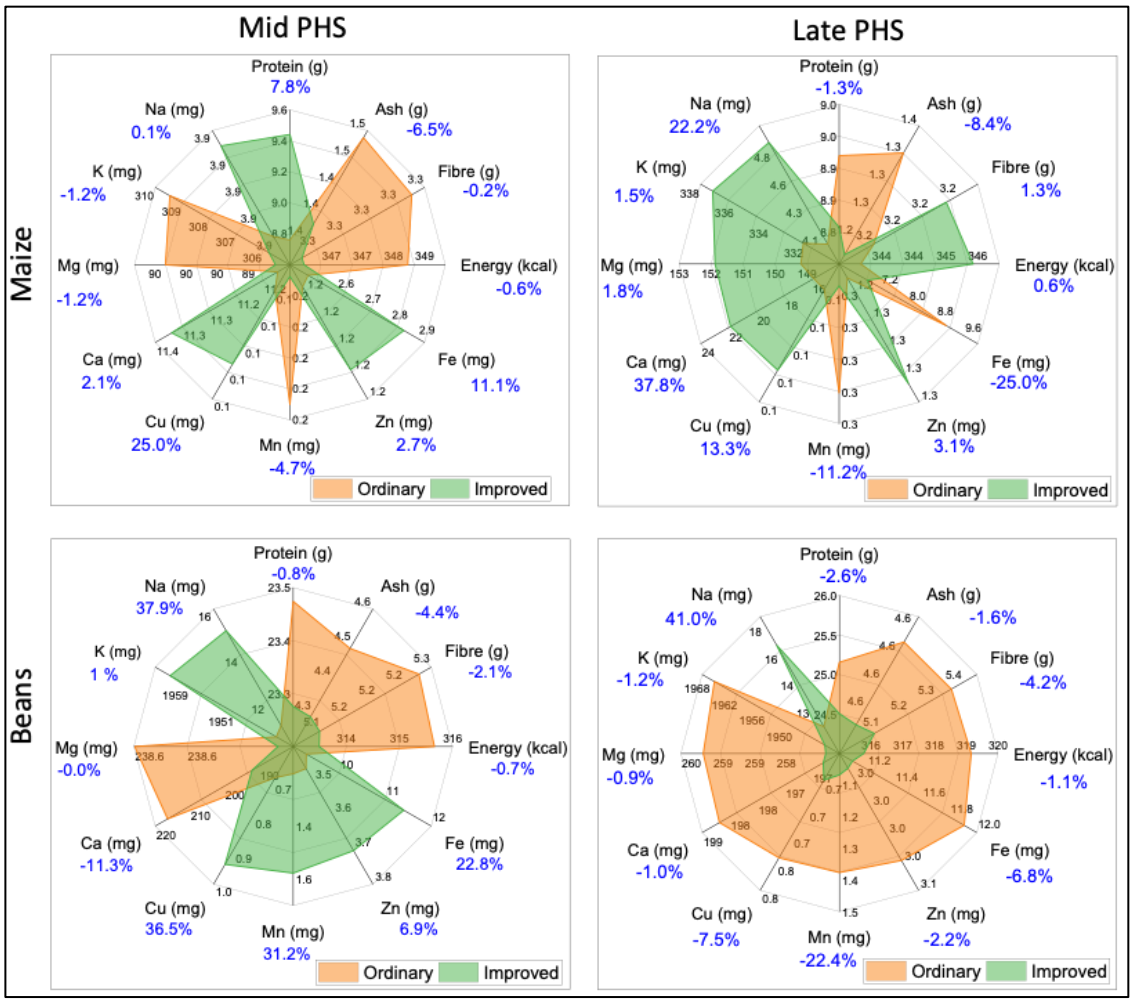

Figure 6. Actual nutrient contents (units per 100 g) of maize and beans as affected by postharvest practice. Mid PHS is mid postharvest stage, 3.5 months after harvest; late PHS is late postharvest stage, 7 months after harvest. The percentages in blue font are the resultant gains or losses.

Loss-adjusted nutrient availability (LANA)

We applied loss data attributed to each of the analyzed samples to convert each measured nutrient content to the potential nutrient availability. The rationale is that production or yield at farm level can be seen in terms nutrient production. Thus, any loss of the harvested products represents a decline in the amount of nutrients available to nourish populations. The nutritional composition data, i.e., actual nutrient contents (ANC) were converted to loss-adjusted nutrient availability (LANA) by multiplying the ANC with the corresponding loss factor computed from the physical loss assessments as (1 – x) where x is the quantity loss expressed as a fraction.

Statistically, practice explained 35% of the variability observed with respect to nutrient availability in maize, and 18% of the variability observed in beans. Thus, the difference between improved and ordinary practices was more palpable in maize than beans. Postharvest stage accounted for 74% and 69% of the variability in maize and beans, respectively. Nonetheless, the interaction between practice and postharvest stage was significant and explained 20% of the

variability in maize and 29% of the variability in beans. With maize, the interaction between practice and PH stage influenced all the proximate components and the macro-minerals (Ca, Mg, K) whereas in the beans, the interaction effect was only significant on protein, ash, carbohydrate, and the availabilities of individual minerals were more influenced by PH stage. The improved practices had an advantage over ordinary practices in terms of the total available protein, calories, and minerals as they abated serious produce damage and loss. As shown in Figure 7, there were inverse linear relationships between grain damage and availability of key nutrients but the nutrient loss rates (e.g., calories) differed with commodity.

