Building Nutritious Food Baskets

Situational Analysis Report for Biofortification and Biofortified Crops in Tanzania

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Abbreviations and acronyms

ADFNS	Africa Day of Food and Nutrition Security
AFCO	AfriCompassion Organization
AGRA	African Green Revolution Alliance
ANSAF	Agricultural Non-State Actors Forum
ARI	agricultural research institute
ASA	Agricultural Seed Agency
ASDP	Agriculture Sector Development Program
ASDS	Agricultural Sector Development Strategy
BNFB	Building Nutritious Food Basket Project
CAADP	Comprehensive Africa Agriculture Development Programme
CIAT	International Center for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
CIP	International Potato Center
DFID	Department for International Development
DHS	demographic health surveillance
DUS	distinctness, uniformity and stability
EAC	East African Community
ESAFF	Eastern and Southern Africa Farmers' Forum
ESDP	Education Sector Development Plan
FAO	Food and Agriculture Organization of United Nation
FARA	Forum of Agricultural Research in Africa
FGDs	focus group discussions
FONATA	Food and Nutrition Association of Tanzania
HIV/AIDS	human immunodeficiency virus/acquired immune deficiency syndrome
HKI	Helen Keller International
HPLC	high performance liquid chromatography
IFPRI	International Food Policy Research Institute
IITA	International Institute for Tropical Agriculture
INSET	National In-service Teacher Training
MATI	ministry of agriculture training institute
MARI	ministry of agriculture research institute
NBS	National Bureau of Statistics
NGOs	nongovernmental organizations
NNS	National Nutrition Strategy
NPT	National Performance Trial
NVRC	National Variety Release Committee
NFFA	National Food Fortification Alliance
NMNAP	National Multi-sectoral Nutrition Action Plan
OFSP	orange-fleshed sweetpotato
PABRA	Pan-Africa Bean Research Alliance
PANITA	Partnership for Nutrition in Tanzania
PER	public expenditure review
QDS	quality declared seed
QPM	quality protein maize
RAC	Reaching Agents of Change Project
RECODA	Research, Community and Development Associates
SADC	Southern African Development Community

SAGCOT	Southern Agricultural Growth Corridor of Tanzania
SARI	Selian Agricultural Research Institute
SUA	Sokoine University of Agriculture
SUGECO	Sokoine University Graduate Entrepreneurs Cooperative
SRI	Sugarcane Research Institute
SUN	Scaling Up Nutrition
TAHA	Tanzania Horticulture Association
TANSEED	Tanzania Seed International
TBS	Tanzania Bureau of Statistics
TDHS	Tanzania Demographic and Health Survey
TFC	Tanzania Food Composition
TFDA	Tanzania Food and Drugs Authority
TFNC	Tanzania Food and Nutrition Centre
TIE	Tanzanian Institute of Education
TOSCI	Tanzania Official Seed Certification Institute
ToT	training of trainers
UNICEF	United Nations Children's Fund
URT	United Republic of Tanzania
USAID	United States Agency for International Development
VISTA	Viable Sweetpotato Technologies in Africa
VAD	vitamin A deficiency
VCU	value for cultivation or use
WFP	World Food Programme
WHO	World Health Organization

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Executive summary

Micronutrient malnutrition, or hidden hunger, is a public health concern in Tanzania. In particular, nutritional anemia and iodine and vitamin A deficiencies remain the main nutritional disorders in the country. The prevalence of vitamin A deficiency is 33% among children under five years of age and 42% among women of reproductive age (TDHS, 2010). In addition, 17% of the children aged 6–59 months are underweight, 46% are stunted and 5% are wasted, reflecting acute or recent nutritional deficits (TDHS, 2016). An average of 58% of the children aged 6–59 months and 45% of the women aged 15–49 years are anemic (TDHS, 2016). The elusiveness of micronutrient deficiencies is compounded by the fact that deficiencies in most of the known micronutrients, specifically vitamins, trace elements and minerals, may display no outward signs or symptoms (Biesalski, 2013). Research shows that inadequate intake of micronutrients may have health consequences even without overt signs of disease (Biesalski & Black, 2016). Indeed, one of the enduring challenges of dealing with micronutrient deficiency is that one can be sufficiently fed and yet still be undernourished. It is for this reason that micronutrient deficiencies are commonly known as hidden hunger. Several approaches that complement one another are employed to address this complex problem in young children and women of reproductive age, including supplementation, food fortification, dietary diversification and biofortification. Biofortification is the process that involves breeding staple crops that are rich in micronutrients. It is cost-effective, sustainable and can easily be used among rural populations not easily reached by other interventions (Bouis & Saltzman, 2017).

The Building Nutritious Food Baskets (BNFB) project was formulated to help reduce hidden hunger by catalyzing sustainable investments for utilization of biofortified crops in Tanzania and Nigeria. In Tanzania, BNFB is focusing on three crops: orange-fleshed sweetpotato (OFSP), pro-vitamin A (PVA) maize and high iron and zinc beans. To better understand the gaps, define the priorities and develop the necessary interventions to address the issues affecting the scaling up of biofortification in Tanzania, the project conducted a situation analysis between October 2016 and May 2017. The primary aim was to gather analytical data and information that establish the baseline status of biofortified crops and nutrition in Tanzania. That information was needed to develop the national advocacy, seed systems and capacity building strategies and plans for 2016–2018 for the project. The study also aimed to identify the key actors in biofortification, to map out the gaps in ongoing complementary initiatives to which BNFB could contribute in closing, and to recommend the necessary action on issues affecting the scaling up of biofortification in the country.

Methodology

Secondary data were collected through a systematic content review of relevant policies, published and grey literature and strategic documents. Primary data were collected through consultations with 36 key informants and stakeholders working in the biofortification, nutrition, agriculture and health areas. These included research institutions, seed companies, civil society organizations, training institutions, traders, consumers, farmers, policy-makers, development partners, agroprocessors, food regulators, and BNFB consortium partners. Additionally, focus group discussions (FGDs) were conducted with farmers purposively selected based on their engagement in nutritious crops in Tanga, Shinyanga, Arusha, Mwanza, Kilimanjaro, Morogoro, Arusha, Pwani, Kagera, Iringa and Mbeya regions. A total of 111 farmers, 67 of whom were female, participated in the FGDs.

Key findings

The findings are analyzed and presented categorized by the three crops, namely, OFSP, PVA maize and high iron and zinc beans.

OFSP

- Six varieties of OFSP have been released in Tanzania, that is Kabode, Ejumula, Kakamega, Mataya Kiegea and UKG 05.

- According to OFSP farmers participating in the FGDs, the average area under OFSP production per household ranged from 0.1 ha to 1.62 ha with the highest recorded yield of 19.76 tons per hectare (ha).

- The two main factors affecting OFSP production in Tanzania were the shortage of quality planting materials and the low preference of OFSP compared with white varieties, owing to its low dry matter. Other factors included drought stress and lack of awareness on OFSP.

- The results indicate that the participating households consumed on average 35.3% of the OFSP they produced while the rest was sold. Overall, production and consumption of OFSP were growing in Tanzania, with 12% of the households in the sampled areas growing the crop.

- Compared to other biofortified crops, OFSP had better awareness and consumption in Tanzania. This is because it was introduced in the country much earlier than the other two crops. Moreover, the actors in the OFSP value chain were diverse. The pioneers in OFSP production in Tanzania are the International Potato Center (CIP), the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), HarvestPlus, the Tanzania Lake Zone Agricultural Research and Development Institute and Helen Keller International (HKI). Currently there are many others in the OFSP value chain such as the Crop Bioscience Solutions Ltd laboratory in Arusha, which is involved in the production of disease-free planting materials through tissue culture; World Vision-Canada; the Sugarcane Research Institute (SRI)-Kibaha; the Agricultural Research Institute (ARI)-Ukiriguru and ARI-Uyole, which are dealing with research and dissemination of OFSP; Sokoine University of Agriculture (SUA), which is involved in training; Njombe Agricultural Development Organization; Catholic Relief Services; Tanzania Horticultural Association (TAHA); the Research, Community and Development Associates (RECODA), which provides support to farmers through training on production technologies; and Viazi Lishe Company, Sokoine University Graduate Entrepreneurs Cooperative (SUGECO), and AFCO Investments, which deal with the processing and marketing of OFSP products.

