Review Article

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Orange-fleshed sweetpotato: Strategies and lessons learned for achieving food security and health at scale in Sub-Saharan Africa

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Abstract: Against a worsening backdrop of climate stress and population growth, drought-resistant, highly adaptable, nutritious orange-fleshed sweetpotato (OFSP) stands out as a sustainable food crop that supports household resiliency, food security, and health. Recognized as one of the cheapest sources of vitamin A (VA), OFSP holds promise as a food-based approach to combat VA deficiency, a significant public health concern in sub-Saharan Africa. Because the dominant white-fleshed varieties have no beta-carotene, research initiated in the mid-1990s set out to adapt, develop, and promote VA-rich OFSP as a more nutritious alternative to non-OFSP types. Multisectorial strategies that integrate agriculture with health or education sectors hold promise as effective strategies to ensure OFSP reaches and meets the needs of those populations at greatest risk of VA deficiency – pregnant and lactating women, infants, and children. In this article, we share experiences, findings, implementation challenges, and lessons learned from four integrated programs in Kenya, Tanzania, Mozambique, and Ethiopia that aimed to improve the nutrition and health of women and children with production and promotion of OFSP. Across these projects, households significantly increased OFSP production. In all but one, changes in OFSP production were accompanied by improved food security and maternal and child diets.

Keywords: orange-fleshed sweetpotato, multi-sectoral, nutrition, health, complementary feeding, vitamin A intakes

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1 Introduction

Adequate nutrition from conception through the first 2 years of life is critical for ensuring long-term health, development, and well-being [1–3]. Yet, despite the well-established role of adequate nutrition during this 1,000-day period, more than one-third of children in sub-Saharan Africa (SSA) are chronically malnourished [4]. As one of the most prevalent micronutrient deficiencies globally, vitamin A deficiency (VAD), defined as serum retinol less than 0.7 μmol/L, remains a leading cause of preventable blindness among young children and contributes substantially to mortality from the infectious disease [5,6]. Biannual high-dose supplementation programs are the intervention of choice in many settings where VAD is a public health concern [6,7], with proven efficacy for prevention of all-cause mortality among younger than 5-years olds in high burden settings [8] and infant mortality in areas of moderate to severe maternal VAD [9]. Increasingly, however, researchers and policy makers question the effectiveness, safety, and sustainability of this approach [10,11], especially given the scaling back of polio vaccination campaigns, the primary delivery platform for vitamin A supplementation (VAS) in much of SSA [12]. Many countries are developing large-scale vitamin A (VA) fortification of sugar or oils to address VAD [12–14]. However, disparities in access, especially among rural, vulnerable populations have been noted with fortification strategies [15]. As a result, interest in food and agriculture strategies to mitigate VAD has risen sharply over the past several years.

Food-based approaches that promote the production and consumption of micronutrient-rich crops are seen as efficacious and sustainable strategies to address not only VAD but also household food insecurity. They are especially important for rural areas where the reach of other VA strategies such as supplementation and food fortification often have lower reach. Orange-fleshed sweetpotato (OFSP), as a staple crop, holds a unique place in food-based approaches to address micronutrient deficiencies.

The efficacy of OFSP to combat VAD is based on the high concentration of beta-carotene, a precursor of VA, in roots and leaves with high levels of bioaccessibility in local diets [16]. The more intense the orange, the higher the beta-carotene content; indeed, just 100–125 g of OFSP meets the daily VA needs of a child younger than 5 years.

The benefits of OFSP go beyond VA, and these additional benefits contribute to its acceptability and effectiveness. Unlike other VA-rich vegetables and fruits, OFSP provides much-needed energy; unlike animal sources of VA or fortified foods, OFSP is financially accessible to poor, rural households. The agronomic properties of OFSP further its appeal – OFSP is less demanding on water and labor inputs than most staple grains and improved OFSP varieties compete agronomically with yields of yellow and white varieties, with many being bred to mature earlier, a plus in land-constrained areas. As well, roots may be harvested piece-meal and/or stored for extended periods. The leaves, in addition to the roots, may be used for food or animal fodder, thus increasing the utilization of the total plant. The leaves are an excellent source of lutein, which aids in preventing macular (eye) degeneration [16–18].

2 History of OFSP in SSA

Sweetpotato (*Ipomoea batatas*, L.) came from the Americas to the African continent in the 1500s [19]. Most Africans believe it is indigenous to the continent, and it is often referred to as the local potato, whereas potato (*Solanum tuberosum*) is associated with colonial times, as it was introduced at the beginning of the twentieth century. For whatever reason, the dominant sweetpotato varieties in SSA are white-fleshed, containing no provitamin A, or yellow-fleshed, with limited to no beta-carotene. Recognizing insufficient intakes of VA in the diets of young children, the International Potato Center (CIP) began selecting for competitive OFSP varieties in the mid-1990s, drawing on improved varieties from other parts of the world or the few local OFSP landraces found on the continent. While widely accepted by young children, most of these varieties were too watery (a reflection of low dry matter) for adults, who prefer mealy (i.e., high dry matter) types. In 2005, CIP and its partners began a program to *Breed in Africa for Africa*, which permitted the development of new OFSP varieties with improved taste and better adapted to different agro-ecologies across SSA. From 2003 to 2009, CIP and partners generated substantial evidence in Mozambique and Uganda, which integrated agriculture-community level nutrition education positively impacted VA intakes and status among children [20–26]. Since 2009, 104 orange-fleshed varieties have been released by 16 SSA countries, of which 62 were new OFSP varieties bred in 13 SSA nations.

2.1 Context for the case study approach: The sweetpotato for profit and health initiative

By 2010, there was solid evidence for the efficacy and effectiveness of OFSP as a key entry point to improve VA intakes of women and young children. This evidence base led to a substantial investment by the Bill & Melinda Gates Foundation in the research program "Sweetpotato Action for Security and Health in Africa (SASHA)". Led by CIP, the aim of this program was to address the remaining bottlenecks to untapping the full potential of sweetpotato. Recognizing that research only makes a difference when it is delivered to the end users, CIP adopted a multipartner, multidonor approach and concurrently launched the Sweetpotato for Profit and Health Initiative (SPHI). The SPHI brought together partners committed to the SPHI's[1] goal, namely to improve the lives of 10 million SSA households in 17 countries by 2020 through access to improved varieties of sweetpotato and their diversified use. Through four community of practice working groups, SPHI-affiliates (or some other words) share dissemination models and learnings to promote best practices.[2] As of September 2019, 6.2 million households had been reached in 15 SSA countries.

The case studies described in this article illustrate the successes, challenges, and lessons learned bringing an integrated OFSP strategy to scale. Descriptions of each project, their approaches to social and behavior change (SBC), and key outcomes are briefly summarized in Tables 1–3. These projects represent efforts undertaken since the launch of the SPHI: (1) Mama SASHA, a research study under the SASHA project; (2) Viable Sweetpotato Technologies in Africa (VISTA)-Tanzania, a dissemination

1 As of September 2018, SPHI members include five donors, three CGIAR-related research for development organizations, two research universities, four international non-governmental organizations, one African regional research coordination association, two regional non-governmental organizations, and one private sector food technology company.

2 Each of these four groups meet annually: breeding and genomics; seed systems and crop management; marketing, processing, and utilization; and monitoring, learning, and evaluation.

project with a strong monitoring and evaluation system, funded by USAID's Feed the Future; (3) Nutritious Foods for Niassa, a dissemination project with a subset of recipients receiving community-level nutrition education, funded by Irish Aid; and (4) Quality Diets for Better Health, a dissemination project with a significant research component, funded by the European Union. The diverse range of settings and designs will demonstrate how formative and iterative operational research can build on knowledge gained in prior research endeavors, facilitating adaption to local setting and implementation success.

2.2 Project 1: Mama SASHA, Kenya

The Mama SASHA Project, a 5-year proof-of-concept project, began in 2010 and explicitly integrated agriculture and community nutrition interventions into antenatal care (ANC) and postnatal care (PNC) public health services in two counties in western Kenya. Its goal was to improve maternal and young child diets, specifically VA intakes, through an integrated health, nutrition, and OFSP delivery strategy. At the time of the project, there existed poor coordination and limited linkages between the agriculture and health sectors in Kenya [27,28]. Thirty-seven percent of rural children younger than 5 years were stunted, and only 23% of rural children in this age range received VAS in the previous 6 months [29]. Of children 6–23 months, fewer than half consumed VA-rich fruits and vegetables in the previous 24 h and only 37% received a minimally acceptable diet. In western Kenya, the geographic focus of Mama SASHA, 23% of children aged 6–59 months were VAD, and coverage with VAS through the health system was low between 15 and 40% depending on the source [30].[3]

To meet its goal, the team set out three broad objectives: (1) strengthen existing information, education, and communication materials and methods for supporting sustainable OFSP production and consumption at health facility and community levels; (2) improve the evidence based on nutrition and health impacts and sustainability of an integrated delivery system for OFSP; and (3) understand the costs and benefits of linking an OFSP-focused agricultural intervention to a nutrition promotion and health service–delivery system serving pregnant women. Foundational to objectives 2 and 3 was improved knowledge and practices of health workers, agricultural extension agents, and community members in regard to the production and consumption of OFSP and VA-rich foods.