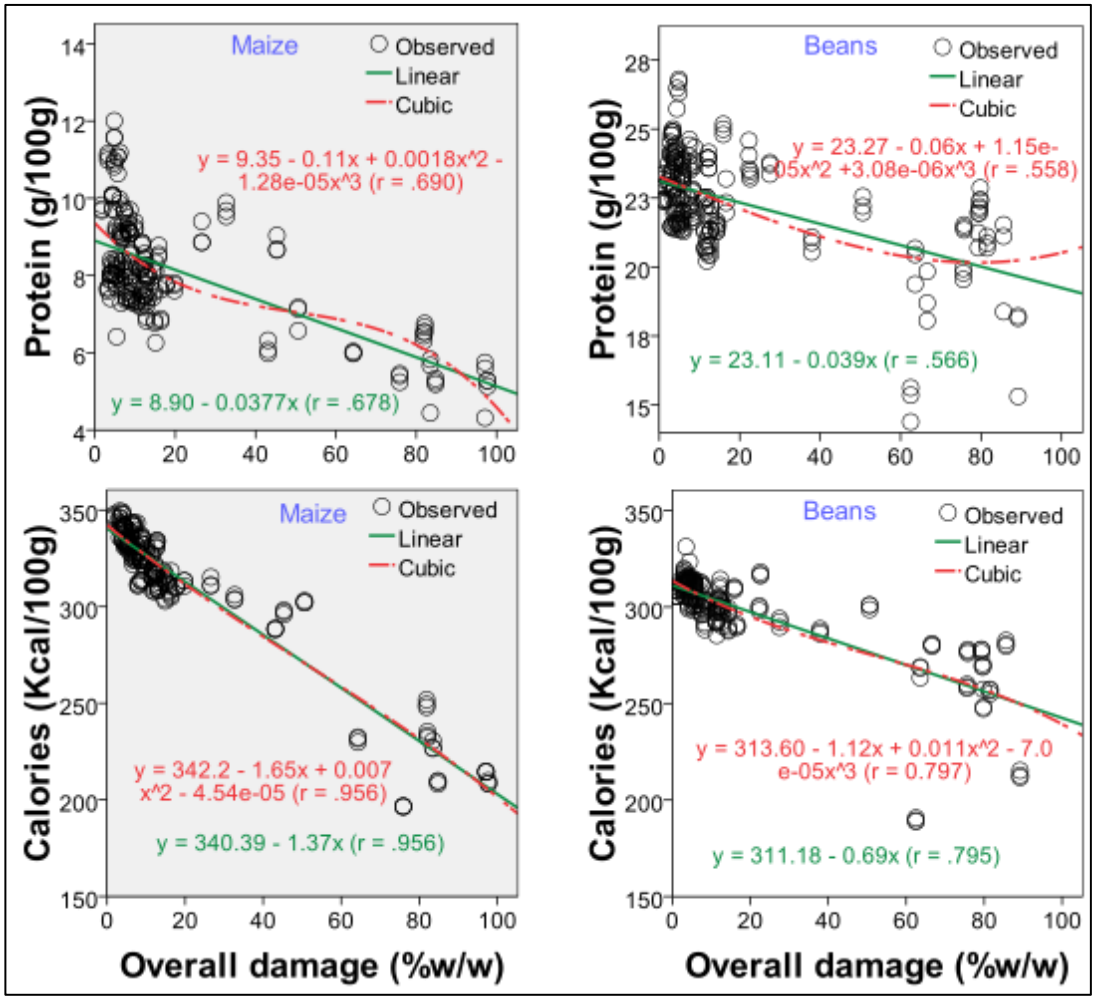

Figure 7. Regression models for protein and calories availability against overall grain damage.

Figure 8 shows the gains in nutrient availability from the use of improved practices on maize and beans at mid and late stages of the postharvest period. For maize, significant gains are evident at the mid stage and late stage. In beans, the gains are mainly on key minerals at the mid stage, but more gains occur at the late stage (e.g., protein +6.5%, calories +8.7). Thus, during the lean period, households and communities at large would have 34% more protein and 40% more calories from the use of the improved postharvest practices for maize as well as 6.5% and 8.7% more protein and calories from beans.

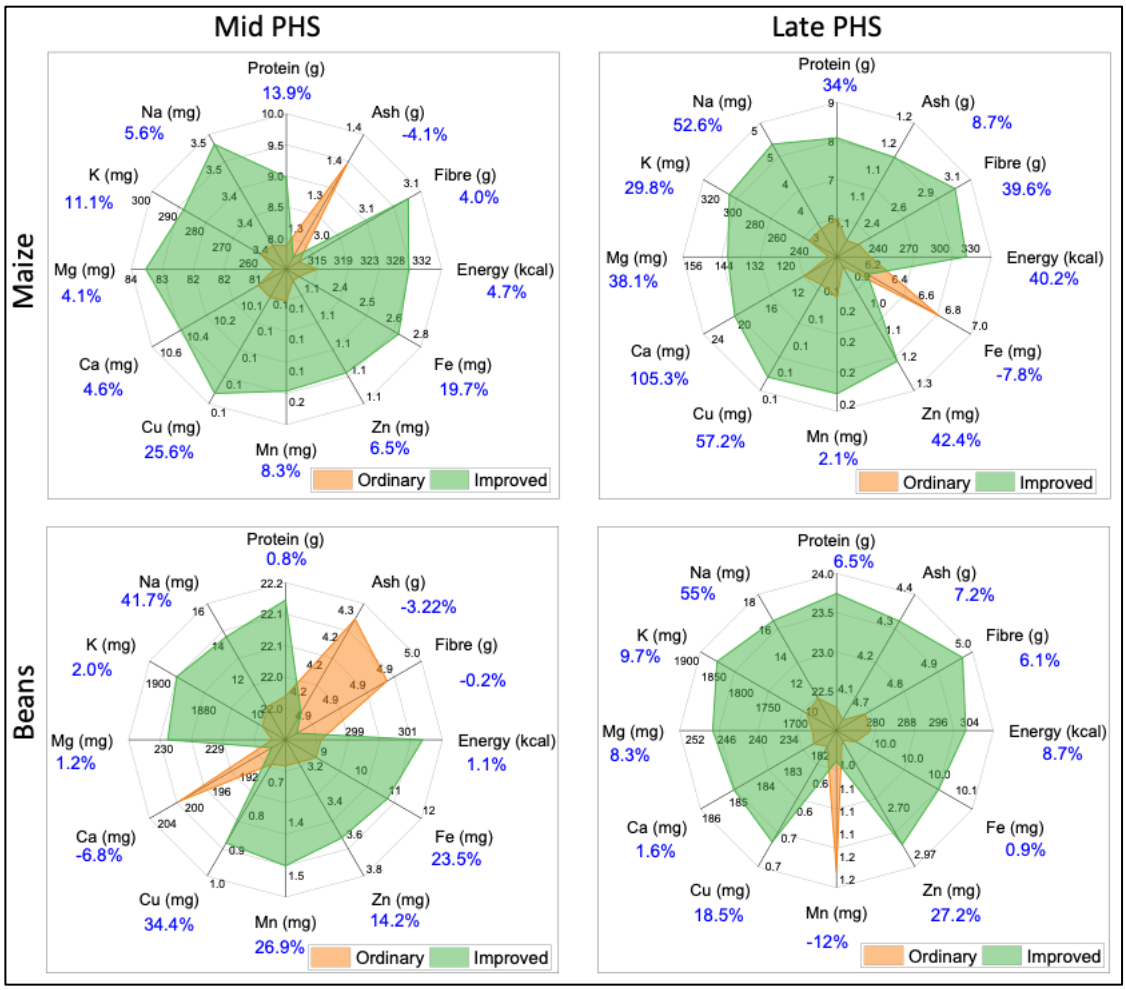

Figure 8. Nutrient availability gains (percentages in blue) of improved postharvest practices on maize (top) and beans (bottom) at mid and late stages of the postharvest season. The contents are units per 100 g.

Implication of the nutrient availability gains for nutrition of households

According to FAO statistics of 2017 (FAOSTAT 2017), the annual per capita consumption of maize in Tanzania is 63 kg (173 g/d). The annual per capita consumption of beans is 17.4 kg (46.7 g/d). Table 3 provides a computation of the potential contribution of maize and beans to different categories of household members based on the national per capita consumption levels and the Recommended Dietary Allowances (RDA). Combined, maize and beans contribute approximately 35% (29–42%) and 49% (37–57%) of the adult RDAs for calories and protein. The various consumer groups also receive good amounts of important minerals except calcium and sodium. Nonetheless, the consumption of maize and beans satisfies none of the RDAs. Households would have to diversify their food sources to obtain sufficient levels of Ca as well as obtain the balances on the other nutrients. Alternatively, they would need to increase the per capita consumption of the two commodities. From the use of improved postharvest technologies, significant amounts of nutrients are salvaged as shown in Figure 8. Considering that food stocks decline substantially in the late stage of the postharvest season, we conducted a computation to assess the contribution of the improved practices on the nutritional resilience of households. We applied production and household data from a baseline survey conducted at

the beginning of the collaboration (https://public.tableau.com/profile/ludiwien.cooreman#!/vizhome/DraftSIA2019/Story1). The average maize production was 875 kg annually (range 50–4500 kg), while the average common beans production was 243 kg (range 50–1800). The average household size was 6.4 (7) members. Table 4 estimates the potential nutritional benefits. Assuming households sold half of the produce and preserved the other half as food supply stocks, they would have sufficient protein and calories for at least one extra month if the improved postharvest practices are duly applied. They would also benefit substantially from the availability of the essential minerals iron, Zn, Mg, and K.