- Over a period of about 4 years now, OFSP has attracted funding of approximately USD 11,457,682. About USD 4 million of this was raised by the Reaching Agents of Change (RAC) project. The main donors have been Bill & Melinda Gates Foundation and USAID, investing about USD 6.8 million and USD 3.6 million, respectively.

- Some of the challenges facing OFSP in Tanzania include its high susceptibility to diseases and pests; conflict between targeting the poorest farmers, who are the most susceptible to undernutrition, and catalyzing commercial production of OFSP; lack of standards of quality for processed OFSP products; and limited capacity in SUA to sustain and upscale the ToT course on 'Everything you ever wanted to know about sweetpotato'.

PVA maize

- The work on PVA maize in Tanzania is recent, and BNFB is the only project currently supporting research and dissemination of the crop. These efforts saw the release in 2016 of two PVA maize varieties by BNFB working in partnership with Meru Agro Company. These varieties were Meru VAH 517, with a beta-carotene level of 8 ppm, and Meru VAH 519, with a beta-carotene level of 14 ppm.

- More research is going on with various genotypes undergoing trials. For example, TANSEED International Ltd received three PVA maize genotypes from the International Maize and Wheat Improvement Centre (CIMMYT) and is bulking the seed for field evaluation.

- There is no commercial production of PVA maize seed in Tanzania at the moment, since it is barely one year since the varieties were released officially.

- Several challenges could potentially face PVA maize in Tanzania. Firstly, hesitation may occur among traders and farmers to invest in PVA maize owing to its little differentiation from yellow, cream or orange maize varieties, which are not necessarily biofortified. Secondly, maize seed and grain production remains unpredictable and significantly low in the changing climatic conditions, and this could discourage small and micro enterprises and large maize grain buyers. Thirdly, the promotion of PVA maize may be affected by cultural factors that might hinder its acceptance and therefore its consumption. For example, Tanzanians associate yellow maize with the relief food of the 1980s. To change this mindset for fast adoption of PVA maize, a lot of awareness creation is needed.

High iron and zinc beans

- Like with PVA maize, work on biofortified beans in Tanzania is just starting. Apart from the work and funding by BNFB, there are some complementary initiatives, particularly in breeding, on high iron and zinc beans supported through the Pan-Africa Bean Research Alliance (PABRA). Currently two high iron and zinc bean genotypes, namely MAC44 and RWV1129, are at an advanced stage in the national performance trial and are expected to be officially released this year. This research work is supported by BNFB.

- With the support of BNFB, multilocational trials for stability and adaptability tests also are going on for eight more high iron and zinc genotypes, which are RWR 2154, KAB06 F2-8-36, KAB06F2-8-35, CODMLB 001, NGWANKUNGWANKU, CODMLB 033, SMC 18 and SMC17.

- In regard to partnerships, CIAT is working on seed systems with the Agricultural Seed Agency (ASA), Meru Agro Company in Arusha, Beula Company, Agri-seed Company in Mbeya, and local seed entrepreneurs. It works in collaboration with local agricultural research institutes such as ARI-Selian, ARI-Makuru and ARI-Uyole, as well as the Ministry of Agriculture, Livestock and Fisheries, to provide training to farmers and researchers.

- The key constraints to private sector involvement in the beans business is the low market demand for bean seed. This is because bean is a self-pollinated crop and therefore its seed can be reused by farmers for several years with minimum loss in yield or quality. Another challenge that could face biofortified beans is that the two varieties lined up for release, MAC44 and RWV1129, are climbers. This could pose significant agronomic challenges for farmers in Tanzania who are accustomed to growing the bush varieties. Other important constraints include the low funding for the local research institutes to conduct field evaluation of new varieties.

- To scale up high iron and zinc beans in Tanzania, more effort is required to speed up research on new varieties and capacity building is needed for the actors in the bean sector on how to mitigate against diseases and pests, and for farmers on the appropriate agronomic practices for climbing bean varieties.

Extent of biofortification prioritization in national policies, laws, strategies, plans and budgets

Most of the national policies, strategies and acts of parliament do not explicitly cover biofortification. The National Agriculture Policy of 2013 (URT, 2013), the Agriculture Sector Development Strategy II (ASDS-II) of 2014 (URT, 2014a) and the Agriculture Sector Development Programme of 2016 (URT, 2016c) have statements on food-based approaches for addressing nutrition goals. The National Multisectoral Nutrition Action Plan (NMNAP) for July 2016–June 2021 (URT, 2016e) has statements on biofortification. The Tanzania Food and Nutrition Policy of 2015 (URT, 2016d) and the five-year strategy for the Ministry of Agriculture, Livestock and Fisheries (2016–2020) are currently under review. Effective advocacy efforts will ensure that biofortification is recognized as one of the interventions for addressing hidden hunger and that it will be explicitly mentioned in these two important documents. Moreover, it is recommended that advocacy efforts be accelerated to ensure that the Government of Tanzania places high priority on biofortification and increases national and local government budgets for the implementation of biofortification programs.

Government's funding priorities on nutrition and biofortification in the 2016/2017 budget

The national budget allocation for agriculture has been decreasing, going from 7.3% of the total government expenditure in 2012/13 to 4.4% in 2016/17. Nutrition sector allocations have been low, standing at 0.15%, 0.2% and 0.22% of the total government expenditure in 2010/11, 2011/2012 and 2012/13, respectively. These indicate that agriculture and nutrition are given low priority, which results in low budget allocations for nutrition programs and hence for biofortification. More advocacy is needed to sensitize decision-makers in the government to give higher priority to the agriculture and nutrition sectors. Moreover, it is recommended that additional funds be set aside to support biofortification, and that biofortification be given the priority level accorded to supplementation and food fortification.

Institutional and structural bottlenecks to address in order to unlock the value chain for biofortified crops

Scaling up of biofortification is hampered by capacity challenges that face important institutions in Tanzania. These include the absence of a high performance liquid chromatography (HPLC) machine at the Tanzania Official Seed Certification Institute (TOSCI) for speeding up the release of biofortified crops, lack of quality standards to support large-scale processing of biofortified crops at the Tanzania Bureau of Standards (TBS) and the duplication of food safety inspection protocols by TBS and the Tanzania Food and Drugs Authority (TFDA). It is recommended that BNFB, through its affiliates' laboratories such as those of HarvestPlus, should support local institutions such as TFDA, SUA and TBS to develop standards and controls for biofortified crops, set standard levels for various micronutrients such as beta-carotene, iron and zinc, and develop protocols for laboratory analysis of micronutrients. Fundraising for the acquisition of HPLC machines for TOSCI and TFNC is also recommended. Moreover, BNFB should support the training of technical staff in these areas and the provision of laboratory equipment for analysis of micronutrients locally.

Key recommendations

The following are the priority areas for BNFB to address in order to scale up biofortification in Tanzania:

- BNFB should support capacity building for agriculture research institutes (ARIs) to design, fundraise for, implement and monitor projects on biofortification. In this process, the development of OFSP varieties tolerant to diseases and pests and research for new varieties should be prioritized in order to expedite the release of promising genotypes of PVA maize and high iron and zinc beans.

- There is a low level of awareness and knowledge on biofortification in Tanzania and social and cultural misconceptions about the crops still persist. These affects both the consumption and adoption of biofortified crops. BNFB should engage in the promotion, training and awareness creation for biofortified crops and products. Events such as Nane Nane agriculture shows and mass media campaigns are particularly recommended to help shift attitudes. However, for effective and accurate messaging, it is recommended that training on biofortification, targeting media professionals be undertaken.