Figure 1 depicts the activities in Mama SASHA intervention communities. Briefly, these included the training of farmers as vine multipliers to produce clean planting materials; enhanced nutrition education provided to pregnant women during ANC visits; provision of vouchers during ANC to pregnant women (once per trimester and at the first postpartum visit) for two[4] varieties of OFSP; redemption of vouchers from vine multipliers located near their clinic; and community-based pregnant and lactating mothers' clubs. These activities were complemented with community sensitization and training of extension officers to support households with OFSP planting and crop management. No pregnant and lactating mothers' clubs, vouchers, or agricultural support for the production of OFSP was provided to controls during the project period; rather, OFSP promotion, including vine distribution in control communities, occurred after the project endline. We noted some minimal contamination of control communities with OFSP; however, uptake of vines in these communities was minimal prior endline. A more detailed description of the implementation, monitoring, and evaluation strategy can be found elsewhere [31].

Mama SASHA reached a total of 5,480 individual women through 215 mothers' clubs and 4,605 women with 7,159 vouchers, surpassing the originally planned target of 900 women. Of those, 4,464 voucher pairs were redeemed by 3,281 women (redemption rate of 62%). Reasons for not redeeming the maximum allowable included (1) coming to the first ANC visit after the first trimester, (2) the vines received at earlier visits were sufficient for household's available land, or (3) because they received vouchers during periods of insufficient rainfall and did not want to redeem them. The program cost per direct beneficiary, excluding research and evaluation costs, was US $155 [32]. However, accounting for repeated interactions of beneficiaries via facility visits, pregnant women's clubs, and interactions with vine multipliers dropped the cost to US $30 per contact.

3 UNICEF and WHO define high VAS coverage as ≥80% (https://data.unicef.org/resources/vitamin-a-coverage/).

4 Kabode (SPK004/6/6) and Vita (SPK004/6) contain 9655 and 7460 mg β-carotene/100 g raw, fresh weight, respectively. With an expected average loss of 20% of beta-carotene is loss during cooking, 100 g of steamed Kabode would have 643 retinol (vitamin A) activity equivalents and steamed Vita would have 497 RAEs. Note that a young child of 1–3 years of age requires 300 RAE daily and children of 4–8 years of age need 400 RAE daily.

Table 1: Case studies of projects including orange fleshed sweetpotato (OFSP) as part of this review

Project	Location	Duration	Reach	Key nutrition and health findings
Mama SASHA	Bungoma and Busia counties, Kenya	2010–2015	5,480 women and their infants	Increased production and consumption of vitamin A (VA)-rich foods and VA intakes by mothers and children. Improved VA status of mothers and reduced stunting among children
VISTA Tanzania	Mbeya, Iringa, and Morogoro districts, Tanzania	Oct 2014–Dec 2017	21,876 primary caregivers of children under 5 years from smallholder farm households received social behavior change communication through monthly nutrition group meetings	Increased production and consumption of nutritious OFSP; significantly increased caregiver knowledge on vitamin A, nutrition, health seeking, and childcare; and significantly improved dietary vitamin A intake, dietary diversity, and food security among beneficiary households
Nutritious Diets for Niassa	Niassa district, Mozambique	Nov 2012–Dec 2016	28,044 households reached with OFSP vines and 18,784 with nutrition education	Small improvements in child diet diversity scores. Average consumption of OFSP among children under 5 years and adults was 3.1 days a week, compared to 1.2 days a week for control children, indicating spillover. Average fruit consumption also significantly higher among intervention than control children
Quality Diets for Better Health	Sidama and Gedeo zones SNNPR, Ethiopia	Jan 2017–ongoing	15,000 direct beneficiary rural households and 60,000 urban consumers	Nutrition training combined with the Healthy Baby Toolkit and OFSP contribute to significant improvement in mother and young child dietary diversity

Table 2: Impacts of Mama SASHA as reported by participants and frontline health and agriculture extension agents

Participants	• Increased household food security • OFSP consumable at any meal • Perceived nutritional value for young infants (6–9 months)
Vine multipliers	• Financial benefit • Recognition from community • Satisfaction with work
Nurses	• Increased ANC attendance for both 1st and subsequent visits • Increased male support during ANC visits
Agricultural agents	• Meeting targets for extension support • Noted nutritional benefits for the community

Table 3: Mechanisms for nutrition, health, and agriculture integration in the Mama SASHA project

Integration meeting	Frequency	Types of participants
Feedback meeting	Monthly	Implementers on the ground: CHW, ANC nurses, vine multiplier farmers, agriculture extension officers, local NGO partners
Network meeting (division level)	Bi-annually	Higher level community health and agriculture actors + implementers on the ground and all NGO partners
Partner meeting	Quarterly	CIP Project Director, CIP agronomist, health systems coordinator, all local NGO partners, Kenya Agriculture Research Institute (KARI) representative, research partners
Stakeholder meeting	Annually	District and provincial stakeholders from Ministries of Agriculture and Health, donors, research partners

The development and evaluation of the Mama SASHA project utilized a multipronged approach – formative work comprised an agronomic and consumer acceptance study of the selected varieties followed by a pilot phase in a contextually similar site geographically proximal to the project sites. Program implementation including community mobilization of pregnant women and voucher distribution in intervention communities began in 2011 following the pilot phase and a baseline survey and continued to December 2013. An endline (repeat cross-sectional) survey was conducted with >1,500 mother–child pairs in intervention and control communities in spring 2014. Also, a nested cohort study followed up 505 women from early pregnancy through 9 months postpartum to assess impacts on maternal and early infant nutrition. Detailed cost data were collected over the entirety of the project.

Among pregnant and lactating women in intervention communities, the project significantly increased OFSP production and consumption and VA intakes [33]. The risk of anemia was lower in late pregnancy among intervention women, while VA status, measured as serum retinol-binding protein, significantly improved in the postpartum period. Maternal wasting in the postpartum period was significantly attenuated among intervention compared to control women. Among children, the intervention increased meal frequency, dietary diversity, consumption of OFSP and VA-rich foods, and VA intakes. There were no impacts on VA status, measured as serum retinol-binding protein, or growth by 9 months postpartum in the cohort study; however, the repeat cross-sectional evaluation noted that those who participated in all program activities (ANC, voucher redemption, and mothers' clubs) had significantly reduced odds of stunting and VAD and improved VA status, as measured by serum retinol-binding protein through blood spots. In total, 55 disability-adjusted life years (DALYs) were averted per year, mostly attributable to improvements in child stunting and maternal anemia. The incremental cost-effectiveness ratio (ICER) was US $2,632 per DALY averted [34]. The Kenyan gross domestic product (GDP) at the time of the program was $994 per person; thus, the ICER fell within the WHO guidelines for cost-effectiveness. Beyond DALYs, additional benefits that were not able to be quantified via ICER estimation included improved sweetpotato yields, enhanced household food security, improved extension services, and increased nutrition knowledge of mothers (Table 1).

Several elements of success for planning, implementing, and evaluating are noted. These included systemic assessment and iterative planning at the beginning and throughout the life of the project. Iterative planning included the collaborative development of the program impact pathway that was revisited annually at least, for

Figure 1: Activities in the Mama SASHA orange flesh sweetpotato promotion proof of concept project in western Kenya. Mama SASHA project activities included (1) community engagement and mobilization events motivated participation in project activities and raised awareness about the importance of antenatal care (ANC), the role of vitamin A (VA) in health, and OFSP as a climate-smart, nutritious crop; (2) trained nurses and community health workers (CHWs) provided pregnant women attending antenatal care (ANC)-enhanced nutrition education including the importance of VA for maternal and child health and OFSP as a VA-rich food. (3) At ANC visits, women also received vouchers (once per trimester and at the first postpartum visit), redeemable for 100 vine cuttings each of "Kabode" and "Vita" varieties of OFSP. (4) Women redeemed these from the vine multipliers located near the health clinics. VMs farmers were selected and trained to produce clean planting materials, provide vines to community members, and provide OFSP production support; (5) women in intervention communities were linked with community-based mothers' clubs where CHWs conducted monthly dialogue and demonstration sessions on nutrition and health, including preparation of VA-rich foods and OFSP for complementary feeding and household diets; and (6) trained agriculture extension officers supported participating households with agronomic advice including OFSP planting and crop management.

benchmarking and fidelity and updated as needed to accommodate changing field and program realities. The team demonstrated a commitment to learning through monitoring and result-driven management, regularly reviewing agronomic and health-related monitoring data to identify areas for modification. Routine monitoring was complemented by operations research and quarterly environmental scans.

Operations research was conducted twice during the project lifetime; once shortly after the pilot was completed in 2010 and again, at the midline of the full project in 2012. The first round of operations research provided insights critical to project design and changes needed before larger-scale implementation and effectiveness testing. Key findings included the need to (1) enhance engagement of men and mothers-in-law in program activities so that women were supported to participate in ANC and mothers clubs as well as grow and prepare OFSP, (2) strengthen health and extension worker training curriculum and establish routine refresher training; (3) standardize service provision of vouchers, and agronomic and nutrition education; and (4) enhance education materials to be more appealing for the local context, easy to use by frontline workers and ensure key messages are clear and coherent. The second round of operations research confirmed whether the identified design changes had been effectively implemented and provided qualitative evidence on program impacts as noted by frontline workers and participants (Table 2).