Table 3. Nutritional contribution of maize and beans to different groups based on per capita consumption (PCC) in Tanzania (maize 172.6 g/day; beans 47.7 g/d).

	Protein	Calories	Fiber	Fe	Zn_	Mn_	Cu	Ca	Mg	K	Na
Composition (units)	g/100 g	kcal/100 g	g/100 g	mg/100 g	mg/100g	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g	mg/100 g
Maize	8.71	348.29	3.60	2.64	0.98	0.12	0.16	8.00	86.22	263.89	6.13
Beans	23.08	315.83	5.25	8.74	2.65	0.82	0.74	161.23	142.34	1249.13	6.85
Nutrient intake from maize based on PCC	15.04	601.16	6.22	4.56	1.69	0.20	0.28	13.80	148.82	455.48	10.58
Nutrient intake from beans based on PCC	11.00	150.55	2.50	4.17	1.27	0.39	0.35	76.86	67.85	595.46	3.26
Total intake (TI)	26.04	751.71	8.72	8.73	2.95	0.60	0.63	90.66	216.68	1050.94	13.84
Contribution to RDA											
(RDA Units)	(g/d)	(kcal/d)	(g/d)	(mg/d)	(mg/d)	(mg/d)	(mg/d)	(mg/d)	(mg/d)	(mg/d)	(mg/d)
RDA children 1–3 yrs	13.00	1000.00	19.00	7.00	3.00	1.20	0.34	700.00	80.00	3000.00	1500.00
TI as % of RDA	200.32	75.17	45.89	124.64	98.47	49.75	185.88	12.95	270.85	35.03	0.92
RDA children 4–8 yrs	19.00	1400.00	25.00	10.00	5.00	1.50	0.44	1000.00	130.00	3800.00	1900.00
TI as % of RDA	137.06	53.69	34.87	87.25	59.08	39.80	143.64	9.07	166.67	27.66	0.73
RDA children 9–13 yrs	34.00	1700.00	26.00	8.00	8.00	1.90	0.70	1300.00	240.00	4500.00	2300.00
TI as % of RDA	76.59	44.22	33.53	109.06	36.93	31.42	90.29	6.97	90.28	23.35	0.60
RDA Adolescent girls (14–18 yrs)	46.00	1800.00	26.00	15.00	11.00	2.30	0.89	1300.00	360.00	4700.00	2300.00
TI as % of RDA	56.61	41.76	33.53	58.17	26.86	25.96	71.01	6.97	60.19	22.36	0.60
RDA women reproductive age (19–50 yrs)	46.00	2000.00	25.00	15.00	9.00	1.60	0.90	1000.00	320.00	4700.00	2300.00
TI as % of RDA	56.61	37.59	34.87	58.17	32.82	37.31	70.22	9.07	67.71	22.36	0.60
RDA adult men (19–50 yrs)	56.00	2400.00	38.00	8.00	8.00	1.80	0.90	1000.00	420.00	4700.00	2300.00
TI as % of RDA	46.50	31.32	22.94	109.06	36.93	33.17	70.22	9.07	51.59	22.36	0.60

RDA pregnant mothers (19–50 yrs)	71.00	2200.00	28.00	27.00	11.00	2.00	1.00	1000.00	360.00	4700.00	2300.00
TI as % of RDA	36.68	34.17	31.14	32.32	26.86	29.85	63.20	9.07	60.19	22.36	0.60
Breastfeeding mothers	71.00	2600.00	29.00	10.00	12.00	2.60	1.30	1000.00	320.00	5100.00	2300.00
TI as % of RDA	36.68	28.91	30.06	87.25	24.62	22.96	48.62	9.07	67.71	20.61	0.60

Table 4. Estimation of the contribution to nutritional security.

	Protein (g)	**Calories (Kcal)**	**Fiber (g)**	**Fe (mg)**	**Zn (mg)**	**Mn (mg)**	**Cu (mg)**	**Ca (mg)**	**Mg (mg)**	**K (mg)**	**Na (mg)**
Amount of nutrients salvaged	*g/100*	*Kcal/100*	*g/100*	*mg/100*	*mg/100*	*mg/100*	*mg/100*	*mg/100*	*mg/100*	*mg/100*	*mg/100*
Maize	2.10	93.20	0.90	-0.42	0.36	0.01	0.04	10.12	39.91	72.37	1.59
Beans	1.54	25.64	0.29	1.34	0.40	-0.13	0.05	11.81	12.06	213.12	4.48
Total amount of nutrients salvaged based on the average annual production: maize: 875 kg; beans 243 kg											
Maize	18,394	815,511	7876	-	3122	53	363	88,564	349,200	633,276	13,909
Beans	3731	62299	706	3265	966	-	117	28,690	29311	517888	10,877
Total (maize + beans)	**22,125**	**877811**	**8581**	**3265**	**4088**	**53**	**480**	**117,254**	**378,510**	**115,1164**	**24,786**
Av. nutrient needs per HH member/d (based on RDI)	45	1888	27	13	8	2	1	1038	279	4400	2150
Total HH nutritional needs/d (7 HH members)	312	13,213	189	88	59	13	6	7263	1951	30,800	15,050
No. extra days of nutrient security: produce not sold)	71	66	45	37	70	4	85	16	194	37	2
No. extra days of nutrient security: 50% of produce sold	36	33	23	19	35	2	42	8	97	19	1

KE-led action 6/Africa RISING Support Area 5: Formulate and deliver actionable postharvest tips that support decision making of farmers for scaling via mobile phone messaging

During the current reporting period, short messages on postharvest management (Annex 1) and nutrition (Annex 2) were formulated. A total of 616 farmers were registered to receive these messages through the Mwanga platform. The beneficiaries are summarized in Table 5.

Table 5. Number of farmers registered to receive postharvest and nutrition messages.

Village	Male	Female	Total
Qaru	42	25	67
Kinihe	22	9	31
Qorong'aida	13	12	25
Basodawish	36	26	62
Khusumay	9	4	13
Endagem	12	23	35
Ngáibara	24	24	48
Upper Kitete	39	11	50
Kilimatembo	6	10	16
Qurus	17	26	43
Rhotia Khainam	33	16	49
Changarawe	18	20	38
Gyekrum. Lambo	21	16	37
Bashay	7	12	19
Chemchem	2	11	13
Buger	17	16	33
Kambi ya Simba	18	19	37
Total	**336**	**280**	**616**

Nutrition messaging: Nationwide, Tanzania faces the double burden of malnutrition which is characterized by the coexistence of undernutrition and over-nutrition within individuals, households, and across the life course. Despite Tanzania's steady decline in the rates of undernutrition over the last two decades, the prevalence and the burden of undernutrition are still high. Undernutrition can result in underweight, wasting, stunting, or micronutrient deficiencies. It is caused by a diet that is inadequate in energy and nutrients that the body needs for good health. Other causes are disease, poor childcare and feeding, poor sanitation, and inadequate access to health services and clean water.

Over-nutrition is caused by eating more food than the body needs and results in overweight and obesity. These conditions increase the risk of noncommunicable diseases such as high blood pressure, diabetes, and heart diseases. Malnutrition reduces life expectancy, weakens the immune system, impairs physical and mental growth, and results in poor school performance and low individual and collective productivity at the national level. Thus, observing a healthy

lifestyle, which includes healthy eating, is important to reach and maintain a healthy weight, reduce the risk of chronic diseases, and promote overall health.