- PVA maize and high iron and zinc bean technologies are still low in the research pipeline, partly due to the complexities in the variety release guidelines and underinvestment. More efforts in research for new varieties and investments are needed to expedite the release of promising genotypes. BNFB should assist local researchers to fast track the release of new varieties by urging TOSCI to allow the use of distinctness, uniformity and stability (DUS) testing and national performance trial (NPT) reports from member states of East African Community (EAC) or Southern African Development Community (SADC).

- BNFB should facilitate the participation of medium and large-scale processors in the value chains of the biofortified crops. Drawing champions and advocates from the private sector to promote the processing of biofortified crops is recommended. Moreover, capacity building for food processors in biofortification, especially on the standards for processed biofortified crop products, product labeling, and application of the protocols for laboratory analysis of micronutrients, is a worthy investment.

- To improve the recognition in government plans and policy documents of biofortification as one of the key interventions for addressing hidden hunger, BNFB should participate in the processes for reviewing the Agriculture Sector Development Plan (ASDP), the five-year strategy of the Ministry of Agriculture, Livestock and Fisheries (2016–2020) and the Tanzania Food and Nutrition Policy (URT, 2016d) to ensure that they cover the biofortification agenda explicitly. Additionally, BNFB should strengthen the National Fortification Alliance by facilitating the inclusion of biofortification in its terms of reference.

- TBS and TFDA have standards for fortified processed products such as maize and wheat flour but not for processed biofortified products. Certification of products enhances their credibility and this is therefore a potential intervention area for BNFB.

- For the fiscal period 2016/17–2018/19 the government allocated Tsh 5.75 billion (USD 2.7 million) to support nutrition programs in 82 districts. It is recommended that BNFB advocate to regions and districts so that some of these resources are allocated specifically to biofortification programs. Potential donors that BNFB can approach for increased investments in biofortification are USAID, DFID/UK Aid, Irish Aid, the Monsanto Fund and McKnight Foundation. Additionally, advocacy among decision-makers will be important to improve the prioritization of biofortification interventions and budget allocation. Biofortification champions and advocates should advocate for more funding through the Ministry of Agriculture, Livestock and Fisheries to spur increased production of biofortified crops and their processed products.

- BNFB should build the capacity of strategic local councils and community-based organizations, faith-based organizations and other civil society organizations to design fundable projects through the ‘Project planning, implementation, monitoring and evaluation course’ designed under the RAC project.

- There is need to strengthen the national breeding program for biofortified crops so that appropriate and market-led varieties are developed, released and disseminated expediently. The recommended strategies to achieve this include advocacy for more investments in

breeding work; development of protocols that prioritize the development and release of biofortified crops; establishment of crop-specific strategies for screening potential promising lines or germplasm; screening and testing of potential lines; continuous capacity building for young scientists on breeding-related technical skills; and introduction of breeding for biofortified crops in the university/college curricula.

1. Introduction

1.1 Background

Micronutrient deficiency, otherwise known as hidden hunger, is one of the main silent killers of children under five years of age and women of reproductive age, i.e. 15–49 years. Most women of that age, infants and young children suffer from deficiencies in vitamin A, iodine, iron, zinc and folate. These deficiencies are associated with high mortality rates, birth defects, anemia, blindness, infertility, increased infections, reduced growth and cognitive defects. In Tanzania, the prevalence of vitamin A deficiency (VAD) is 33% among children aged 6–59 months (Fig. 1) and 42% among women of reproductive age (TDHS, 2010), while anemia prevalence among these groups is 58% and 45%, respectively (TDHS, 2016).

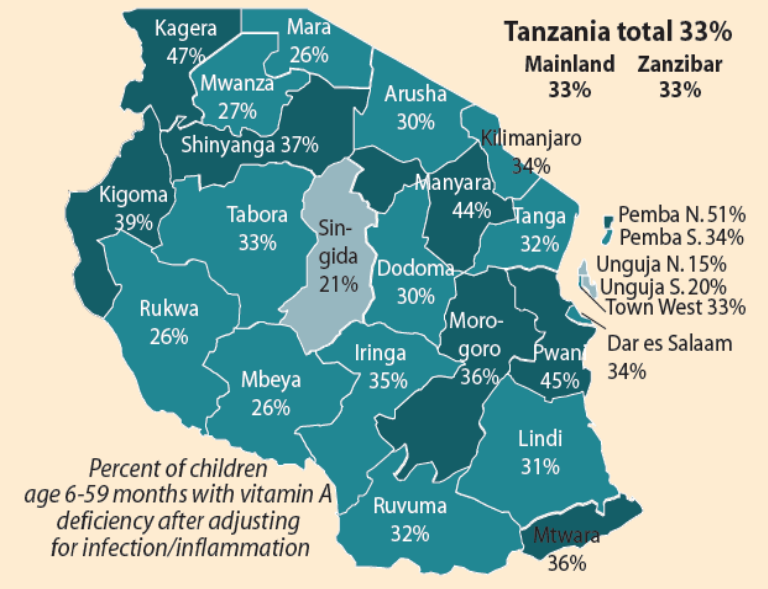

Figure 1: Percentage of children aged 6–59 months with VAD in Tanzania

Source: TDHS (2010)

The ravages of hidden hunger may be veiled but are dreadful nonetheless. For example, the damage malnutrition causes in the first 1,000 days of life is mostly irreversible (Anonymous, 2012). During pregnancy women often become more nutrition deficient with the requirement to provide nutrition for the baby too. This can impact their health and that of their baby (Haider & Bhutta, 2015). Widespread micronutrient deficiency has been associated with high maternal, perinatal and neonatal mortality rates; pre-term birth and stillbirth birth defects; maternal anemia; blindness; intra-uterine growth restriction; infertility; altered immune response; increased infections; and reduced growth and cognitive deficits in the newborn (Wessells et al., 2017).

To mitigate micronutrient malnutrition, nutrition education to promote the consumption of diversified diets, supplementation and food fortification are some of the classical strategies deployed in Tanzania. Although these strategies have attained results, they have several limitations. For example, for their success, these interventions require transport and logistical arrangements for the supplies to reach users, critical mass awareness, ability of users to buy the products, a vibrant manufacturing sector, and access to markets and health care systems, all of which are often not available to people living in remote rural areas (Mayer et al., 2008).

Tanzania is implementing a number of strategies to combat micronutrient malnutrition challenges in children and women of reproductive age. These include nutrition education focusing on the

provision of education on the consumption of specific crops such as carrots for vitamin A and sweetpotato leaves and amaranth for iron, or on the diversification of food to supply a wide range of micronutrients. Another strategy is food fortification, which involves the addition of micronutrients in food products. In Tanzania, mandatory large-scale food fortification focuses on maize and wheat flour and cooking oil at the industrial level. Micronutrient powders also are available to add to baby foods. However, such interventions are program specific and not countrywide. Micronutrient supplementation is focused on vitamin A primarily for children under five years and iron and folic acid for pregnant women. This is in line with the strategies of the dietary approach that focus on behavior change communication to promote the consumption of adequate amounts of micronutrient-rich food sources.

Biofortification is implemented in Tanzania although not across the country. It is adopted as an approach to complement the efforts to reduce micronutrient deficiencies. Biofortification is the process of breeding nutrients into food crops through conventional methods. It provides a sustainable, long-term strategy for delivering micronutrients to rural populations in developing countries (Saltzman et al., 2013). Evidence shows that biofortification offers the most effective, sustainable, least-cost delivery model to supply the micronutrients of nutritional importance, namely iron, zinc, vitamin A, lysine and tryptophan. For instance, consuming 125 g of most orange-fleshed sweetpotato (OFSP) varieties can supply the recommended daily allowance of vitamin A for children and non-lactating mothers (Waized et al., 2015). Some of the biofortified crops such as PVA maize and OFSP have been introduced in the country.