Others have noted that the ability of community-based agriculture projects to improve nutrition, health, and development outcomes greatly depends on the intensity with which targeted households participate in program activities [35]. Yet understanding what factors drive participation is rarely a focus of monitoring. To that end, we conducted two rounds of qualitative operations research, once during the pilot phase and once at project midterm, routine monitoring of participation, and included questions in evaluation surveys to assess barriers and facilitators to participation. This approach allowed us to examine drivers

of participation in an iterative fashion and in greater depth; we were able to rapidly and flexibly identify and respond to factors influencing participation. For example, a core component of implementation was the utilization of community-selected CHWs to mobilize participants, to lead community-based mother groups, and support education and voucher distribution at facilities. Through operations research, we learned that CHWs not only carried out routine health promotion activities but also assisted women to redeem their vouchers for vines and served as a valuable resource to support women in all aspects of recommended practice. CHWs received a small transportation stipend from the government but no salary. However, mid-way through the project period, the government reduced the transportation stipend by half. This reduction significantly impacted the level of engagement that CHWs could provide to the project and hence the degree to which women were motivated. The project responded by sourcing funds to top up the stipend, but CHW motivation and ultimately participant engagement remained lower than before the cuts. As a result, respondents in intervention communities who gave birth after the CHW's stipends were reduced were less likely to participate fully in project activities [36]. In this case, participation in community-based nutrition-focused project was sensitive to the promotional and health education role played by CHWs. Through routine and in-depth monitoring and operations research, we were able to document the importance of CHW incentives to motivate participants.

We also noted that households with higher transaction costs for participation (i.e., they were farther from clinics and/or vine multiplier farms) had lower participation, while those with greater wealth were more likely to participate. It is possible that the participants endowed with land and other resources were better able to spend the time and effort required for full participation [36]. Such resources may include the labor to grow and maintain sweetpotato or perform household chores, access to transportation to visit the health facilities and vine multiplier farms and pay fees for some services at the health facility. These findings lend strong support to the need to ensure that programs are designed in such a way that they do not further exacerbate wealth disparities.

A well-defined organizational strategy that included clear management, research, and implementation roles and responsibilities for partners, as well as effective use of regular planning meetings and tools supported efficient program management. Organizational management and result-based monitoring included the use and annual updating of a well-vetted log frame to track activities, outputs and milestones, quarterly partner meetings, annual work plan meeting, semi-annual and annual donor reporting promoted continual communication, milestone assessment, problem solving, and planning. To facilitate effective organizational management through the life of the project, the team developed a communication strategy for all implementing partners that included partnership health checkups administered and were reviewed annually. Finally, a key ingredient for success was the sustained and intentional integration of nutrition, health, and agriculture sectors throughout the life of the project, mechanisms for which are outlined in Table 3.

2.3 Project 2: VISTA, Tanzania

In Tanzania, more than one-third (33%) of children aged 6–59 months and 37% of women aged 15–49 years are estimated to be VAD [37] with pregnant women having a higher prevalence (39%). The prevalence of stunting, underweight, and wasting among children aged 0–59 months is 34, 14, and 5%, respectively [37]. At the global level, the global hunger index for Tanzania in 2017 was 28.8, placing it at 97 among 119 countries [38]. Given the important role of agriculture as the main source of both food and income for smallholder farming households in Tanzania, nutrition-sensitive agricultural development as a multisectoral approach is imperative for addressing poor child malnutrition in particular and improved household feeding in general.

The Feed the Future Viable Sweetpotato Technologies in Africa (VISTA) Tanzania project, funded by the United States Agency for International Development (USAID) – Tanzania, was a 3-year initiative executed by the CIP and its partners in Tanzania from October 2014 to December 2017. The overall goal of the VISTA-Tanzania project was to improve dietary diversity, food security, and incomes in Tanzania, especially among farmer HH with children younger than 5 years. The aims were to extend the production, consumption, and marketing of OFSP products among 21,000 smallholder farmers and engage at least 20 medium-scale farmers in rural communities in 7 districts in Mbeya, Iringa, and Morogoro regions. Sweetpotato is a staple crop in these regions, produced mainly for home consumption; roots are consumed boiled, roasted, or deep fried. However, sweetpotato leaves are also consumed as a common green leafy vegetable and are available in both rural and urban markets.

Briefly, VISTA-Tanzania used agriculture extension officers from the seven intervention districts to select eligible households from villages that traditionally grow sweetpotato. From each district, about 25 villages were

selected, and approximately 3,000 HH that met the inclusion criteria were included as project beneficiaries. The project included a start-up diagnostic phase, an inception phase, and an implementation phase beginning in mid-2015, with recurrent activities from June 2015 through August 2017. A diagnostic phase was undertaken during the first 6 months during which time rapid rural appraisals were conducted to identify locations, technologies, stakeholders, partners, and varieties of OFSP available in the proposed project intervention districts [39–41]. This period allowed for partner identification, clarification of roles and responsibilities, work plans and budgets, as well as the co-creation of the intervention design, implementation, and monitoring plan.

Based on lessons learned from the Mama SASHA intervention [31,32,34,42] and the VISTA baseline and formative assessments, we applied the following approach in the scaling of the VISTA intervention in Tanzania. The project selected and trained CHWs from each of the intervention villages in the district in nutrition education and counseling as well as appropriate practices on maternal, infant, and young child feeding during the first 1,000 days of a baby's life. Trained CHWs established and ran community-level pregnant and breastfeeding women's clubs with monthly meetings attended by pregnant women and primary caregivers of children younger than 5 years. Enhanced nutrition education materials (Table 4) were prepared as job aids including a desk-sized (A3 format) set of counseling cards with eight lessons that were adopted from other CIP projects, including (1) healthy mothers during pregnancy; (2) healthy eating; (3) VA; (4) biofortification; (5) infant feeding; (6) OFSP benefits; (7) growing OFSP; and (8) creating a kitchen garden and planting fruit trees.

Similar to Mama SASHA, the project trained and supported village-level agriculture extension officers (VAEOs) and decentralized vine multipliers (DVMs). DVMs supported and broadened the production of disease-free vines for household distribution, and VAEOs provided vines to households and supported beneficiaries in their homes with agronomic advice especially related to OFSP planting and crop management. Unlike Mama SASHA, the project also engaged seed and root entrepreneurs (SREs) and trained and supported them to establish secondary multiplication sites as sweetpotato enterprises on a cost-share basis. Thirty SREs received initial and refresher training on agri-business and sweetpotato agronomy for 2 years. Business training included business planning, enterprise viability/economic analysis, financial access, and supply chain coordination and management, all of which were intended to enhance the SRE's development in agri-business or agri-entrepreneurship. Agronomy training included general sweetpotato and OFSP agronomy, dry-season seed conservation of OFSP planting material, Triple S (storage in sand and sprouting), and net tunnel technology. The SREs were able to establish financially sustainable medium-scale seed (and root) enterprises, which were linked upstream to the source of quality pre-basic OFSP planting material and downstream to individuals and community groups demanding planting material. Ultimately, at least four such enterprises serviced the needs of each target district.

The implementation phase, the period when vines were distributed and education activities implemented, ran from August 2015 to August 2017 (Figure 2). Households who received OFSP planting materials from DVMs and VAEOs were also provided with a brochure that described (1) planting, caring, and harvesting of sweetpotato (OFSP), including how to avoid the crop being infested by the sweetpotato weevil; (2) VA sources, uses, and benefits; (3) infant and young child feeding; and (4) OFSP benefits and uses. The benefits of producing and consuming OFSP were conveyed to the larger community through semi-annual field days that highlighted the new varieties, methods for preparing OFSP, and business opportunities for the commercial production of OFSP. To facilitate enhanced community nutrition education, the CHWs were provided with the job aids described previously to be used for monthly mothers' club sessions. Through the use of the district-level local government authority (LGA) team and VAEOs, each HH was initially supplied with 100 cuttings of clean OFSP planting materials or vines of any of the five varieties ("Kabode," "Ejumula," "Kakamega," "Mataya," and "Kiegeya"). Follow-up distribution of planting materials to these households was carried out during the second and third year of the intervention. This ensured that each eligible household received at least 300 vine cuttings of the OFSP varieties by the end of the project. As well to support appropriate agricultural practices, step-down training at the community level were conducted by 674 community and non-governmental organization (NGO) agriculture and health/nutrition officers. Training focused mainly on OFSP production and utilization (including OFSP nutrition and VA) and were practical in nature, with beneficiaries visiting plots where sweetpotato production was demonstrated for teaching purposes. From this training, household members were taught to initially bulk the planting materials received (300 cuttings) to approximately 1,800 cuttings, sufficient to plant about 0.05 hectares (ha)[5] of OFSP root

5 1 hectare = 10,000 m^2; 0.05 ha = 500 m^2.