Nutrition communication using ICT has the potential to boost nutritional literacy and empower individuals and communities to take a more proactive actions towards managing their diets, eating habits, and wellbeing. Research studies testing the use of SMS /text messages to promote the adoption of healthy behavior have shown positive results (Marquis et al. 2009). Mobile phone messaging (texting) is less prone to technological exclusion because many farmers or households in Tanzania already have access to mobile phones. As of 2019, the Global System for Mobile Communication Association estimated mobile phone ownership in Tanzania to be 82% of the total population. Furthermore, the developed ICT-based resources can be easily distributed and accessed across a range of ICT-based platforms. Nutrition messages were developed on five topics: classes of food; food preparation and hygiene; water and sanitation; mother, infant, and young child nutrition; water and sanitation; and environment and personal hygiene (Table 6). The full list of messages is presented in Annex 1.

Table 6. Nutrition messages.

	Message category	**Rationale/content**
1	Classes of food	Consumption of the six classes of food: 1. Cereals, roots, and tubers 2. Legumes and foods of animal origin 3. Vegetables 4. Fruits 5. Fats and oils 6. Water and drinks
2	Food preparation and hygiene	Guidelines for safe food preparation: 1. Choice of food and preparation for safety 2. Optimal cooking for nutrition and safety 3. Cooked food/protection from contamination 4. Reheating of cooked foods 5. Contact between raw foods and cooked foods 6. Hand, utensils, and surfaces hygiene 7. Water use
3	Water and sanitation	Guidelines for drinking water treatment and sanitation: 1. Hygiene requirements of drinking water 2. Water sterilization and storage 3. Water handling utensils
4	Mother, infant, and young child nutrition	Guidelines for complementary feeding: 1. Breastfeeding 2. Nutrition of breastfeeding mothers 3. Introduction of complementary feeding 4. Preparation of complementary foods 5. Hygiene practices
5	Environment and personal hygiene	Guidelines for 1. Domestic and animal waste disposal 2. Maintaining clean food environment

Postharvest messaging: Messages were formulated to communicate improved harvesting and handling practices, and storage. Storage hygiene was emphasized. The full list of messages is given in Annex 2. Proper sanitation and hygiene in food facilities is recognized as the foundation of effective integrated pest management (IPM) programs for stored products throughout the postharvest supply chain. Generally, good sanitation programs reduce the abundance and diversity of pests including rodents and insects. Decreased sanitation could reduce the efficacy of chemical, physical, and cultural pest control 1.3–17-fold under poorer compared to better sanitation (Morrison et al. 2019). In the context of modern improved pest control where the trend is a progressive turn towards the use of chemical-free methods, sanitation and good postharvest practices that reduce pest abundance should lend more meaning to technologies such as hermetic bags. The time to send out the messages is tailored to address resilience by boosting preparedness, that is, providing early awareness to the farmers on when and how the next postharvest activity is to be done in line with the local postharvest calendar.

KE-led actions 3, 4, & 5: Installation of demonstrations in new villages and initiatives to link farmers to technologies

KE led the implementation of actions to build the capacity of farmers. The actions included product knowledge training in new villages. In the present reporting period, lead farmers, supported by village postharvest committees, trained 699 new farmers, and demonstrated postharvest technologies in 17 new villages: 10 Generation 2 villages, and 7 spreading villages (Endamyaweti, Marera, Kilimamoja, Gendaa, Dofa, Tloma, and Endashangweti). The details are presented in Table 7 and Figure 9.

Table 7. Number of new farmers trained and involved in demonstrations in Generation 2 villages.

Village	Group	Male	Female	Total
Qaru	Jupiter	21	20	41
	Amani	26	22	48
Kinihe	Nufaika	18	19	37
	Amkeni	28	11	39
Qorong'aida	Juhudi	15	15	30
Basodawish	Mchangani	27	4	31
	Muungano	19	27	46
Khusumay	Songambele	10	4	14
Endagem	Jiinueni	9	19	28
	Kilimo sasa	3	13	16
Ngáibara	Ushindi	12	11	23
	Duday	3	24	27
Upper kitete	Umoja	22	7	29
	Rift valley	23	5	28
Kilimatembo	TIITA	7	10	17
Qurus	Maendeleo	11	17	28
	Meka	6	16	22
Spreading villages	-			195
Total		**260**	**244**	**699**

Figure 9. Lead farmers and KE install demonstrations of improved storage technologies in new villages. Photo credit: Musa Chamwilambo/KE.

During the current reporting period, four artisans who had earlier received training on silo fabrication continued to manufacture the silos locally to ensure easy accessibility of the technology in the community (Fig. 10). These artisans continued to receive orders from farmers. Farmers also continued to be linked with private manufacturers of hermetic bags (Fig. 11).

Figure 10. Trained artisans complete metal silo fabrication tasks at a local yard. Photo credit: Musa Chamwilambo/Kilimo Endelevu.

Figure 11. Farmers celebrate after receiving their bulk order of AgroZ hermetic bags from the local A to Z Textile Mills. Photo credit: Musa Chamwilambo/Kilimo Endelevu.

Partnership/linkages with other projects

- KE mobilized lead farmers and extension staff, guided lead farmers on the installation of technology demos, and bore the costs for the training of farmers in new villages.
- A to Z Textile Mills—manufacturers of hermetic storage bags, drying tarpaulins, and Aflasafe® (pre-harvest aflatoxin control product) (http://azpfl.com/index.php/en/)—was our private sector partner that provided postharvest management inputs—hermetic bags.
- WorldVeg continued to demonstrate vegetable technologies. As a way of enhancing nutrition integration, Africa RISING postharvest partnered with WordVeg to generate and formulate nutrition messages. WorldVeg is also demonstrating techniques for the preparation of safe nutritious meals.
- TARI Makutpora—formulation and translation of nutrition messages.
- Esoko—database management and transmission of messages.
- TARI Uyole—message refining and alignment to national goals.

Conclusions and recommendations

Postharvest food loss is measurable reduction in quantity or quality of foodstuffs after harvest. Such losses destabilize food supply and erode the nutrition of households and communities. Allowing postharvest food losses to continue unabated is wasteful as resources will be used to produce nutrients that do not nourish families. Food systems are more resilient if farmers are able to take measures that prevent erosion of the produced nutrients along the supply chain. This in turn enables more diverse dietary choices, enhancing the resilience of communities. As demonstrated in the activity involving the estimation of the nutritional gains of improved postharvest handling and storage of maize and common beans, the widespread adoption of the improved practices would make the protein and calories needed to nourish families available for at least 30 more days, consequently contributing to the nutritional resilience of Karatu farmers, households, and community. Reducing food loss can stimulate local enterprises, generate employment opportunities, and diversify local economies (e.g., fabrication of storage devices) making the system more resilient. Adequate storage also enables farmers to use their excess produce as collateral to access credit and a reduction in postharvest losses would increase the incomes of smallholders as they can have more produce to sell. Next steps should encourage agribusinesses around postharvest management. Kilimo Endelevu should continue to monitor the adoption of the various technologies with the aim of supporting the budding enterprises such as silo fabrication by local artisans.