Although biofortification is yet to be fully scaled up in any country (Thompson & Amoroso, 2011), Tanzania has made some initial progress. The country was among the five countries that implemented the RAC project from 2011 to 2014. That project focused on advocacy for increased investment in OFSP to combat vitamin A deficiency (VAD) among young children and women of reproductive age and also built the institutional capacity to design and implement gender-sensitive projects to ensure wide access and utilization of OFSP. Through the RAC project, 17 country advocates were trained to engage in creating awareness and undertaking advocacy for investment in OFSP, and about USD 4 million was raised for OFSP, 3.2% of which came from local government authorities.

The Building Nutritious Food Baskets Project (BNFB) builds upon the successes of RAC to broaden the scope of biofortification by adopting a food basket approach. BNFB targets the three crops of OFSP, high iron and zinc beans and PVA maize. This three-year (2016–2018) project is funded by the Bill & Melinda Gates Foundation and is implemented by a partnership of six institutions, which are the International Potato Centre (CIP), International Centre for Tropical Agriculture (CIAT), International Maize and Wheat Improvement Centre (CIMMYT), International Institute for Tropical Agriculture (IITA), the Forum for Agriculture Research in Africa (FARA) and HarvestPlus, along with the Government of Tanzania through its national institutions, including the Sugarcane Research Institute - Kibaha, the Tanzania Food and Nutrition Centre (TFNC) and the Ministry of Agriculture, Livestock and Fisheries and its national agricultural research institutes. The project has two specific objectives:

- Strengthen the enabling environment for increased investments in biofortified crops;
- Strengthen institutional and community capacities to produce and consume biofortified crops.

Before embarking on the implementation of BNFB in Tanzania it was important to conduct a situation analysis. The primary aims of the situation analysis were to gather analytical data and information to establish the baseline status of the key thematic components of the project, identify the key actors, map out the gaps in the ongoing complementary initiatives that BNFB could add value to, and recommend the necessary action on issues affecting the scaling up of biofortification in the country.

1.2 Objectives of the situation analysis

1.2.1 General objectives

The situation analysis focused on gathering information to:

- Improve the understanding of the decision-makers and stakeholders working on biofortification in the country;
- Identify the causes of the slow uptake of biofortification;
- Identify mechanisms to support the national and decentralized planning and development processes, including influencing strategies, budgets and national policies to contribute towards creating an enabling environment for scaling up biofortification;
- Determine the current levels of funding and investments in biofortification from the development partners and the government;
- Analyze the extent to which biofortification was prioritized in national policies, laws, strategies, plans and budgets;
- Strengthen the knowledge base on the current consumption patterns of biofortified crops and their products;
- Map out the key actors, needs of the communities and bottlenecks to be addressed in order to unlock the value chains of the biofortified crops in the country and prioritize interventions that need to be implemented, and specifically identify the actors, needs and bottlenecks relating to advocacy and promotion of biofortification, seed systems, and institutional and individual capacity building and training opportunities;

1.2.2 Specific objectives

- Use available data and other information to accurately identify the key actors in the scaling up of biofortified crops and the trends and patterns of consumption of biofortified crops and their products, disaggregated by relevant segments of the country and of the population;
- Identify and analyze the barriers and bottlenecks that prevent disadvantaged groups from accessing and benefiting from biofortification, including the social, political and economic conditions that result in shortfalls in the creation of an enabling environment for the scaling up of biofortification;
- Assess the current investment patterns in biofortification and the main donors to approach to unlock increased investments for biofortification;
- Analyze the extent to which biofortification is prioritized in national policies, law, strategies, plans and budgets. This would include an analysis of the extent to which there is an enabling environment for the realization of the scaling up of consumption of biofortified crops, including the promotion of positive social norms and behaviors, organization of services, and enhancement of institutional capacities at the national, subnational and community levels;
- Analyze the government's (and its agencies') policy and funding priorities as far as nutrition and biofortification are concerned;
- Analyze the current institutional and structural bottlenecks to address in order to unlock the value chain for the biofortified crops in the country, including in the varietal release policies and criteria and for the biofortified varieties currently in the pipeline for release;
- Assess the needs of the population/communities and the bottlenecks/gaps to be addressed, and prioritize the interventions that need to be implemented, such as advocacy, promotion, seed systems' strengthening, and institutional and individual capacity building and training opportunities;
- Assess the potential sociocultural factors, including consumer perception and attitudes, affecting the adoption and use of biofortified crops;
- Assemble key information on the efficacy of biofortified foods, for evidence-based advocacy and policy formulation;
- Identify the key national and regional advocacy platforms actively focusing on biofortified foods.

2. Literature review

2.1 Agriculture in Tanzania

Tanzania's economy grew steadily between 2014 and 2016 at an average annual rate of about 7% driven by the robust growth in the financial services, construction, mining, trade, and telecommunication sectors. However, poverty remains prevalent and stagnant with 43.5% of the Tanzanian population living below the international poverty line of USD 1.25 per day (UNDP, 2016). Poverty can lower the purchasing power to acquire adequate and nutritious food, leading to both macronutrient and micronutrient deficiencies and overall undernutrition (Mwanri, 2013).

Agriculture accounts for 31.1% of the GDP and employs 68% of the workforce living in rural areas (World Bank, 2017). Given its role as the main source of food and livelihood for the majority in the country, the agriculture sector has substantial potential to reduce poverty and food insecurity. However, agriculture in the country is mainly performed in small-scale farming, which adversely affects its level of productivity. Several challenges affect agricultural productivity including low public investment in agricultural research and development, inadequate agricultural financing, poor production techniques, underdeveloped markets and market infrastructure, low farm-level value addition, and poor rural infrastructure.

2.1.1 National budgetary allocation for agriculture

The level of budget allocation for agriculture in relation to other priority sectors for 2015/2016 and 2016/2017 is shown in Fig. 2. For the two years, the transport sector had the highest budget followed by education, health, agriculture, energy and water. These allocations indicate that the agriculture sector is given a low priority despite its centrality in driving economic growth and development in the country.

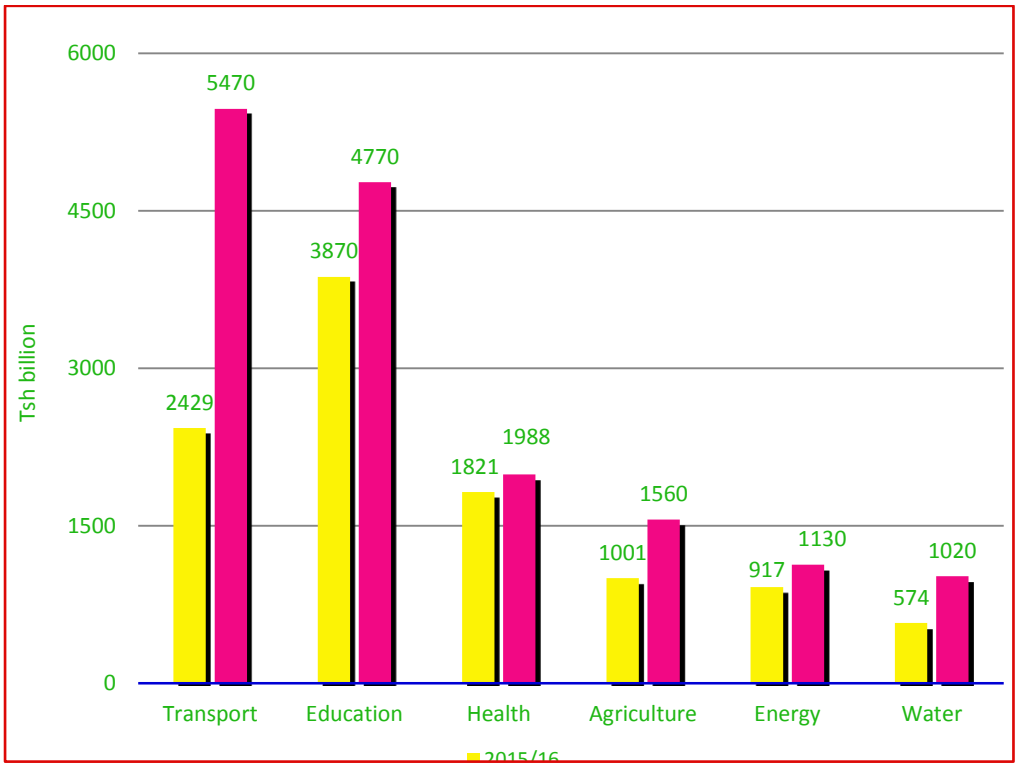

Figure 2: National budget allocation by sector from 2015/2016 to 2016/2017

Source: Budget speeches and Citizens Budget (2016/17)