Table 4: Key nutrition topics, delivery platforms, and activities included in the social and behavior change strategies of the four representative projects

	Mama SASHA	VISTA	Niassa	QDBH
Messages	Six cards: 1. Healthy mothers – antenatal care, iron and folic acid supplements, mosquito net use, healthy eating 2. Healthy Eating – food groups, hand washing and hygiene 3. Vitamin A (VA) – role in body, food sources and preparing VA-rich foods 4. Infant feeding – exclusive breastfeeding, complementary feeding 5. Orange-fleshed sweetpotato (OFSP) – as a source of energy and VA; ways to prepare OFSP 6. Growing OFSP – land preparation, vine selection, planting, weeding and hill-ups, and harvesting 7. Creating a kitchen garden and planting fruit trees (VISTA)		1. Local foods are better than highly processed packaged foods 2. OFSP is a protective food and OFSP and groundnuts are friends 3. Young children need enriched porridges to make their bodies grow 4. Young children have small stomachs compared to adults. Give two snacks and three meals a day 5. Breast milk is very healthy and helps the baby grow. The mother should continue to give it when she falls pregnant again or falls ill 6. The pregnant woman should eat additional food when pregnant, especially body-building and protective foods 7. You can enrich porridges when pounding, cooking or serving, adding body-building and protective ingredients at every meal 8. OFSP is a protective food as well as an energy staple	Triple S for OFSP VA-rich foods and OFSP for the family Maternal nutrition during pregnancy and exclusive breastfeeding Enhancing porridge/porridge thickness Age-appropriate meal frequency and amount Responsive feeding Feeding the sick child
Platforms	Antenatal care: enhanced counseling by nurses during visits (Mama SASHA) Community-based pregnant woman's clubs, cooking/recipe demonstrations Step-down training at community level on OFSP agronomy and postharvest handling and utilization Farmer-field days at community level		Step-down training at the community level: animators train mother counselors, each training 10 women monthly for 6 months Literacy groups included OFSP as a topic with local language booklets and cooking demonstrations	Family-focused Health Living Clubs
Materials/activities/ consumables	Flipcharts, cooking/recipe demonstrations/field days	Flipcharts, cooking/recipe demonstrations	Flipcharts (two local languages and Portuguese), cooking/recipe demonstrations; culinary contests; calendars; t-shirts and capulanas-decorate cloth worn as skirts (for trainers)	Take home materials; radio dramas, healthy baby toolkit; recipe demonstrations
Implementing partner for SBC	Ministry of Health, PATH	Ministry of Health	Catholic Archdiocese (Diocese de Niassa) and provincial health department SETSAN, the multisectoral food and nutrition secretariat at the provincial level For nutrition training during literacy sessions: Associação Progresso	Ministry of Health, People in Need

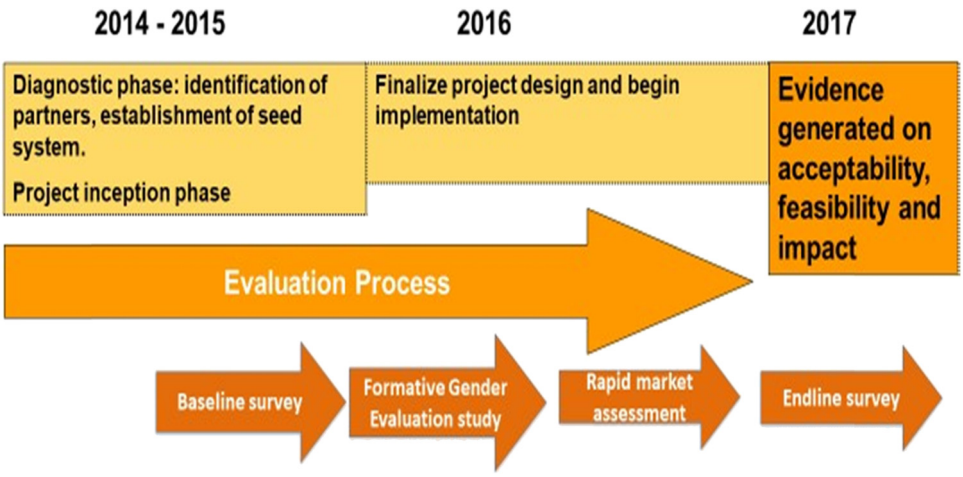

Figure 2: Illustrative timeline depicting the implementation and evaluation process for the VISTA-Tanzania project. Mama SASHA, Niassa, and Quality Diets for Better Health applied similar processes to implementation and evaluation.

production, which was enough to meet the annual dietary VA requirements of five household members (Table 5).

The monitoring and evaluation strategy assessed the feasibility, acceptability, impact, and hence overall effectiveness and sustainability of VISTA-Tanzania. Table 6 summarizes the project outcome logic, key processes through which the project operates, and the framework for M&E. The project used three main sets of activities to monitor and evaluate key project outputs and outcomes. First, to assess project implementation and measure outputs, beneficiary communities (e.g., tracking pregnant and breast-feeding women's clubs and numbers of women per club session) and the type of messages delivered at the monthly club meetings, including cooking demonstrations, were regularly monitored. On the agriculture side, continuous monitoring occurred for vine distribution to eligible households, frequency of home visits by VAEOs for monitoring, and OFSP production.[6]

Second, a qualitative formative gender evaluation study was used to assess the influence of gender on project implementation [40]. In addition, a rapid market assessment was carried out to determine the commercial potential of OFSP in the project intervention districts and beyond [41]. Finally, two rounds of cross-sectional household surveys were conducted with farmer households with children younger than 5 years. The surveys compared outputs and outcomes between beneficiary households at baseline and endline relative to the control communities.

Evidence generated through the monitoring and evaluation strategy suggests that VISTA-Tanzania increased the production and consumption of OFSP; significantly increased caregiver knowledge on VA, nutrition, health-seeking, and childcare; and significantly improved dietary VA intake, dietary diversity, and food security among beneficiary households.

Sweetpotato production and food security:

- By endline, 42% of households produced OFSP compared to 0.4% at baseline. The proportion growing white varieties declined from 73% of households to 33%.
- The proportion of households experiencing high food insecurity fell from 34% at baseline to 16% by the endline survey.

Dietary changes:

- The proportion of households consuming OFSP in the previous 24 h increased from 0.4 to 46%, while the number of children consuming OFSP increased from 0.4 to 42%.
- Nutrition knowledge, in general, and VA knowledge, in particular, increased among caregivers by 63%.
- The proportion of households with adequate dietary diversity increased by 72% from baseline to endline; young child dietary diversity adequacy increased by 18%.

6 As part of monitoring, a Mother–Baby trial of 16 OFSP varieties (11 clones and five released varieties) was evaluated for two growing seasons, 2016/2016 and 2016/2017. These clones and varieties showed good adaptability in all sites where experiments were set. However, three clones – "Naspot 12" (which grows vigorously but with minimal root formation), 06/069 (which has poor vegetative and root yield), and D6-02 (does not perform well, especially in moisture-stress soil) were deemed not to perform favorably in all the selected agroecologies. Researchers and farmers recommended these be dropped from the cohort. For that reason, it was recommended that 13 varieties (eight clones and five released varieties) be taken to the next step of the release process (i.e., distinctiveness, uniformity, and stability and national performance trials).

Table 5: Comparison of key outcomes across the four representative projects

Outcomes	Mama SASHA Kenya	VISTA Tanzania	Niassa Mozambique	QDBH Ethiopia
Increased OFSP production	Yes	Yes	Yes	Yes
Improved household food security	Yes	Yes	NA	Yes
Increased household OFSP consumption	Yes	Yes	Yes	Yes
Increased household dietary diversity	Yes	Yes	NA	Yes
Increased OFSP consumption by children	Yes	Yes	Yes	Yes
Improved infant and young child diet quality	Yes	Yes	Yes	Yes
Improved infant nutritional status	Yes	NA	NA	No
Increased OFSP consumption by mothers	Yes	Yes	Yes	Yes
Improved maternal diet quality	Yes	Yes	No	No
Improved maternal nutritional status	Yes	NA	NA	NA
Income	Yes	Yes	Yes	No

Yes, effects were statistically significant at $p < 0.10$; No, effects were null or not statistically significant at $p < 0.10$; NA, outcomes were not assessed.

- The consumption of VA-rich foods increased by 63% between baseline and endline. These improvements could be attributed to project nutrition activities at the mothers' clubs run by CHWs.

VISTA-Tanzania took a deliberate "results-based management" approach and carefully documented and analyzed the planning, implementing, and evaluating process. This has enabled CIP and partners to extract lessons and recommendations for future multisectoral program design. Some of the main lessons learned from the VISTA project include:

- To support the design and stakeholder ownership of innovative approaches, a thorough diagnosis of institutional and market systems is instrumental. Substantial time is needed for the diagnostic phase and redesigning the implementation activities based on findings from that phase.
- Thinking through the program theory of change and updating the impact pathway or logical framework can ensure integration of the various sectors and disciplines. It can provide guidance for appropriate combination of both qualitative and quantitative monitoring.
- Because of the multisectoral nature of such interventions, multiple evaluation components may be required to respond to the different models and disciplines of evidence present in the different sectors.
- Integration across the multiple sectors required substantial coordination, networking, and organizational and local government authority support.
- There is a need for integrated cross-discipline training and refresher training (e.g., on agriculture, nutrition/health, marketing, gender integration, and data management) for the various implementing partners to ensure that all key stakeholders adequately understood all components of the intervention.
- Regular quarterly partners' meetings for the implementation team and broader network of stakeholders of the project were necessary to continuously review, plan, and update key stakeholders of the project progress. This emphasizes the importance of allocating sufficient resources to critical organizational and management meetings that are essential for supporting integrated approaches to have a sustainable impact.
- Community-level implementing staff including ward and village agricultural extension officers and CHWs served as the backbone to program implementation; effective engagement of these frontline staff was critical to the success of the project.
- Establishment and training of community-based vine multipliers or decentralized vine multipliers and SREs were critical to ensure adequate availability of a clean source of planting materials for downstream uptake by farmers and other root producers.

VISTA-Tanzania was effective in integrating OFSP into the farming and food systems of the seven project intervention districts in Tanzania. The positive agricultural and nutrition outcomes documented throughout the project period came about because household members were empowered through adoption of OFSP technologies and management practices. The project approach also supported longer-term sustainability as evidenced by high levels of buy-in and engagement from the onset, including the project's capacity to mobilize community members and engage key stakeholders, especially the local government leadership at the district level.