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Annexes

Annex 1: Nutrition and Hygiene messages (Swahili)

Makundi ya vyakula
1. Kula mlo wenye mchanganyiko wa wanga, protini,mafuta, madini,vitamini na maji. 2. Kula makundi ya vyakula katika uwiano sahihi, muda sahihi, kiasi cha kutosha kuepuka magonjwa yatokanayo na upungufu wa virutubisho. 3. Kula nyama, samaki, jamii ya kunde,maziwa, mayai, dagaa kama chanzo cha protini kwa ukuaji wa mwili na akili. 4. Weka kiasi kidogo cha Mafuta ya mimea kwenye chakula kusaidia ufyonzwaji wa baadhi ya vitamini 5. Kula samli, siagi, nyama, samaki, mbegu zitazo mafuta kama chanzo cha mafuta ili kuupa mwili nguvu. 6. Kula mboga-mboga na matunda kupata madini na vitamini kulinda mwili na magonjwa. 7. Weka wanga sehemu ndogo ya mlo wako kuepuka uzito uliopitiliza na magonjwa yasiyoambukiza.

8. Kula vyakula vyenye nyuzinyuzi (makapimlo)nyingi ili kurahisisha uyeyushwaji wa chakula tumboni.
9. Tumia kiasi kidogo cha mafuta, chumvi na sukari kuepuka magojwa yasiyoambukiza.
10. Kula vyakula vinavyopatikana kwa urahisi na vipo kwenye msimu.
11. Lima, pika, kulala mbogamboga za asili kwa afya bora.

Usafi na uanddaji chakula

1. Safisha jiko, kusanya uchafu na mabaki ya vyakula katika chombo chenye mfuniko na tupa kwenye shimo la takataka.
2. Ivisha vyema vyakula vya aina ya nyama, samaki na mayai kuepuka magonjwa ya kuambikiza.
3. Osha matunda na mboga-mboga zinazoliwa bila kupikwa kwa maji safi.
4. Osha mboga –mboga kabla ya kukatakata ili kuhifadhi virutubishi.
5. Pika mboga-mboga kwa muda mfupi ili kulinda virutubishi.
6. Weka mboga-mboga na matunda kwenye maji ya moto kabla ya kukausha ili kuhifadhi virutubisho.
7. Weka mafuta kidogo kwenye mboga-mboga wakati wa kupika kurahisisha upatikanaji wa baadhi ya vitamini.
8. Nawa mikono kabla ya kuandaa chakula, kumlisha mtoto, kusafisha mtoto aliyejisaidia, kumhudumia mgonjwa na kupenga kamasi.

Usafi wa Maji

1. Chemsha maji ya kunywa, kutengenezea barafu au juisi kwa muda wa dakika tanoili kuua vimelea vya maradhi.
2. Badilisha maji yaliyochemshwa kwa ajili ya kunywa ndani ya masaa 24.
3. Kunywa maji safi na salama ya kutosha, angalau lita moja na nusu kwa siku na Zaidi wakati wa joto kali.
4. Kula vyakula vyenye maji au vinywaji kuongeza maji mwilini kama supu, madafu, togwa na juisi halisi za matunda.
5. Tunza maji ya kunywa katika chombo safi chenye mfuniko.
6. Tumia chombo maalum chenye mpini mrefu kuchotea maji ya kunywa kutoka kwenye mtungi au ndoo.
7. Osha vyombo vya kutayarishia chakula na kupakulia kwa sabuni au majivu.
8. Anika vyombo vilivyooshwa kwenye chanja au kausha kwa kitambaa safi.

Mama mjamzito na watoto

1. Mama mjamzito kula mlo kamili wenye virutubisho vyote kidogo kidogo kwa mda mfupimfupi ili kulinda mwili na kujiandaa na unyonyeshaji.
2. Mpe mtoto kuanzia miezi sita hadi miaka 4 chakula chenye mchanganyiko wa makundi yote sita ya chakula.
3. Mama mjamzito kula lishe bora kuzuia kudhoofika na kuongeza hatari ya kupata malaria, na upungufu wa damu.
4. Mpe mtoto lishe bora ili kuzuia Udumavu wa mwili na akili.
5. Mama mjamzito hudhuria kliniki mapema kujilinda mwenyewe na mtoto.
6. Nyonyesha mtoto miezi sita ya mwanzo maziwa ya mama yana virutubisho vyote muhimu.

Mazingira

1. Usitupe takataka ovyo, zuia uchafuzi wa mazingira na kuhatarisha maisha ya binadamu na wanyama.

2. Hifadhi sehamu sahihi takataka hatarishi kama kinyesi cha binadamu na wanyama, maji machafu, taka za viwandani na kilimo na mifuko ya plastiki.
3. Safisha mazingira, elimisha na hamasisha jamii juu ya usafi wa mazingira.
4. Tumia choo bora chenye kuta na mlango imara wenye kitasa au komeo na paa imara lisilovuja.
5. Tupa kinyesi katika tundu la choo na funika choo kwa mfuniko wenye mkono.
6. Tumia vifaa vinavyorahisisha usafi na kuzuia kugusa uchafu moja kwa moja.
7. Nawa mikono na sabuni baada ya kutoka chooni, kudeki, kusafisha choo au takataka.

Annex 2: Postharvest messages

	Stage	English	Swahili version	When to send message
1	Harvesting	The timelier the harvest the better the quality; harvest when husks turn brown, cobs hang down, or kernels are hard, and resistant to scratching by the thumbnail.	Uvunaji kwa wakati ubora wa mavuno; mazao yasikae muda mrefu shambani. Vuna punje zinapokuwa ngumu na kutofikichika kwa urahisi kwa kucha.	Early July
2	Harvesting	Harvested produce is alive and can get diseased; remove husks immediately and dry cobs on tarpaulin or clean platform to improve storability.	Mazao yaliyovunwa ni hai hushambuliwa na magonjwa; baada ya kuvuna ondoa maganda na kausha mahindi katika magunzi kwenye turubai au kwenye kichanja safi ili yahifadhiwe vizuri.	Mid July
3	Harvesting/threshing	Harvested produce is alive and can get diseased and become poisonous; separate rotten/moldy cobs before shelling.	Mazao yaliyovunwa ni hai, na hushambuliwa na magonjwa na kutengeneza sumu; chambua yaliyooza/ukungu kabla ya kupukuchua.	End July
4	Harvesting/threshing	Harvested grains are alive and can get easily diseased when wounded; use method that does not break grains during shelling.	Mazao yaliyovunwa ni hai. Yakipata majeraha hushambuliwa na magojwa. Tumia njia isiyosababisha majeraha wakati wa kupukuchua.	End July
5	Drying	Harvested grains are alive; They get easily diseased when stored moist; dry well and verify dryness of grain moisture is < 13% during storage.	Mazao yaliyovunwa ni hai na hushambuliwa na magonjwa yakihifadhiwa na unyevu; kausha vizuri unyevu usizidi asilimia 13 wakati wa kuhifadhi.	1st week August
6	Storage (early)	Clean grain, better storage: winnow grain, remove dirt, and trash to keep off insects.	Mazao safi, uhifadhi bora: pepeta, ondoa uchafu na safisha kuepuka wadudu.	2nd week August
7	Storage (early)	Insects require air to survive and damage stored produce; stop them by storing produce in air-tight containers always.	Wadudu wanahitaji hewa kuishi na kuharibu mazao yaliyohifadhiwa; hifadhi mazao kwenye vyombo visivyoruhusu hewa wakati wote.	3rd week August
8	Storage (early)	Clean food, safe food, more money! Use hermetic bags or other air-tight devices to store without chemicals.	Chakula safi, salama na pesa zaidi! kuhifadhi bila kutumia kemikali tumia mifuko au vifaa vingine visivyoruhusu hewa kupita.	3rd week August