The Government of Tanzania is a signatory to the Maputo Protocol (2003),[1] which requires governments to allocate at least 10% of the national budget to agriculture. The agriculture sector budget was below 10% of the national budget[2] for each year from 2012/13 to 2015/16, and it showed a declining trend, going from 7.3% in 2013/2014 to 4.4% in 2015/2016 (Table 1).

Table 1: National budget for agriculture between 2013 and 2016

Financial year	Total national budget (Tsh billion)	Total budget for agriculture (Tsh billion)	Share of the national budget allocated to agriculture (%)
2012/2013	15,191.94	1,103.60	7.3
2013/2014	18,248.98	909.10	5.0
2014/2015	19,853.33	1,084.70	5.5
2015/2016	22,495.50	1,001.40	4.4

Note: Tsh 2,100 = 1 USD approximately.

Source: Compiled from national budgets from 2012/2013 to 2015/2016

The resource allocations to key investment areas within the agriculture sector for 2015/16 and 2016/17 are shown in Table 2. The 2015/2016 budget shows high investment in rural electrification, input supply to smallholder famers, and borehole drilling and dam construction respectively. Biofortification can benefit from this budget, particularly from allocations to research and input supplies to small-scale farmers, which largely include subsidies. Currently, the government provides subsidies on maize seed. This means that subsidies can be directed to PVA maize, which meets both the staple crop and nutrition crop criteria.

Table 2: Resource allocation to key investment areas within the agriculture sector for 2015/16–2016/17

Key investment areas	2015/16 (Tsh billion)	2016/17 (Tsh billion)
Rural electrification	378.1	587.6
Borehole drilling and dams construction	42.2	38.8
Warehouse and markets	7.2	79.54
Inputs to smallholder farmers	96.1	25
Investment in large-scale plantations	7.9	3
Irrigation infrastructure	7.1	NA
Research	7.1	21.7
Rural roads (transfer to local government authorities)	34.12	50.96

Note: Tsh 2,100 = 1 USD approximately.

Source: Compiled from Citizens' budget and budget speeches for 2015/16 and 2016/17.

[1] In Maputo, Mozambique (2003), the African Union (AU) Summit made the first declaration on creating the Comprehensive Africa Agriculture Development Programme (CAADP) as an integral part of the New Partnership for Africa's Development (NEPAD). CAADP is Africa's policy framework for agricultural transformation, wealth creation, food security and nutrition, economic growth, and prosperity for all.

[2] Excluding the resources allocated at the local council level.

2.1.2 Food security situation

The Tanzania population was estimated to be 44.9 million in 2012 (URT, 2013). The current population is estimated to be 57.8 million (United Nations, 2017). About half of the country's total harvested land is allocated to cereals, of which maize is dominant as the staple food crop. Maize yields are typically low at 0.75 t/ha. Roots, i.e. cassava and potatoes, account for 15% of the harvested land (WFP, 2013). The annual production of cassava fresh root is about 5 million tons, with a productivity of 8 t/ha, while the average sweetpotato yield is 4.5 t/ha. These productivity levels are below the crops' potential, which according to Pima (2015) should be at least 20 t/ha for cassava and 10 t/ha for sweetpotato.

Tanzania ranks 96th out of the 118 countries on the 2016 Global Hunger Index (IFPRI, 2016). The food security and vulnerability assessment conducted in the country shows that in 2010/11, 730,000 households, or 8.3% of all households in Tanzania, were classified as having poor dietary intake. Moreover, 18% of households were classified as having poor dietary diversity, and 52% as directing a high share of their expenditures to food, indicating that the country had a high level of economic vulnerability (WFP, 2013).

2.1.3 Health and nutrition status

Like any other developing country, Tanzania is faced with the double burden of malnutrition with high levels of undernutrition, which is more pronounced than overnutrition. Micronutrient deficiencies are of public health importance, including deficiencies of vitamin A, iron and iodine. These are more pronounced among children under five years and women of reproductive age. The nutrition status and anemia in children and women of reproductive age is shown in Table 3. Although the levels of stunting in children have dropped significantly from 42% in 2010 to 34% in 2016 (TDHS, 2016), they are still unacceptably high. The National Multisectoral Nutrition Plan 2016–2021 targets to reduce stunting to 28% by 2021 (URT, 2016e).

Table 3: Nutrition status among children and women of reproductive age in Tanzania

Nutrition	Tanzania	Urban	Rural
Prevalence of stunting among children (6–59 months) (%)	34	25	38
Prevalence of underweight among children (6–59 months) (%)	14	9.1	15.2
Prevalence of wasting among children (6–59 months) (%)	5	3.8	4.7
Prevalence of anemia among children 6–59 months (%)	58	54	59
Prevalence of anemia among women of reproductive age (15–49 years) (%)	45	45	45
Prevalence of thinness among women of reproductive age (15–49 years) (%)	9.5	7.3	10.6
Prevalence of breastfed children aged 6–23 months receiving a minimum acceptable diet (%)	9.8	13.2	8.6
Prevalence of women age 15–49 overweight or obese (%)	28	42	21

Source: TDHS (2016)

2.2.5 Addressing micronutrient deficiency

Micronutrient deficiencies are certain to occur wherever diets lack diversity. The common interventions implemented to alleviate these deficiencies in Tanzania include supplementation, food fortification and promotion of dietary diversity. Biofortification is gaining increasing recognition.

Food fortification

The Tanzania National Health Policy (2003), together with the National Nutritional Strategy of 2012, identifies food fortification as among the strategies to reduce micronutrient deficiencies in the

country. The Government of Tanzania passed a legislation in 2011 (Notice No. 205 of 22 July 2011) that makes fortification of cooking oil and wheat and maize flour mandatory in the country. The legislation was gazetted in 2012, when the government in collaboration with the private sector, mainly food industries, started its implementation (HKI, 2012a). Small-scale or rural area fortification is also practiced in some program-specific areas in Tanzania.

Supplementation

In 1987 Tanzania began including vitamin A capsules in kits distributed through the essential drugs program in government-run primary health care facilities. To increase coverage, vitamin A supplementation was introduced in routine immunization services in 1997. Periodic dosing of vitamin A supplements is provided to children aged 6 to 59 months, usually every six months (TFNC, 2012). This is one of the many deliberate strategies to reduce child morbidity and mortality and enhance child survival. Children aged 6–11 months receive 100,000 IU of vitamin A as droplets and those aged 12–59 months receive 200,000 IU. The coverage of vitamin A supplementation among children aged 6–59 months is 41% (TDHS, 2016).

Iron and folic acid supplementation targeting pregnant women and children is done through the reproductive and child health clinics. Supplementation occurs concurrently with the promotion of the production and consumption of iron and vitamin C rich foods, i.e. through education and provision of resources for the production of food crops known to contain high levels of iron, and through the public health measures for the control of malaria and worm infestations implemented by the parasite control program of the Ministry of Health.