Table 6: VISTA-Tanzania outcome logic

Objectives	Outputs	Direct outcomes	Development outcomes	Impacts
Objective 1: Increased production and consumption of OFSP varieties through an integrated agriculture–nutrition technology set	Five agro-ecologically adapted OFSP varieties with market-preferred attributes available for uptake by root producers	Planting materials of nutritious and productive OFSP varieties widely available	Increased production and availability of nutritious OFSP in HH and local markets	Increased incomes by smallholder farmers due to increased production and adapting of new technologies
	Twenty eight entrepreneurs establish financially sustainable medium-scale seed (and root) enterprises linked to upstream source of quality pre-basic OFSP planting material and downstream individual and community group demand for planting material	Male and female smallholder farmers plant quality OFSP vines and apply improved agronomic practices	Increased productivity and intensification of OFSP within diversified cropping systems	Better food security among the community
	Twenty one thousand smallholder farmers receive OFSP planting material and training			
Objective 2: Improved nutrition knowledge and practices	Seventeen thousand five hundred HH receiving SBCC, including knowledge on OFSP utilization and consumption	Caregivers have improved knowledge of nutritional importance of OFSP and vitamin A	Increased intake of OFSP and other vitamin A-rich foods by vulnerable HH members	Improved dietary diversity, in particular, improved levels of vitamin A intakes and among vulnerable HH
	Seven hundred community heads (staff) trained in improved nutrition counseling	HH have improved capacity to utilize OFSP for all members with focus on infant nutrition		
	Five nutrition messages and counseling in target districts including vitamin A-rich foods and OFSP			
Objective 3: Root producers and traders utilize improved storage and marketing of fresh OFSP roots	Technologies for improved storage and marketing of fresh roots disseminated	Improved root storage practices	Reduction of on-farm postharvest losses	Increased agricultural incomes in SP value chains, with at least 50% of this income accruing to women
	Selected fresh OFSP root market chains improved	Increase availability of OFSP roots in selected markets Increased gender-equitable income opportunities for OFSP farmers	OFSP fresh root markets profitably supplying nutritious foods	

(*Continued*)

Table 6: (*Continued*)

Objectives	Outputs	Direct outcomes	Development outcomes	Impacts
Objective 4: Improved evidence-based and policy support	Thirty staff from government of Tanzania and NGOs trained in SP ToT Strengthen the evidence for OFSP production and nutrition support in target districts Learning events for stakeholders at district and national levels	Increased knowledge on SP and technical capacity in key organizations for program implementation "Business case" for each technology developed for different farmer types and consumers Stronger awareness of agriculture and nutrition linkages in policy forums and wider society	Improved quality of SP and wider agriculture–nutrition programming and service delivery Improved policy and investment environment for nutrition-sensitive agriculture	Increased investments in scaling-out OFSP technologies beyond target districts

2.4 Project 3: Nutritious OFSP for Niassa, Mozambique

The overall objective of the *Nutritious Sweetpotato for Niassa* project, funded by Irish Aid, was to improve the intakes of VA and energy of at least 20,000 rural households with women and young children younger than 5 years. In 2010, before project design and implementation, the Niassa Province of Mozambique reported an average population density of 11–12 persons per square kilometer (persons per km^2), substantially lower than the average national population density[7] of 30 persons per km^2. In addition to being very rural, the province suffered from very high rates of child malnutrition: national statistics indicate that 47% of children younger than 5 years of age were stunted in 2011 [43].

Results from a baseline survey with 396 households in July–August 2013 indicated that agriculture was the most important income-generating activity with 90% of households engaged in agriculture. Fifty-eight percent of households had access to lowlands during the dry season, but these lowlands were not widely exploited for agricultural use. Three-quarters of households were producing some types of sweetpotato, including 9.1% who were already growing OFSP. Notably, women dominated the production of roots. Roots were primarily produced for household consumption; only 4% of households producing sweetpotato reported selling roots. Levels of basic nutritional knowledge among caregivers were low.

With the promotion of improved OFSP varieties, the project aimed to improve diets through increased OFSP yields. However, a key factor in encouraging the uptake of new varieties is potential income generation value, especially in impoverished contexts. Therefore, the Niassa project sought to introduce a more explicit income generation component, as compared to other case studies presented in this report, using market-based approaches to create demand for OFSP roots. This market-based approach included the development of a marketable product, OFSP "Golden Power Bread," which ultimately created a demand for fresh roots. This explicit market linkage was included to assure that at least 20% of households growing OFSP earned at least $50/year from OFSP sales.

Additional objectives included household food security and longer-term project sustainability and scalability. For the latter, the project aimed to strengthen the capacity of key government and NGO partners to integrate nutrition-sensitive interventions into their ongoing programs, and

7 2007 Mozambique National Census data.

for the former, the project aimed to promote second-season cropping to tackle the widespread "hunger season." By interacting closely with provincial-level policymakers through SETSAN, the multisectoral food and nutrition secretariat, local government, and the provincial Ministry of Agriculture, the goal was to fully integrate OFSP into provincial-level, multisectoral planning, and implementation efforts concerning food security and nutrition. Sustained access to quality planting material and best agronomic practice training concerning OFSP was to be assured through building the capacity of government research and extension personnel in addition to setting up a decentralized network of trained farmers skilled in multiplying quality planting material, known as DVMs.

The principal target groups included poor, rural women with young children (under 5 years of age) in sweetpotato-producing areas within eight districts: Chimbunila, Lago, Muembe, Sanga, Mandimba, Cuamba, Mecanhelas, and Lichinga. However, attention was also given to men, especially influential community leaders and husbands and mothers-in-law (as they often have considerable say in child-caring practices). CIP led the 4-year effort. The Associação Progresso (AP) and Diocese de Niassa (Anglican diocese) were the official partners over the 4 years, the latter responsible for implementing the nutrition education component. The IIAM (National Research Program) substation in Lichinga collaborated in on-farm trials, prebasic seed production, and monitoring and evaluation. União dos Componeses e Associações de Lichinga (UCA) joined the project during year 1. Additional collaboration started in year 3 with the extension personnel of the District Services for Economics Activities (SDAEs) for mass vine dissemination and data collection and for the coordination of all OFSP activities at each district.

Of note, the 15 improved drought-tolerant OFSP varieties released in 2011 had never been tested in Niassa province. During the first 18 months, widespread on-farm trials were conducted with nine varieties to select the best four, in terms of performance and consumer preference, for each district. During this same period, farmers were identified and trained to be DVMs to ensure sufficient quality planting material.

The community-based nutrition component was developed in three phases that comprised a formative research phase and two implementation phases. The *Formative Research* phase (March–April 2014) was undertaken by an experienced nutritionist who had been living in Niassa over 10 years as was familiar with the two major communities, Yao and Nyanja, who had very different cultural beliefs and languages. The phase comprised key informant interviews, focus group discussions, and the implementation of short-term Trials for Improved Practice.[8] Formative research led to the development of a set of training cards, each with a key nutrition message (Table 2), to be delivered over six group sessions conducted by trained mothers at the community level. One message in particular addressed the widespread belief among mothers, discovered in formative research, that packaged products such as Jolly Juice and biscuits, which were perceived as "modern" foods, were better for the young child than foods grown at home. Training cards to support nutrition education on these topics were produced in Portuguese and two local languages.

The *first phase* of implementation (2014–2015) included (1) pilot implementation of the full nutrition education modules developed in Sanga District, under the direction of the Archdiocese and (2) training of 83 literacy educators OFSP production and cooking demonstration in the four districts managed by AP. Pilot implementation of the full nutrition education modules included a training of trainers, cascade training, and community events that engaged households in OFSP and nutrition-related activities. A first-line training of trainers (ToT) on nutrition was held for 18 participants (10 women and 8 men). These 18 trainers then trained 703 mothers with young children at the district level. These trainees subsequently trained another 2,275 mothers with children younger than 5 years during the six education sessions held monthly. Cooking demonstrations were essential in this program. As one trainer stated: "Nutrition must be practiced, not just talked about." For the literacy program managed by AP, the 83 trained literacy educators led classes for 1,176 participants in their literacy groups (55% women) and held a contest on OFSP nutrition with 135 participants (106 women) in four districts. Three of the districts had winners who grow OFSP and process OFSP. In addition, a culinary contest using OFSP was held in five districts in conjunction with presentation of plays stimulating OFSP awareness.

At the end of the First Phase, the training package of nutrition education and activities was revised based on the experience in the field. Then, in the *Second Phase of Implementation* (*the scaling phase*), a revised training package of six topics delivered over 6 months was applied

8 Based on the Trials for Improved Practices methodology described in the study by Dicken et al. [44], based on observations and discussions with the caregiver to learn about current young child feeding practices, a series of recommendations were developed, then let the caregiver select and try and implement the recommendation, providing feedback to the researcher as to whether it was doable. In addition, OFSP roots were supplied to get initial reactions to the introduction of the crop.

in a step-down approach referred to as the "15–20–10," that is, 15 animators/village: 20 counsellors/animator: and 10 households/counsellor. The target reach with this design was 3,035 thousand households/village. Seven villages in Sanga district were involved with 14–16 animators at each village. Some of the counsellors did not reach their objective, and in total, 13,109 households were reached. Among the literacy groups, AP trained 80 community promoters (24 women) in nutrition.