9	Storage (early)	Clean environment, better storage: keep old harvest far from new harvest.	Mazingira safi, uhifadhi bora: weka mazao ya msimu uliopita mbali na mazao ya msimu mpya.	4th week August
10	Storage (regularly)	Clean environment, better storage: keep non-grain item away from stored grain.	Mazingira safi, uhifadhi bora: Weka vitu visivyo nafaka mbali na mazao yaliyohifadhiwa.	4th week August
11	Storage (regularly)	Clean environment, better storage: keep domestic animals and trash rubbish dumps far from grain store.	Mazingira safi, uhifadhi bora: weka wanyama wanaofugwa na jalala mbali na ghala.	1st week September
12	Storage (regularly)	Clean environment, better storage: sweep away spilt grain, dirt, and trash on the floor and hidden areas every week to keep off insects and rodents.	Mazingira safi, uhifadhi bora: Ondoa mahindi yaliyoanguka chini, uchafu, na takataka nyingine sakafuni na maeneo yaliyofichika kila wiki ili kuzuia wadudu na panya.	2nd week September
13	Storage (regularly)	Protect your food: inspect your store regularly; fix falling walls, leaking roofs, avoid dampness from floor or wall.	Linda chakula chako! kagua ghala mara kwa mara; rekebisha kuta na mapaa yanayovuja. Chukua hatua za kudhibiti unyevu.	3rd week of September
14	Storage (regularly)	Protect your food: inspect your store soundings regularly; clear the surrounding and install rodent control measures.	Linda chakulachako! kagua ghala mara kwa mara; Fyeka maeneo yanayozunguka ghala. Chukua hatua za kudhibiti panya na wadudu.	4th week September

Part II: Vegetable production activities

Overview

Activity name:	Africa RISING East and Southern Africa Project and Iles de Paix (Islands of Peace) Partnership in Karatu District, Tanzania
Activity start date:	01 September 2019
Activity end date:	30 September 2020
Name of prime implementing partner:	World Vegetable Center (WorldVeg)
Major counterpart organization (s):	• Iles de Paix (Islands of Peace) • International Livestock Research Institute (ILRI) • International Center for Tropical Agriculture (CIAT) • International Institute of Tropical Agriculture (IITA)
Contact person:	Dr Sognigbe N'Danikou Email: sognigbe.ndanikou@worldveg.org
Implementation team:	• Sognigbe N'Danikou (WorldVeg) • Inviolate Mosha (WorldVeg) • Hassan Mndiga (WorldVeg) • Christopher Mutungi (IITA) • Ben Lukuyu (ILRI) • Job Kihara (CIAT) • Ayesiga Buberua (Iles de Paix)
Geographic coverage (districts, regions):	Karatu District, Arusha Region, Tanzania
Reporting period:	01 March 2020 – 30 September 2020

Executive summary

Implementation of project activities has been delayed in the reporting period due to the Covid-19 outbreak. All the planned field trips by WorldVeg staff had to be suspended from April to end of June 2020, to adhere to safety measures as recommended by officials. During that period, the technical backstopping to farmers was provided through collaboration with the government extension staff posted to Karatu District who visited the trials and met with the farmers to discuss the progress and challenges and provided advice as deemed appropriate.

In the reporting period, WorldVeg supported the beneficiary farmers in eight villages of the first generation, on GAP, keyhole gardening technology, and pest and disease management. Practical

training on GAP was provided to 32 people (56% women), including 27 lead farmers and five extension agents (Figs 1 and 2). A training was also provided to 70 people (47% women), including 64 farmers, on improved nursery management specifically on seedbed preparation, and vegetable seed sowing in nursery beds and trays. The comparison of the performance of the nurseries established following the improved nursery techniques (using GAP) and farmer practices indicated higher quality of the seedlings produced following GAP. Overall, the average investment in the GAP nurseries for the three crops (tomato, African nightshade, and Ethiopian mustard) used in the eight villages was TSh13,546.56 per farmer, versus TSh21,265.16 for farmer practices (Table 1). In these investments, chemical pesticides and watering bills were higher in those nurseries that followed the farmers' practices.

Technical backstopping was provided to IDP for scaling GAPs in Generation 2 villages in Karatu, and for the training of farmers on safe and sustainable vegetable production. A total of 52 participants were trained, (19 male (37%) and 33 females (63%)). These included 34 lead farmers from nine villages, 10 extension officers, one district representative, five IDP staff members, and two interns attached to the KE project (Fig. 14).

A baseline survey was conducted to identify the most common pests and diseases present in the project sites. The results indicated that pest and disease incidence was most important on tomato, compared to the other two crops, i.e., Ethiopian mustard and African nightshade, which are traditional African vegetable species (Table 8).

The data of the baseline household survey conducted in 2019 was analyzed and the report prepared. This baseline survey conducted in Karatu aimed to understand the production of vegetables and the dietary diversity and nutritional status of rural farmers in Karatu District as a way to establish the research and training needs for improved vegetable production systems. A questionnaire was prepared and answered by a total of 487 vegetable farmers. The results indicated that the commonly grown vegetable crops were tomato, onion, African eggplant, Ethiopian mustard, Chinese cabbage, and African nightshade. The main foods consumed by the households were cereals, spices, condiments and beverages, vegetables, oils and fats, sweets, legumes, nuts and seeds, and fruits. Meat products (i.e., poultry, offal, fish, etc.), eggs, milk, and milk products were rarely consumed by many households. Ninety percent of what was consumed was purchased. The average household dietary diversity score (HDDS) was 6.15, which means that, on average, households consumed six food groups over the preceding 24 hours. Intervention households had a higher HDDS (6.33) compared to the control households (5.98) ($P < 0.01$). Sixty-two percent of the farmers knew that vegetables contain nutrients needed for growth and health while 38% were not so aware. Most farmers were not aware of the minimum required daily vegetable intake. About 26% of vegetable farmers perceived vegetable farming to be more risky than cereal production, mainly because of the dry nature of their areas, the lack of reliable markets, and the persistent challenge of pests and diseases. The study recommends the strategic development partners and project stakeholders to design interventions that will provide education especially on the nutritional value of vegetables, improved practices for increased vegetable production, improved health of household members and their communities, and increase household income. The full baseline survey report is attached in Annex 1. This baseline forms part of the impact evaluation of the Africa RISING project in Karatu using the Difference in Differences (DiD) method. The endline surveys are planned for 2021.

WorldVeg actively participated in the *nane-nane* organized by the government in Simiyu during 1–10 August 2020 (Fig. 4). The event provided an opportunity for interested active actors in the agricultural sector to publicize their innovations to a critical mass of targeted end-users specifically the smallholder farmers. About 1000+ (55% male and 45% female) persons including farmers, agribusiness entrepreneurs, exhibitors from different agricultural related sectors, youth groups, and students visited the WorldVeg pavilion.