Dietary diversification

Studies on dietary diversity in Tanzania show almost consistent results indicating that Tanzanians in general consume poor quality diets. For instance, a study conducted in the Morogoro region established that the majority of the households consumed foods in the cereals group in relatively large quantities compared with other food groups. A stiff porridge made of maize flour (ugali) was the most often consumed cereal dish followed by rice. The study established that the consumption of protein from animal sources was significantly low in all districts (Kinabo et al., 2016). In another study among rural women from three districts in northeastern and central Tanzania, one third of the participants had an alarmingly low dietary diversity score of only two to four food groups per day. The findings indicated that research participants and their households consumed a very basic diet consisting mainly of cereals and vegetables (Keding et al., 2012).

Increasing food production all year round adopting a food basket approach is needed to achieve nutritional improvement in the country. This can be realized through collaboration across sectors and wide application of innovations and approaches proven to solve nutritional problems. Additionally, nutrition education is necessary as it offers an important link in attaining the desired changes. Its implementation targets should include increasing awareness and knowledge among policy-makers and the public, promoting the desired behavior regarding food and nutritional practices, and increasing the diversity, quality and quantity of family foods.

Biofortification

Biofortification forms an important component in strengthening the dietary diversity base. Biofortification as an intervention is fairly recent in Tanzania. Biofortified crop varieties for PVA maize and OFSP have been released officially in the country. Efforts to release biofortified iron and zinc beans are going on. Biofortification as an approach provides important opportunities and advantages: it is a sustainable and long-term strategy for delivering micronutrients to rural populations (Saltzman et al., 2013) and it is also cost-effective.

2.3 Scaling up nutrition in Tanzania

Hartmann and Linn (2008) define scaling up as "expanding, replicating, adapting and sustaining successful policies, programs or projects in geographic space and over time to reach greater number of rural people". The concept refers to any form of expansion of an intervention as a means to achieve widespread benefits for the population, and it is not an end in itself. Gillespie et al. (2015) report nine elements central to the scaling up of the impact on nutrition:

- Having a clear vision or goal for impact;
- The nutrition-relevant action(s) to be scaled;
- Creating an enabling organizational context for scaling up;
- Establishing the drivers such as catalysts, champions, systemwide ownership, and incentives;
- Choosing contextually relevant strategies and pathways for scaling up;
- Building operational and strategic capacities;
- Ensuring adequacy, stability and flexibility of financing;
- Ensuring adequate governance structures and systems;
- Embedding mechanisms for monitoring, learning and accountability.

Translating the current political commitment to nutrition into large-scale impact on nutrition will require committed attention to these elements.

Tanzania joined the Global Movement on Scaling Up Nutrition (SUN Movement) in June 2011 and committed to improving nutrition in the country at scale. This was solidified by former President H.E. Jakaya Kikwete's membership in the SUN Movement Lead Group. Given the multisectoral nature of nutrition interventions, the Prime Ministers' Office, where the country SUN Movement focal person is based, was identified to lead the county's nutrition coordination.

The SUN Movement's focal person prioritized three areas for scaling up nutrition in Tanzania, which were the translation of priority nutrition objectives into planned activities and budget allocations on an annual basis, the improvement of the capacity for nutrition at regional and district levels, and the finalization and costing of the National Nutrition Strategy (TFNC, 2012). That strategy ended in 2015 and was replaced by the National Multi-sectoral Nutrition Action Plan (NMNAP), 2016/17–2020/21. The role of NMNAP is to guide the government and its partners in nutrition in the implementation and scaling up of high impact interventions to improve the nutritional status of all Tanzanians. NMNAP is divided into three components, based on its areas of focus:

- **Nutrition-specific interventions**. These interventions address the causes of malnutrition at the immediate causal level. NMNAP has costed implementation plans to scale up (1) promotional services for infant and young children feeding, (2) key interventions to fight micronutrient deficiencies, i.e. vitamin A deficiency, iodine deficiency and iron deficiency, (3) services for the integrated management of acute malnutrition, and (4) management of diet-related non-communicable diseases.

- **Multisectoral nutrition response.** This component addresses the causes of malnutrition at the underlying and basic causal levels. To avoid duplication of other sectoral plans on nutrition, NMNAP focuses on multisectoral coordination, advocacy and capacity building activities with the aim of creating synergies between nutrition and interventions with proven impact on nutrition in the key sectors of health, including family planning and HIV/AIDS; water, sanitation and hygiene; food security and agriculture; education, including early child development and school nutrition; and social protection.

- **Multisectoral nutrition information system.** This component is designed to track the progress on nutrition through regular national nutrition surveys and reviews such as demographic health surveys, multisectoral nutrition scorecard and nutrition sector reviews.

2.4 Adoption of certified seed and seed systems

Both the public and private sectors are engaged in seed systems. The public sector is involved in formulating regulations and their enforcement and producing and marketing seed, whereas the private sector is more focused on seed production and marketing. As at May 2013, there were 55 private companies engaged in seed systems, and they were coordinated through the Tanzania Seed Trade Agency, which was formed in 2002 (ESAFF, 2013).

Tanzania has a total of 14,642,284 ha of arable land. Maize is considered a priority crop and it occupies 41% of the farm land, while beans occupy 750,000 ha and sweetpotatoes 200,000 ha (ASARECA, 2014). It is estimated that 5.3% of the total cultivated area in Tanzania is planted with certified seeds. Certified seed is available mainly for maize, sorghum, sunflower, rice and wheat. Private seed companies have been producing and marketing certified seed in Tanzania since 1989, particularly for maize. Private agrochemical dealers mainly sell certified seeds. Other seed types including for legumes, sorghums and some amount of maize are produced by the Agriculture Seed Agency (ASA), community-based organizations or members of farmers' associations such as Matandao wa Vikundi vya Wakulima Tanzania and Tanzania Farmers' Association. These are engaged in the production of contract certified seed and quality declared seed and their distribution (ASARECA, 2014). The volume of imported and domestically produced certified seed from private sources from 2007/08 to 2011/12 was estimated at 16,545 t. It was estimated to reach 33,000 t by 2015/2016 (USAID, 2013).

3. Study approach and methodology

3.1 Study approach

A participatory approach was adopted to conduct the situation analysis for BNFB. The study engaged the participation of potential project partners, policy-makers, agricultural research institutes, training institutes, agricultural extension officers, farmers, development partners, private companies, civil society organizations, regulators, traders and consumers. During the consultation process, qualitative information was collected using checklists tailor made to target each category of stakeholders.

3.2 Description of the study areas

The study areas for the situation analysis were identified by considering three factors: (1) the presence in the area of farmers who had adopted any of the biofortified crops targeted for intervention under BNFB, i.e. OFSP, PVA maize or high iron and zinc beans, (2) the existence of recognized actors in a specific biofortified crop value chain, and (3) the area's convenience in accessibility. The identification of the study areas where FGDs were undertaken was made by considering available information from literature, project related documents, the researchers' experience and prior information on the areas where interventions on biofortified crops had been implemented. The situation analysis covered locations in four agricultural zones with different agroecological zones. The Eastern Zone was selected for PVA maize; the Eastern, Northern, Lake Victoria and Southern Highlands zones for OFSP; and the Northern, Southern Highlands and Eastern Zones for high iron and zinc beans. Overall the study covered 11 regions and 18 districts and municipalities. Appendix 1 shows the stakeholders consulted in the districts/municipalities.

3.3 Techniques

3.3.1 Document review

The study included a systematic review of the national policies and strategies and documents related to BNFB project.

National policies and strategies

A total of eight policy documents, seven strategies and one act of parliament were reviewed (see Appendix 2) to determine the extent to which they mainstreamed or articulated issues of biofortification.

RAC and BNFB project documents

Ten project documents on BNFB and RAC were reviewed. The goal was to get a good understanding of the current project and facilitate interpretation and discussion of the findings of the situation analysis. The BNFB project documents that were reviewed are listed in Appendix 3.