The broad objectives of the projects were achieved based on monitoring data and an endline survey conducted among 1,032 households in June–July 2016. These included:

- A total of 28,044 received OFSP through project channels directly, of which 78% had children younger than 5 years, with 37,262 children benefitting. At endline, 96% of intervention households and 13% of control households (no project participation) were growing OFSP.
- A total of 18,784 households (17,009 females) participated in nutrition training. Intervention households were consuming OFSP on average 3.1 days/week. Sixty-two percent of all direct beneficiary household had access to nutrition education.
- At endline, mean household mean diet diversity scores did not differ significantly between beneficiary and control households. For young children, the mean beneficiary score (4.78) was slightly higher than that for the control children (4.19; maximum score 6).
- Significant progress was made through promoting staggered planting and use of the lowlands in the off-season to increase food supply during the hunger season. The households using lowland areas for vine conservation increased from 41% in 2013 to 58% in 2015, and the use of small garden plots rose from 14% to 26%. At endline, 24% of households reported planting year-round. Farmers producing roots in the "off-season" were selling, on average, 15 Mt/kg compared with 3 Mt/kg during the peak harvest period (April–July).
- The average yield of OFSP during a December 2015 assessment and the endline in June–July 2016 were 15.5 and 10.5 Mt/ha, respectively. One explanation for the lower yield during the endline was the drought that occurred during the growing period that season. Nonetheless, yields are ~50% greater than the national yield at 6 Mt/ha.
- Fifty two percentage of the farmers producing OFSP sold part of their roots. Among those selling, the average quantity sold was 1,064 kg. Average household revenue from OFSP sale is US $53.78, above the project target goal of $50. Thirty-two percent of households sold OFSP on the roadside near their house, 28.6% at home, and 22.6% at their nearest local markets. This facilitates the participation of women in marketing. Thirty-one percent of households reported women alone receiving money from sweetpotato sales, with women and children receiving 14% and men alone 41%.
- There was strong government buy-in, with SETSAN supplied cumulatively 4,435 kg of OFSP vines to eight districts outside of the intervention zones (135 kg in 2015 and 4,300 kg in 2016) and OFSP appearing as part of the government multisectoral plan (2015–2019) for reducing stunting. SDAEs in Niassa have continued to promote OFSP after the project ended.

In the provincial capital, Lichinga, OFSP is the predominant flesh type for sale. The emphasis on the marketing component developed as part of this project strengthened household commitment to growing OFSP as they saw the benefits of OFSP for income generation. Unfortunately, the indicators capturing increased consumption of nutritious foods, including OFSP, are weaker than 24 h food recalls. However, like most dissemination projects, more complex nutrition indicators are often not included in evaluation given budgetary and measurement capacity constraints.

2.5 Project 4: Quality Diets for Better Health, Ethiopia

Thirty-nine percent of children younger than 5 years are stunted in Southern Nations, Nationalities, and Peoples' Region (SNNPR), Ethiopia [45] and approximately 13% of children of 6–59 months suffer from VAD [46], estimates that are similar to national prevalence rates. However, total energy and protein intakes of young children in SNNPR are the lowest of any region in Ethiopia. Roots and tubers make up more of the diets of young children in SNNPR than in other regions [47,48], and diets are generally lacking in diversity. In 2016, only 13% of young children of 6–23 months had minimum dietary diversity [45]. Furthermore, only 7% met minimum acceptable diet, a combined indicator of dietary diversity and age-appropriate meal frequency. In SNNPR in 2016, just below half of the young children of 6–23.9 months (48%) had consumed any VA-rich food in the previous day, particularly concerning because only 47% of these same children had received VAS within the past 6 months.

The Quality Diets for Better Health (QDBH) project is a 54-month, European Union-funded nutrition-sensitive OFSP promotion project in SNNPR, Ethiopia. Implementation is led by CIP, in partnership with People in Need (PIN),

Emory University, the Southern Agriculture Research Institute (SARI), and local government. The main goals of the project are to introduce and increase the production of OFSP as a bioavailable, food-based source of VA and improve the quality of diets, particularly for infants and young children.

Project area and scale-up: The project is implemented in 42 *kebeles* (wards) across four *woredas* (districts) in the Sidama and Gedeo zones in Southern Nations, Nationalities, and Peoples' Region (SNNPR). Before project implementation, farming of white-fleshed sweetpotato was more common in the Sidama[9] zone than in Gedeo. Khat is an important cash crop in the Sidama *woreda*, while coffee is an important cash crop in both zones. Enset, or false banana, is a starchy staple that acts as an important food security crop, as, despite taking several years to mature, it tends to be drought resistant and can be harvested at any time of the year.

The project endeavors to achieve its goals through four main objectives: increase production of OFSP, enhance community-based nutrition education, create and strengthen market linkages, and rigorous monitoring and evaluation. To achieve its *first objective*, the project established 83 private and public vine multiplication sites and trained Agriculture Development Agents to provide 15,000 households with OFSP vines and knowledge necessary for homestead OFSP production. To achieve this scale, the project organized ToTs and stepdown training to reach experts, development (rural extension) agents, and community facilitators at the regional, zonal, woreda, and kebele levels. The Agricultural Technical and Vocational Education and Training (ATVET) College in Sodo, SNNPR, has incorporated elements of this training in its regular program to ensure the sustained increase in the institutional capacity to develop OFSP farming in the region. The project tested seven new cultivars – three bred locally at SARI and four brought in from Uganda because the locally available cultivar, Kulfo, was not acceptable. The participatory assessment of agronomic and sensory properties of the candidate varieties allowed for the selection of three new cultivars, officially released in November 2019. Compared to Kulfo, these three have higher and more stable yields, are less sensitive to diseases, and have a higher dry matter content. The latter is crucial for consumer acceptance.

The *second objective* is to engage men and women from 15,000 households – the project's direct beneficiaries – in nutrition-focused SBC. The project reaches direct beneficiaries through the formation of Healthy Living Clubs (HLCs), groups of 30 households from the same *kebele*, that meet monthly for learning about OFSP agriculture and/or nutrition. HLCs were facilitated by the Ministry of Health, Health Development Army (HDA) volunteers. Similar to its agriculture-focused ToT, the project uses a nutrition-focused ToT approach for community facilitators (hired to coordinate project implementation at the kebele level) and for government Health Extension Workers (HEW)[10] who supervise the HDA volunteers.

The nutrition SBC component particularly focuses on VA and OFSP as a source of VA, and complementary feeding of infants and young children of 6–23 months of age. Formative research before HLC formation provided contextual understanding of the barriers and boosters of optimal infant and young child feeding, and acceptability of key project elements, including the HLC format and OFSP roots and leaves [49]. Formative research and the design tool, The Behavior Change Wheel [50,51], informed development of a structured curriculum that included family goal setting and problem-solving, audio stories, cooking demonstrations, taste testings, participatory learning to convey key messages, and the development of culturally appropriate educational materials for families to use at home [52]. In addition, year 1 beneficiary households participated in a cluster-randomized trial to evaluate a behavior change innovation, the "Healthy Baby Toolkit" (HBT; Figure 2), designed to promote optimal nutrition in the first 1,000 days.[11] Findings from the trial informed scale up of this innovation into remaining *kebeles* later in the project.

The *third objective* aims to enhance OFSP value chains through the expansion of OFSP farming in other *woredas* with the capacity to supply roots to the fresh root market and support the development of OFSP-containing processed foods for urban markets, thereby increasing VA delivery to urban consumers and simultaneously increasing OFSP demand from rural producers. The development of this objective posed extra challenges as a consumer survey

9 Sidama was separated from SNNPR and became an independent region on June 18, 2020.

10 HEW are women with at least grade 10 education who have been hired and trained by the government and are stationed in health posts in each *kebele* where communities members can receive services including vaccinations, prenatal checkups, delivery assistance, family planning, nutrition counseling, and other services. HEWs supervise and train HDA volunteers

11 The HBT (Figure 2) consists of three items: (1) a feeding bowl with markings to promote age-specific feeding frequency and portion size, (2) a slotted spoon to promote thicker, more energy-dense complementary foods, and (3) an accompanying pictorial counseling card that provides instruction on use of materials, and also uses images to promote dietary diversity and hygienic food preparation and handling. The HBT was qualitatively evaluated in India [53], Kenya [54], Tanzania [55], and Malawi [56].

conducted by the project indicated that Hawassa's 410,000 inhabitants eat around 2.3–2.9 kg per capita per year of sweetpotato, considerably less than the national average of 10 kg per capita per year. Moreover, monitoring of key urban markets in the project area revealed that the target *woredas* do not play a significant role in market supply. Further studies confirmed that sweetpotato farmers in the targeted *woredas* sell only small amounts of sweetpotato roots within their *kebele* or *woreda*. Hawassa City receives roots from other sources within the region. Based on these findings, the project approached around 50 farmers in an additional *woreda* in Sidama with experience in market-oriented maize farming and supplied them with enough planting material to cover over 5 hectares of land with the potential to yield about 100 tonnes per production cycle. The project has now disseminated vines to 35 *woredas* in Sidama and SNNPR (Gamo, Gedeo, Hadiya, Kembata, Konso, and Wolayita zones).

The second challenge is the production and marketing of new food products for OFSP. Processed foods that use sweetpotato as an ingredient are virtually unknown in SNNPR. The promotion of new recipes and processed foods that incorporate OFSP are two important avenues to achieve wider adoption and increased consumption. To that end, the project works with small-scale, mostly female-managed businesses to produce common food items such as *injera* (a typical Ethiopian pancake-like flat bread), *dabo* (conventional yeast-based bread), doughnuts, and biscuits, replacing part of the cereal flour with OFSP puree. One *injera* maker, one baker, and one biscuit baker are now producing OFSP-containing products on a regular basis processing about 300 kg of OFSP per month.