Achievements

Project Outcome 1: Productivity, diversity, and income of crop-livestock systems in selected agro-ecologies enhanced under climate variability						
Output 1.1: Demand-driven, climate-smart, integrated crop-livestock research products (contextualized technologies) for improved productivity, diversified diets, and higher income validated for specific typologies in target agroecologies [and scaled in Outcomes 4 and 5].						
Activity	**Planned Sub-activities**	**Planned deliverables**	**Achievements towards deliverables during the reporting period (refer to data – tables, figures, plates under Section D)**	**Deviation from planned milestone and explanation**	**Custom indicators/ deliverables this period (e.g., reports, publications…)**	**Deviation from custom indicator targets and explanation**
1.1.2 Evaluate and implement pathways that are effective at improving access to seeds and clonal materials of modern varieties of legumes, cereals, vegetables, forages and livestock.	1.1.2.1 Assessment of the benefits of management technologies on performance of improved vegetable varieties (Season 2)	1.1.2.1: Season 2 data on impact of improved management practices on vegetable production collected.	• ToT on safe and sustainable vegetable production conducted. • ToT on best nursery practices • 64 demo trials established, and biophysical data collection is ongoing	The 2020 data collection not yet complete. Experiment establishment and data collection were delayed due to a late project start in February 2020 and then due to the Covid-19 outbreak.	Meeting and training reports (see supplementary materials) available at: • http://africa-rising-wiki.net/File:WvG-IdPToT-March2020.docx • http://africa-rising-wiki.net/File:WorldVegdemomngttrainingdocx.docx • http://africa-rising-wiki.net/File:WVegToT.docx • http://africa-rising-wiki.net/File:WVegdemomonitoring.docx	Data not yet reported in dataverse due to the delays caused mainly by the Covid-19 outbreak.
		1.1.2.2: One Farmer field	Could not be organized due to Covid-19outbreak.	Delayed because of the outbreak.		The farmer field day could not be organized due to Covid-19.

		days conducted				
		1.1.2.3: One draft paper on the impact of improved management practices.	Adoption of sustainable agricultural technologies for vegetable production in rural Tanzania: trade-offs, complementarities and diffusion". Revised version under review in the International Journal of Agriculture and Sustainability.		Draft manuscript	
		1.1.2.4: One success story published	One success story published and can be accessed at **Link 1**		Success story online.	

Project Outcome 3: Food and feed safety, nutritional quality, and income security of target smallholder families improved equitably (within households)						
Output 3.1: Demand-driven research products to reduce postharvest losses and improve food quality and safety piloted in target areas [and scaled in Outcome 5]						
Activity	**Planned Sub-activities**	**Planned deliverables**	**Achievements towards deliverables during the reporting period (refer to data – tables, figures, plates under Section D)**	**Deviation from planned milestone and explanation**	**Custom indicators/ deliverables this period (e.g. reports, publications…)**	**Deviation from custom indicator targets and explanation**
Activity 3.1.1: Conduct packaging and delivery of postharvest technologies	3.1.1.1 Assess the impact of nutritional messaging on farmers nutritional	3.1.1.1: Sensitization meetings in the new villages.	Sensitization conducted in all the farmer groups in the first 8 intervention villages, and in the 8 new villages. The latter were surveyed in 2019	Completed in the previous reporting period.	Meeting and training reports, available at http://africa-rising-wiki.net/File:WvG-IdPfarmerfeedbackmeetings-March2020.docx	None in the reporting period.

through community and development partnerships with iterative review, refining, and follow-up.	knowledge, attitude and practices, and household nutrition status, in partnership with Islands of Peace.		baselines as control villages for the impact evaluation.			
		3.1.1.2: Baseline survey report (covering SI domains)	Baseline survey was conducted among 8 intervention villages and 8 control villages. The baseline data is analysed and the report is completed.	Baseline report is finalized and attached in Annex 1. The delivery of the baseline report in March was not possible due to changes in project staffing	Baseline report.	Deviation – late delivery. The baseline report is now delivered.
		3.1.1.3: 350 farmers trained on nutrition messages	Delayed—due to Covid-19 outbreak		Nutrition training report. Not in the reporting period	
		3.1.1.4: At least two new vegetable-based recipes developed and promoted (excluding those previously developed by WorldVeg).	Delayed—due to Covid-19 outbreak.		Recipe report. Not in the reporting period.	

		3.1.1.5: At least four food kiosks/ restaurants incorporate one or more vegetable recipes in their food menu.	Delayed—due to Covid-19 outbreak.		Recipe report. Not in the reporting period.	
		3.1.1.6. At least 1 success/blog story	One success story published and can be accessed at **Link 1**.		Success story online.	
		3.1.1.7. Partners include nutrition education in their existing /new programs	IDP and RECODA have included the nutrition education materials developed in their ongoing programs.		Technical report. Not in the reporting period.	

Project Outcome 5: Delivery and uptake of SI innovations through building functional partnerships among research and development institutions enhanced.						
Output 5.2: Improved mechanisms for effective linkages and strategic partnerships with public, private, and other initiatives for the release, diffusion, and adoption of validated technologies established.						
Activity	**Planned Sub-activities**	**Planned deliverables**	**Achievements towards deliverables during the reporting period (refer to data – tables, figures, plates under Section D)**	**Deviation from planned milestone and explanation**	**Custom indicators/ deliverables this period (e.g., reports, publications…)**	**Deviation from custom indicator targets and explanation**
5.2.2: Map and assess relevant stakeholders to establish dialogue for the exploration of mutual synergies for scaling delivery of validated technologies.	5.2.2.1: Partnership with Iles de Paix (IDP) for increasing the adoption of improved vegetable varieties and good agricultural practices (GAP) in vegetable production in 9 new villages in Karatu.	5.2.2.1: Provide technical backstopping to IDP to efficiently scale the technologies in 9 villages.	34 lead farmer trainers, 10 extension officers, 5 IDP staff, 2 intern students, and 1 district representative were trained on sustainable vegetable production. Participants were trained on the following: • Principles of sustainable vegetable production • Good quality seed, improved nursery practices, and their management • Organic farming, natural pesticides, and IPM • Production and utilization of African traditional vegetables.	None in the reporting period	Meeting and training reports, available at - http://africa-rising-wiki.net/File:Wvegmonitoringbackstopping.docx	None in the reporting period

Analysis and interpretation of achievements

Sub-activity 1.1.2.1: Assessment of the benefits of management technologies on performance of improved vegetable varieties (Season 2)

An experiment which compared the effectiveness of improved nursery practices (using GAP) compared to farmer practices indicated higher quality of the seedlings produced following GAP. Overall, the average investment in the GAP nurseries for the three crops (tomato, African nightshade, and Ethiopian mustard) was TSh13,546.56, while each control farmer spent around TSh21,265.16 (Table 1).

Table 8. Average nursery production costs following the GAP and farmer practices in Karatu. (1USD = approx. TSh2300). GAP = good agricultural practices, FP = farmer practice.

Village	Cost following GAP (TSh)	Cost following FP (TSh)
Buger	13,172.50	22,078.75
Chemchem	14,825.00	20,437.50
Gyekrum Lambo	13,693.75	24,705.00
Rhotia kainam	12,737.50	19,641.63
Slahhamo	11,560.00	19,647.00
Bashay	14,306.25	19,237.63
Kambi ya Simba	14,690.00	16,921.25
Changarawe	13,387.50	27,452.50
Average per village	**13,546.56**	**21,265.16**

The baseline insect and pest survey at the onset of the demo trials indicated higher insect incidence on tomato followed by African nightshade (Table 9). Aphids were more common on Ethiopian mustard and African nightshade, while mites were recorded only on the Solanaceae crops (tomato and nightshade). Leaf miners were only recorded on tomato. On average, disease prevalence was higher on tomato (28%) and Ethiopian mustard (25%) compared to African nightshade (6%). Early blight mainly occurred on tomato, while virus-like symptoms were essentially recorded on Ethiopian mustard and African nightshade.