Key informant interviews

Key informants from the BNFB consortium partners, government ministries and departments, development partners, NGOs, national agricultural research institutes and private sector companies were purposively selected for consultation, based on the guidance from the BNFB project. In total, 36 individuals were consulted/interviewed. The list of the institutions represented is available in Appendix 4.

Focus group discussions

Focus group discussions (FGDs) were held with small groups of farmers engaged in the production of maize, beans or OFSP. A checklist was prepared and used as a guide to collect information. The items on which information was collected included sources of biofortified crops, advantages of biofortified crops, area under biofortified crop production, volume of biofortified crop production, markets for biofortified crops, consumption patterns for biofortified crops, and barriers along the production value chain of biofortified crops. FGDs with farmers was conducted in Mkanyageni village in Muheza district, Igomaa village in Mufindi district, Kalenga village in Iringa Rural district, Msomera village in Handeni district, Ihanda village in Mbozi district, Madege village in Gairo district, Ibuti village in Gairo district, Musozi and Malegea in Ukerewe district, Nyafla village in Ilemela district, Mwasonge village in Misungwi district, Tengeru village in Arumeru district, Matanzi village in Mkuranga district, Balairuba village in Bukoba district and Ibingo village in Shinyanga Rural district. In total the FGDs in the 15 districts had 111 participants, 44 of whom were male and 67 were female (see Appendix 5).

3.4 Sampling techniques

Participants in both the FGDs and key informant interviews were purposively selected. The FGD groups represented farmers mainly and agricultural extension officers to a lesser extent. The participants in the FGDs were randomly selected from the participating villages. However, the selection process considered the representation of both female and male farmers. Participants in the key informant interviews were selected based on their role in the agriculture, nutrition, education and health sub-sectors.

3.5 Data collection tools

Ten checklists were developed targeting the diverse categories of the institutions and groups identified, which were development partners, implementing partners, civil society organizations, consumers, farmers, food processors, food regulators, policy-makers, research and training institutions, seed companies, and regulators. A guide for the farmers' FGDs also was developed.

3.6. Data processing and presentation

The information collected was extracted from the checklists for each group of key informants and FGDs and entered into Excel spreadsheets. The information, which was mainly qualitative, was analyzed and synthesized using content analysis. The results of the analysis were presented in narrative format. Data obtained from the secondary sources were used to reinforce, qualify and triangulate the information from the primary sources.

3.7 Limitations of the study

The areas for field data collection were selected by considering their accessibility and existence of established contacts of key informants. For example, a farmers' FGD was conducted in Mbozi district in Mbeya region instead of Chunya district, although the latter could have been producing more OFSP. The wide geographical area in which biofortified crops are found, especially OFSP, and the limitations of time and funds made it impractical to conduct household interviews.

The absence of released biofortified varieties of beans and the recent release of PVA maize meant that there were inconsistencies in the depth of information and coverage among the targeted biofortified crops.

Data on government investments in agriculture (section 2.1.1) were not sufficiently disaggregated to show the specific allocations for agricultural activities at the local councils' level. Caution should therefore be taken in interpreting those data.

The primary data on OFSP (Appendix 7) were self-reported by a small sample of the farmers who participated in the FGDs. The data may therefore not be representative of the OFSP farmers in the districts. Additionally, the data on the productivity of and on the area planted with OFSP may be contentious. This is because most sweetpotato farmers harvest the crop piecemeal (Stathers et al., 2012) and often misreport acreage (World Bank, 2013).

4. Key findings

4.1 OFSP

OFSP roots (photo: Godfrey Mulongo)

4.1.1 Trends and patterns of the consumption of OFSP

Tanzania is the second largest producer of sweetpotato (*Ipomoea batatas* Lam.) in East Africa after Uganda, with an annual production of about 1 million tons (FAOSTAT, 2014). The production of sweetpotato increased from 1.3 million tons with productivity at 2.9 t/ha in 2007 to 3.5 million tons with productivity at 4.4 t/ha in 2014 (FAOSTAT, 2014) (Appendix 6). This rise in yield may partly be due to the increasing production of OFSP, which according to farmers' FGDs was replacing the traditional sweetpotato varieties.

Six varieties of OFSP were released between 2010 and 2016, namely Kabode, Ejumula, Kakamega, Mataya Kiegea and UKG 05. The agronomic characteristics of these varieties are summarized in Table 4. Moreover, CIP in partnership with the Sugarcane Research Institute (SRI), Kibaha, has seven other varieties currently undergoing evaluation for official release. These are SPKBH 06/266, NASPOT 13, SPKBH 06/676, NASPOT 9, G40_02, SPKBH 03/03 and ex-Luambano.

The estimates by the farmers interviewed on the area under OFSP cultivation and the yield of OFSP roots per household are shown in Appendix 7. The average area under OFSP ranged from 0.1 ha to 1.62 ha per household. The major factors that affected the area put under OFSP cultivation, the crop's yield and the number of households engaged in its production were shortage of planting materials and drought stress caused by delayed planting. According to ARI Ukiriguru, the production of OFSP had been increasing proportionally with the availability of planting materials. The production status of OFSP is shown in Appendix 7.

Table 4: Characteristics of released OFSP varieties

Variety	Beta-carotene content µg/100 g fwb	Maturity period	Root yield productivity (t/ha)	Dry matter content (%)
Kabode	11,030	4 months	16	30.5
Ejumula	7,760–14,370	4 months	14.7	33
Kakamega	3,760	4 months	16.5	32
Mataya	5,000–6,000	3–4 months	13	25–30
Kiegea	1,500–2,000	3–4 months	13	25–30
UKG 05	2071	4 months	12	31

The average yield levels and forms of OFSP consumed by the households participating in the study are summarized in Appendix 8. The survey results indicate that 35.3% of the roots produced was consumed by the household (Appendix 8). Overall, the situation analysis established that the production and consumption of OFSP were growing in Tanzania. Earlier studies in a few districts across the country indicated that the level of adoption of OFSP was lower than 2% (e.g. Okello et al., 2017; VISTA, 2016; Waized et al. 2015)[3]. However, this study found that in the districts where the crop had been introduced, adoption rates were at 12%. Moreover, compared to the other biofortified crops such as high iron and zinc beans and PVA maize, OFSP was relatively well known and consumed in Tanzania. This is because it was introduced in the country much earlier than the other two. Fig. 3 shows the households producing OFSP in the sampled sites.

[3] A study conducted in the Lake Zone in 2012 found that of more the than 600 households surveyed only 7% and 2% grew and consumed OFSP, respectively (Waized et al. 2015). A VISTA baseline survey conducted in 2015 covering 549 households in Gairo, Ulanga Iringa, Mbozi, Wanging'ombe and Chunya districts found out that only 0.4% of the households consumed OFSP. Another survey covering 732 households in Mara, Mwanza, Shinyanga and Kagera found that only 2% of the households consumed OFSP (Okello et al., 2017)