The *fourth and final objective* of the QDBH project is to rigorously monitor and evaluate program activities for iterative learning and program improvements and to build an evidence base for project scale up and sustainability. Overall project monitoring and evaluation consist of three main activities. One is the registration of beneficiaries of OFSP planting material and HLC members. The second is the monthly monitoring of the implementation of the HLC program, and the third activity consists of baseline and endline surveys in 26 of the 42 kebeles using a quasi-experimental RCT model. Baseline data were collected in December 2017 and the endline in December 2019. The endline was completed 1 year before the end of the project to ensure control communities could benefit from the intervention.

Taking lessons from Mama SASHA, a key component of monitoring, is qualitative operation research or process evaluation to assess implementation. From May to June 2018, Emory University conducted a qualitative process evaluation to assess fidelity of program implementation [57]. The process evaluation was qualitative in nature and assessed program functioning and fidelity related to the implementation of the agriculture and nutrition components, project monitoring, frontline worker training, ag-health interfacing, and partner collaborations. Challenges, successes, weaknesses, and strengths were identified. A stakeholder workshop facilitated the review and joint development of strategies to address challenges and constraints discovered during the process evaluation. Table 7, an illustrative table, summarizes the findings and relevant recommendations.

Longitudinal study: Finally, like Mama SASHA, a nested cohort study was implemented to evaluate the added value of the HBT to enhance OFSP promotion and community nutrition education. Shortly after OFSP vine distribution, Emory University established a cohort of 605 households participating in the HLCs for a 1-year, longitudinal study. The primary outcomes of the study were VA and energy intake. A baseline survey was conducted from December 2017 to January 2018, with enrollment of all households with a child younger than 6 months. A follow-up, midline survey was conducted in August 2018 (when the infants were older than 6 months), and a final endline survey was conducted in February 2019. The follow-up midline and endline surveys included multiple-pass, 24 h dietary recall of infant diets.

Project Progress and Outcomes: The project has successfully achieved its implementation targets to date. One is the creation of the capacity to produce planting material in the target *woredas*. While in 2017, all planting materials were sourced outside the project area, and in 2019, 21 farmers and 19 farmer training centers in the target *woredas* supplied around 3.9 million cuttings for 6,300 beneficiaries in 42 kebeles. By 2020, local multipliers will have supplied planting stock to the remaining beneficiary households as well as to famers and training centers in 30 other scaling-out *woredas*. Although analyses are still in progress, we noted important and significant ($p < 0.001$) nutritional gains. At endline, the mean Household Food Insecurity Access Score (HFIAS), Women Dietary Diversity Score (MDDS-W), and Child Dietary Diversity Score (CDDS) of respondents in intervention *kebeles* who declared to have been HLC members were 19% higher than non-HLC members in the control *kebeles*. The mean total frequency of VA-rich food intake by the child of beneficiaries was 63% higher than controls, whereas the percentage of children with adequate VA intake was 16.4% among beneficiaries against 7.1% among controls. OFSP roots contribute 12.5% of the mean plant VA frequency among beneficiary children [58].

Table 7: Illustrative summary of findings and recommendations from the QDBH process evaluation

Recommendation	Rationale and explanation	Supporting findings
HLCs		
Strengthen procurement and distribution systems for materials. If dishes cannot be purchased for each HLC, ask participants to bring their own to the necessary sessions	As the project scales up, it is important that all staff are using their time most efficiently. Consider having a set of materials (speakers, pots, dishes) for each kebele that can be shared by the different HLCs. If that is not feasible, it still needs to be assured that all necessary materials will be available during HLCs. This could be done by asking participants to bring different dishes and supplies. Material lists are provided for each session in the curriculum; these should be used as a checklist to ensure that all materials are acquired before the scheduled HLC	• It was challenging for HDAs to facilitate sessions, particularly cooking demonstrations without the necessary dishes and supplies • HDAs and CFs reported spending a lot of time locating materials for HLC sessions • Asking beneficiaries to bring their own dishes has been used with success in previous projects (IPIN) • Necessary supplies cannot always be acquired in Dilla (e.g., staff cannot find a large enough quantity of pots in Dilla)
Provide HDAs with the curriculum, a simplified guide of each HLC (similar to the current monitoring checklist), or notebooks to remember what happens in each session	HDAs have varying levels of literacy. If they are not capable of reading the full curriculum or taking notes during training, providing them with at least a simplified guide of each HLC session could be useful. It could serve as a reference during the session to remind them of the different components of each session	• HEWs and CFs reported that HDAs sometimes come back to them for additional training because they cannot remember what is supposed to happen during a HLC session • HDAs asked for tools to help them remember the curriculum and facilitate the session
Agriculture		
Create a standardized agriculture curriculum for agriculture DAs and CFs to use for training HLC participants	As the project expands to additional kebeles, it will become increasingly complex to closely supervise what training HLC participants are receiving. CIP staff will be less directly involved in training at the kebele level and less able to support DAs and CFs in this training. Creating a curriculum will help to ensure that the intervention remains similar across kebeles and help maintain higher training quality	• It was difficult to establish which agriculture activities took place, when they took place, and if they occurred in all kebeles with all HLC participants • Different respondents (HLC participants, Ag DAs, HDAs) gave different accounts of what agriculture training was provided
Conduct an adapted HLC Session 6: Vitamin A and OFSP for the family before vine distribution	It is important that participants are aware of the benefits of OFSP before receiving vines. Currently, a nutrition session on vitamin A does not occur until session 6, months after vines are distributed. If OFSP roots are not available for a demonstration at this time, the session should be adapted to include other sources of vitamin A that are available	• Participants were reluctant to plant vines initially because they saw sweetpotato as an inferior crop • Participants felt that there was an overlap in sessions 6 and 7, which both have a cooking demonstration and are currently held one after the other
Monitoring		
Create a joint agriculture and nutrition monitoring form for CFs to use during their household visits	This could include adapting the current agriculture monitoring form, or creating a new one. This form should be kept simple and short to minimize burdens on CFs and households. Nutrition information to be collected could include: What was the last HLC topic? What did you do at last HLC? What goal did you select? Conduct a visual check to see if the tools are present	• CFs report visiting households to check gardens and HLC message retention, and behavior change • Research assistants, with the support of CFs, collect household level agriculture data

(*Continued*)

Table 7: (*Continued*)

Recommendation	Rationale and explanation	Supporting findings
Establish information flow and designate responsible parties for all monitoring data. This should include at a minimum: what indicators are collected; how they are collected and by whom; who enters the data and who compiles it; who reports to who and how it is used to improve project implementation	Collecting, entering, analyzing, and reporting monitoring data takes considerable time and effort. This needs to be taken into consideration when establishing this monitoring plan. An organizational chart with all project stakeholders may be useful when specifying roles, responsibilities, and channels of communication	• Monitoring data was not available for use until months after HLC sessions happened and could not be used for real time program adjustments • Partners have different ideas of who is responsible for which monitoring activities, what monitoring data are necessary to collect and at what intervals
Training		
Utilize opportunities for experience sharing within kebeles	Since there are multiple HLCs per kebele, it is possible for HDAs to attend each other's HLC and learn from one another. This type of experience sharing should become a regularly scheduled part of project activities. The HDA should attend another HLC as a participant. Afterward, they should discuss with the other HDA, CF, and HEW about what went well and what could be improved	• HDAs and CFs had positive things to say about experience sharing and want more • Recommended by extension officers
Provide additional support and supervision to cascaded agriculture training	Closer CIP supervision of trainees cascading training to the next level should be given to ensure that quality is maintained throughout, especially when those leading it do not have an agriculture background. As the project scales, and CIP is less directly involved in training new DAs, CFs, etc. it is important to ensure that those who are conducting this training regularly can do so while maintaining its integrity	• CFs remember little agriculture training • HLC participants and HDAs have varying reports of the agriculture training they received and facilitated (HDAs)
Agriculture-health integration		
Conduct joint activities (training or experience sharing, etc.) with HEWs and Ag DAs to ensure both have sufficient background on the project's core agriculture and nutrition concepts	This could help initiate relationships and improve collaboration between agriculture and health at the kebele level. It could be incorporated into existing experience sharing or training (i.e., invite Ag DAs to part of HEW training or *vice versa*)	• Ag DAs say they want more nutrition training and want to better support HEWs • HEWs receive agriculture training; Ag DAs to not receive nutrition training • HEWs and Ag DAs often have differing opinions on how well collaboration between them is happening
Collaboration		
Strengthen coordination between partners	The research assistants, field coordinator, and extension officers should be in regular communication or in-person meetings to ensure that they are aware of what the others are doing, their work is well coordinated, and time is used most efficiently	• Community facilitators receive conflicting instructions from partner organizations • Mentioned as a challenge among project staff

Early results also suggest that, compared to children in a control group, children in the group randomized to receive OFSP and the HBT had improved infant and young child feeding practices, particularly at the midline survey that occurred during a food insecure season. Children who received both OFSP and the HBT also had higher odds of increased VA intake at the endline survey. We also observed that households receiving

OFSP promotion with or without the HBT were protected from seasonal food insecurity, had improved knowledge of VA, and complementary feeding, and that these children had lower odds of caregiver-reported illness in the 2 weeks prior to the endline survey.