Table 9. Status of insect pests and diseases, and beneficial insects at the onset of demo trials in Karatu District.

Farm No.	Crop	Variety/ cultivar	Plant age (months)	Intercropped with	Tot. plants assessed	Diseases					Insects			
						Disease name	Mean disease severity*	No. of infected plants	Disease prevalence (%)**	No. of healthy plants	Insect pest	Beneficial insect	Total insects in the field	Insects/ plant
1	Tomato	Tanya	2	No	10	Early blight	2.7	6	60	4	Liriomyza spp.		8	0.8
2	Ethiopian Mustard	Rungwe	1.5	Nightshade, Chinese mustard, and cabbage	10	Virus-like	4	1	10	9	Aphids		16	1.6
2	Tomato	Tanya	2	Monocropping	10			0	0	10	Liriomyza spp.		53	5.3
3	Tomato	Tanya	2.5	Monocropping	10	Early blight	2.9	7	70	3	Liriomyza spp.		8	0.8
4	Nightshade	Nduruma	2	Monocropping	10			0	0	10	Aphids		4	0.4
5	Nightshade	Nduruma	2.5	Monocropping	10	Virus-like	5	4	0	6	Red spider mites		35	3.5
5	Ethiopian Mustard	Rungwe	2	Monocropping	10	Virus-like	4	2	0	8	Aphids		4	0.4
6	Tomato	Tanya	2	Monocropping	10	Virus-like	2.1	7	0	3	Aphids		45	4.5
6	Tomato	Tanya	2	Monocropping	10			0	0	10	Red spider mites		7	0.7
7	Nightshade	Nduruma	2	Monocropping	10			0	0	10		Ladbird beetles	5	0.5
7	Tomato	Tanya	2.5	Monocropping	10	Early blight	3.3	4	40	6			0	0
7	Ethiopian Mustard	Rungwe	2	Monocropping	10	Virus-like	3.6	8	80	2			0	0
8	Ethiopian Mustard	Rungwe	2	Monocropping	10	Virus-like	3.8	5	50	5			0	0
9	Nightshade	Nduruma	1.5	Monocropping	10	Virus-like	3	2	20	8	Red spider mites		30	3
9	Ethiopian Mustard	Rungwe	2	Monocropping	10	Virus – mottled leaves	2	1	10	9	Aphids		17	1.7
10	Nightshade	Nduruma	2	Monocropping	10	Virus – mottled leaves	2.5	2	20	8			0	0
11	Ethiopian Mustard	Rungwe	2.5	Monocropping	10	Virus-like	4	3	30	7	Aphids		2	0.2

Farm No.	Crop	Variety/ cultivar	Plant age (months)	Intercropped with	Tot. plants assessed	Diseases					Insects			
						Disease name	Mean disease severity*	No. of infected plants	Disease prevalence (%)**	No. of healthy plants	Insect pest	Beneficial insect	Total insects in the field	Insects/ plant
12	Nightshade	Nduruma	2	Monocropping	10			0	0	10	Aphids		19	1.9
11	Ethiopian mustard	Nduruma	2	Monocropping	10	Virus-like	2	2	20	8	Aphids		4	0.4
13	Ethiopian mustard	Rungwe	2	Monocropping	10			0	0	10	Aphids		22	2.2

***Disease severity scoring scale**

Scale	Description
1	Unaffected or no symptoms observed (visually healthy)
2	Mild symptoms: 1–25% of the assessed plant or plant part is symptomatic
3	Pronounced symptoms: 26–50% of the assessed plant or plant part is symptomatic
4	Severe symptoms: 51–75% of the assessed plant or plant part is symptomatic
5	Very severe symptoms with defoliation or plant death: 76–100% of the assessed plant or plant part is symptomatic

Disease severity is an estimate of the extent (intensity) of symptoms (damage) caused by a disease to a plant/plant part.

****Disease prevalence is the percentage of the diseased plants to the total number of plants assessed**

$$= \frac{\text{The total number of diseased plants}}{\text{The total number of plants assessed}} \times 100\%$$

Sub-activity 3.1.1.1: Assess the impact of nutritional messaging on farmers nutritional knowledge, attitude and practices, and household nutrition status, in partnership with Iles de Paix

Nothing to report for the reporting period.

Sub-activity 5.2.2.1: Partnership with Iles de Paix (IDP) for increasing the adoption of improved vegetable varieties and good agricultural practices (GAP) in vegetable production in nine new villages in Karatu

Nothing to report for the reporting period.

Summary of the innovations' SI potential (tabulated as in the following section or given as radar charts)

None available in the reporting period.

Capacity building during the reporting period

Title of training	Venue	Dates	Trainee category	Number of trainees	Percent women
Training on improved nursery management specifically on seedbed preparation, vegetable seed sowing in nursery beds and trays, in 1st generation villages	Karatu	6–11 July 2020	Lead farmer trainers and government extension agents	70	47%
Training of Trainers course (ToT) on sustainable vegetable production in the 2nd generation villages—partnership with IDP	Karatu	18–22 August 2020	Farmers group representatives, IDP technical staff, and government extension agents	52	63%
Train extension agents and farmers on data collection in demo plots	Karatu	31 Aug–5 Sept 2020	Farmers group representatives, and government extension agents	32	56%

Challenges and measures taken

Project activities have been delayed as a result of the Covid-19 outbreak. In addition, more than 40% of the nursery and demo trials (26 out of 64) were flooded in June 2020. For instance, 95% of tomato seedlings could not survive the flooding. New nurseries and experiments were re-established in August 2020 to complete the second season of the GAP trials. All these have delayed many deliverables. Thus, a no-cost extension request was submitted to IITA to be able to finalize the activities, which were suspended due to unforeseen events.

Partnership/linkages with other projects

- Africa RISING is partnering with the Kilimo Endelevu (KE) project by Iles de Paix (IDP) to scale best-bet technologies in Karatu. Other partners are Mtandao wa Vikundi vya Wakulima Tanzania (MVIWATA) and Research Community and Organizational Development Associates (RECODA).

- WorldVeg has linkages with Mboga na Matunda (MnM) project and TAHA in Zanzibar and Arusha. These projects have benefited from nutrition materials and scaling technologies validated during Africa RISING Phase 1 in Zanzibar.

Lessons learned

The Covid-19 outbreak is showing that current production and food systems are still vulnerable to external shocks. This has also disrupted the social networks and is fragilizing collective actions by farmers to improve their knowledge and market access.

Monitoring and Evaluation

Feed the Future indicators

The FtF indicators have been submitted.

Success stories

One success story was published in March 2020 and is accessible at **Link 1.**

Annexes

Figure 12. Trained farmers sowing seeds in plastic trays (left); identification of pests on a farmer's field (right). Photo: Inviolate Dominick/World Vegetable Center.

Figure 13. Farmers presenting their vegetable keyhole gardens, which they constructed after receiving training facilitated by WorldVeg in March 2020. Photo: Inviolate Dominick/World Vegetable Center.

Figure 14. Training on pests & diseases in Rhatia Kainam village (top left), preparation of nursery bed (top right), preparation of natural pesticides (bottom left), and explanation of nutrition benefits of vegetables (bottom right). Photo credit: Inviolate Dominick/WorldVeg.

Figure 15. WorldVeg staff explaining the importance of vegetables as a source of vitamins to combat hidden hunger and recipe preparation methods to a youth group at the National Agricultural Exhibition at Simiyu, Tanzania. Photo credit: Inviolate Dominick/WorldVeg.