Challenges and project learnings to date: The QDBH project faced four major challenges. As described earlier, the first was the absence of locally adapted OFSP varieties that were acceptable to farmers and consumers. The second challenge was the local agro-ecology. Some target communities are in mountainous areas with steep slopes unsuitable for planting or elevations >2,500 m above sea level and too cold for sweetpotato farming. Moreover, because farming plots of beneficiary households were small, the project needed to identify additional locations suitable for OFSP production on a scale that would achieve sufficient supply of roots to urban consumers. In response, the project negotiated with local governments to include additional woredas. The third challenge concerned the local farming system that was dominated by shadow-casting shrubs (khat) and trees (coffee, enset). Sweetpotato does not thrive in shade. As well, baseline data from Gedeo found that only a minority of farmers (30%) grew any type of sweetpotato, potentially due to incompatible farming systems. This meant that, in addition to the challenge of encouraging farmers to substitute the dominant white-fleshed variety by OFSP, the project faced the additional challenge of convincing some farmers with no sweetpotato growing experience to grow OFSP.

The final challenge concerned governance and inter-ethnic tensions. In 2018, the densely populated Gedeo region received 900,000 refugees from a neighboring region. In 2018 and 2019, civil unrest between ethnic groups created a new flux of refugees. These challenges highlight how local conditions will likely deviate from expectations; thus, it is imperative that projects collect the appropriate agro-ecological and sociocontextual information beforehand and include sufficient flexibility for ongoing adjustments during implementation. Social and political instability are, unfortunately, risks that are less easy to prepare for, but understanding sociocultural norms may facilitate project preparation and resilience.

3 Conclusion and takeaways

Nutrition-sensitive agriculture is a proven strategy to improve maternal and child diets in low- and middle-income countries [59–61], the effectiveness of which is enhanced with stronger integration of gender and women's empowerment and health and nutrition social behavior change communication (often referred to simply as nutrition education) [60,62,63]. However, the magnitude of improvements seen with nutrition-sensitive agriculture, even those with gender and nutrition education strategies, often falls short of what is expected. It is plausible that inconclusive results stem, not from the potential effectiveness of these programs but rather from the highly diverse processes and approaches used in the design, planning, implementation, monitoring, and evaluation of these programs. Thus, efforts to improve the impact of nutrition-sensitive agriculture projects on nutrition outcomes continue; this is especially the case in SSA and South Asia where poor diet quality and maternal and child undernutrition persist.

OFSP, as a climate-smart and highly nutritious staple crop, holds promise as a crucial commodity to include in nutrition-sensitive agriculture efforts at scale. We argue that the nutrition, food security, and income generation benefits of OFSP can be more efficiently and effectively exploited by integrating promotion of OFSP cultivation with gender and nutrition-sensitive engagement of families and communities, enhanced and integrated training of agricultural extension, and advocacy with policy makers and private sector. From the case studies presented here, we identified several key actions that emerged as necessary to such integration.

(1) Engage local stakeholders and leadership, budgeting for and establishing clear and functional mechanisms for continued engagement, and training and support throughout the life of the project with the goal of capacity strengthening for sustainability. Engagement must include not only health and nutrition but also private sector and industry to identify value chains for OFSP that promote market demand creation. Market-based demand generation runs the risk of undermining the nutritional goals of these programs if no OFSP is retained for home consumption and/or income earned is not used in the purchase of nutrition and health-promoting foods, especially for very young children and women. Engagement of agriculture and health extension services, along with social marketing campaigns, is likely important to ensure families are aware of both the market and household health value of OFSP and other nutritious food options for maternal and child health.
(2) Prioritize and value the role of the front-line community worker for their critical role as the backbone of program implementation. Such awareness entails ensuring frontline workers are appropriately equipped with

training, job tools, supportive supervision, and that their compensation or incentives are appropriately matched to efforts and performance. Such prioritization sustains motivation and reduces turnover with downstream effects of greater beneficiary engagement, participation, impact, and ultimately cost-effectiveness.

(3) OFSP is an effective entry point as a nutrition-sensitive agricultural intervention; from an agricultural perspective, it is a low input, climate resilient, and low labor crop; its leaves and roots can be consumed in numerous types of household dishes and components not consumed by the households used to supplement livestock. With adequate market demand creation, OFSP can serve as a vital income generation opportunity, especially for women. To facilitate smooth integration of OFSP into community diets, formative research is critical to ensure varieties meet both agroecological demands as well as palatability standards of communities (moisture, texture, and flavor). While model farmers are typical platforms for disseminating agriculture innovations, model mothers may be an analogous model for the development, testing, and dissemination of recipes that use OFSP, especially in the context of infant and young child feeding and maternal nutrition in pregnancy and during breastfeeding.

(4) Invest sufficient time, energy, and resources into the development and implementation of strong nutrition-focused SBC. For the projects presented here, this included the use of formative research and theoretically informed systematic approaches to inform intervention design and implementation. In addition, this also included investment in monitoring and qualitative process evaluations to assess fidelity and detailed participation/engagement issues, the latter of which allowed us to make needed course corrections. Finally, several projects tested innovative SBC approaches in the context of program delivery.

(5) Given that the goals of these projects include improved health and economic well-being of women and children, attention to gender norms and influences of these on participation and capacity to benefit from project participation is paramount. In the projects presented here, this attention to gender included not only strategies to engage husbands and other influential household members in support for women's participation but also understanding local agro-ecologies and farming systems and timing nutrition education and community engagement activities with agricultural planting and harvesting cycles to avoid additional burdens being placed on women. Further attention to gender in OFSP promotion programs and agriculture and livestock projects, more broadly, is needed to ensure projects do not increase women's time and labor burdens. Given women's time poverty and its implications for women's own health and well-being and that of their families [62], identifying and testing innovations to reduce women's time and labor burden should be a priority area for implementation research in nutrition-sensitive agriculture.

(6) Emphasize market-based demand generation. Having a marketing component contributes toward sustaining permanent adoption of OFSP, as the revenue generated is highly valued. Typically, the area under OFSP expands when the family engages in commercialization. In addition, the reach of the benefits of OFSP also expand to urban consumers as marketing campaigns create awareness of OFSP's health benefits. As mentioned earlier, care must be taken to balance market-centric approaches with SBC strategies that promote the consumption of OFSP and other nutritious foods among producer households.

(7) Use of program impact pathways/theory of change to guide all aspects of program design, implementation, planning, management, monitoring, and evaluation. Especially critical to program success was allowing the theory of change to be a living document that teams returned to frequently in planning and monitoring. In short, the ToC served as an ongoing to reinforce partners' contributions and responsibilities to achieving integrated project goals. As part of this, projects should include rigorous and routine monitoring with periodic qualitative process evaluation to capture not only how program implementation functioned and fidelity to the program model but also document engagement and participation by community members; this includes capturing information that allows for documentation of who participates, who does not and why as well as the role of household/gender dynamics in influencing participation; routine and periodic qualitative process evaluation can identify early on the potential of the project exacerbate disparities or exclude the most vulnerable due to opportunity costs or other barriers.

Despite the many lessons learned, there remain unknowns in terms of implementation best practices and innovations needed to enhance delivery, engagement, uptake, and impacts. For example, we have made great strides in understanding what the critical components are to ensure nutrition-sensitive agriculture achieves the anticipated diet-related behavior changes [61], but questions remain

Figure 3: The Healthy Baby Toolkit used in the Quality Diets for Better Health Project, SNNPR Ethiopia.

about the most effective delegation of roles and responsibilities for providing nutrition education across health and agriculture sectors [64]. Also, additional work is needed to understand how and whether behavior change, both in terms of agricultural practices and improved diets, are sustained over time. To date, there has been limited exploration on the long-term sustainability of OFSP promotion programs in terms of changes over time in how communities value OFSP, whether improved diet practices are sustained and/or amplified, and what health, economic, and food security impacts and tradeoffs occur with enhanced production over the longer term.

Second, can impacts be enhanced through integration of additional sectors, for example, education? If nutrition education and nutrition-sensitive agriculture practices, as life skills, were to be integrated into primary and early secondary school curricula, significant cost savings may be realized in the long term. These cost savings would be realized not only when taking nutrition-sensitive agriculture innovations to scale but also nutrition and health programs. Activities that integrate awareness of nutrition and nutritious diets into school based agriculture programs may be a practical strategy to support sustained and scalable change.

Another challenge to community-based nutrition-sensitive agriculture, including OFSP, is the cost per direct beneficiary. Sustainability and scalability is a function of cost balanced against returns on those costs. However, estimating costs and benefits of integrated programs is more challenging than for direct nutrition interventions such as supplementation. This complication arises not only because of the varied intersectoral costs to consider but also because of the myriad spillover benefits that go beyond health, for example, household food security, women's empowerment, and poverty reduction. Innovations in estimating cost-effectiveness and cost-benefit are needed to allow for the development of rigorous economic arguments that can be used in decision-making processes by governments regarding sustaining and scaling nutrition-sensitive agriculture innovations.

Abbreviations

ANC	antenatal care
ATVET	Agricultural Technical and Vocational Education and Training
CIP	International Potato Center
CHW	community health worker
DVMs	decentralized vine multipliers
EU	European Union
HEWs	health extension workers
IYCF	infant and young child feeding
MoA	Ministry of Agriculture
MoH	Ministry of Health

NGO	nongovernmental organization
OFSP	orange flesh sweetpotato
QDBH	Quality Diets for Better Health
SASHA	Sweetopotato for Security and Health in Africa
SNNPR	Southern Nation's, Nationalities' and People's Region
USAID	United States Agency for International Development
VA	vitamin A
VAD	vitamin A deficiency
VAS	vitamin A supplementation
VAEO	village agriculture extension officers
VISTA	Viable Sweetpotato Technologies in Africa

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