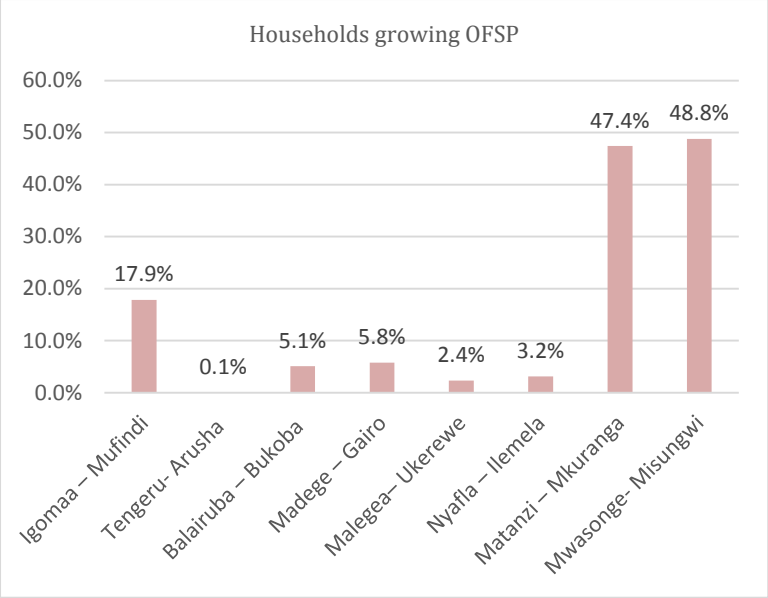

Figure 3: Households growing OFSP

4.1.2 Key actors in OFSP

The beginning of the work on OFSP in Tanzania can be traced to around 2005 when ASARECA, HarvestPlus and CIP, through the Regional Potato and Sweetpotato Improvement Programme in Eastern and Central Africa, began supporting national breeding efforts for OFSP. The first important development project, DONATA (2008–2013), was funded in 2008, covering the Lake Zone. That project was implemented by the Tanzania Lake Zone Agricultural Research and Development Institute with backstopping from CIP. It was followed by the Scaling up of OFSP Using the Agricultural Innovation System Approach project in Kagera region (2012–2013), which introduced a more systematic value chain methodology. In the more recent past, CIP and Helen Keller International (HKI) implemented the RAC project from June 2011 to December 2014. Among the key partners in RAC were Sokoine University of Agriculture (SUA) and SRI-Kibaha. RAC and its implementing partners and advocates helped to raise a total of USD 4,033,501.50 for OFSP projects in Tanzania, with 2.76% of this coming from the local government. RAC built the capacity of SUA to conduct the 10-day ToT course on 'Everything you ever wanted to know about sweetpotato'. To have a critical mass of farmers producing and consuming OFSP, RAC applied a cascading model for capacity development, where experts in agriculture, nutrition, health, marketing and gender were trained in a 10-day workshop facilitated by CIP, HKI and other national experts after which they became the facilitators for shorter and contextualized ToTs for various levels of audiences, including colleagues, extension officers and decentralized vine multipliers. This upscaling approach ensured that the training was cascaded down to farmer trainers, who then trained the end-users in their communities. This training model saw RAC train 3,000 agents of change, 51.4% of whom were female. Moreover, RAC facilitated the expansion of the area under vine multiplication in Tanzania, which increased the vines harvested from the primary sites. In total, 4.2 ha of clean primary vines were established and maintained during the three years of RAC. The vines were distributed to decentralized vine multipliers and farmers, who established 12.1 ha of vines, enabling 1,155 households to receive OFSP vines.

Currently CIP is implementing the VISTA project in partnership with local research institutions such as SRI-Kibaha, ARI-Ukiriguru, ARI-Uyole and SUA among others. The VISTA project was designed to expand the production and utilization of nutritious OFSP in seven districts in Mbeya, Iringa and Morogoro regions. It provides training to community health workers and local government and district nutrition officers on nutrition education, counseling and agronomic practices, as well as

distribution of OFSP planting materials. VISTA partners with SUA in building the capacity for OFSP production and utilization. Through the project, 713.3 ha of OFSP have been established in Tanzania. The VISTA project is funded by USAID-Feed the Future at a level of USD 3 million. The Bill & Melinda Gates Foundation is supporting the implementation of the activities to scale up biofortification to reduce hidden hunger through the BNFB project with USD 5 million funding for both Tanzania and Nigeria over three years. Moreover, CIP is also collaborating with the Mikocheni Agricultural Research Institute on the development of low cost virus disease diagnostic kits for sweetpotato. Additionally, CIP is collaborating with the African Green Revolution Alliance (AGRA) in providing technical backstopping to the national sweetpotato breeding programs, including in capacity building and in providing scholarships for breeders.

Other OFSP projects include a SRI-Kibaha four-year project, funded at USD 4.8 million for two countries, that is piloting the use of rural primary school-going children as a mode to fast track the access to improved sweetpotato varieties in Tanzania and Uganda. The Tanzania Lake Zone Agriculture Research and Development Institute has been implementing a three-year project ('Keeping disease free vines closer to the farmers' or 'Kinga Marando'), which aims to validate the efficacy of the net tunnel technology for vine multiplication by farmers. The Marando Bora project was implemented between 1999 and 2012 in the Mara, Mwanza, Shinyanga and Kagera regions.

Farm Africa is working on an OFSP project that targets 3,000 farmers in 10 villages in the Morogoro region of Tanzania. The Big Lottery project, funded at about USD 0.6 million, aims to better the livelihoods and incomes of farmers through improving the production, processing and marketing of OFSP.

A number of NGOs and private sector companies in Tanzania are involved in various components of the OFSP value chain. The Crop Bioscience Solutions Ltd's laboratory in Arusha is involved in the production of disease-free planting materials through tissue culture. World Vision-Canada, SRI-Kibaha, ARI-Ukiriguru, ARI-Uyole, Sokoine University Graduates Entrepreneurs Cooperative (SUGECO) and some individual farmers undertake decentralized vine multiplication. The Njombe Agricultural Development Organization, Catholic Relief Services, the Tanzania Horticultural Association (TAHA) and RECODA provide support to farmers through training them on production technologies for OFSP (see Appendix 9 for the key OFSP stakeholders). TAHA provides training to farmers on OFSP production in the Arusha region, and according to the TAHA advocacy manager, the cumulative value of their support on OFSP over the past three years is estimated at Tsh 150 million (USD 68,902). According to Match Maker Associates (2017), TAHA is also developing a satellite commercial production business model for OFSP in Tanzania linked to an Israel-based offtaker, Mehadrin Group. Also, TAHA has acquired more than 162 ha of land in northern Tanzania and has trial production of OFSP going on. RECODA supports farmers in the Northern zone and Singida region on OFSP farming through training and seedling production in mini tunnels, an expenditure with a cumulative value of Tsh 57 million (USD 26,183) in 2016. The Tanzania Home Economics Association and the KOLPING Society of Tanzania provide training to farmers on processing of OFSP. The Viazi Lishe Company and SUGECO are involved in processing OFSP products. Their main products are flour, crisps and biscuits. AFCO Investments produces VITA flour, which contains OFSP ingredients and is available in supermarkets such as Shoppers, A to Z, Homes Super Market, Americana, Mobile Plaza, and Shop and Save in Upanga. The Matoborwa Company in Dodoma has plans to add OFSP products to the sweetpotato products it processes, which are chips from white-fleshed and cream-fleshed sweetpotatoes. Other OFSP stakeholders include ARI-Hombolo, for seed production, research and value addition; Mennonite Economic Development Associates, for seed production; World Vision Canada, for seed systems; and Farm Radio International for OFSP promotion through radio.

4.1.3 OFSP value chain

Temu et al. (2014) observe that the OFSP value chain in Tanzania, and indeed for the entire sweetpotato crop, is still 'short', non-diversified and composed primarily of micro- and small-scale enterprises that mostly handle both processing and retailing. Another of their observations is that the national supply chains for OFSP in Tanzania have only recently come into being and have few specialized linkages, such as those with contract farming schemes.

Input suppliers

The main inputs procured by OFSP farmers from input suppliers are seeds or vines. OFSP vines are mostly obtained from informal suppliers. Mmasa and Msuya (2012) aver that input suppliers are not vertically integrated with producers and that farmers normally search for seeds for planting from their fellow farmers and seldom from recognized sources. ARIs are key formal suppliers of OFSP vines. Other input suppliers are TOSCI, for variety release, and NGO programs, for outreach. Village-based vine multipliers also are important informal suppliers. The supply of good quality vines is the critical constraint for OFSP value chain development. Other service providers for sweetpotato growers include oxen and tractor owners, who provide farm tillage services to farmers (Mmasa and Msuya, 2012).

Producers

OFSP root production is undertaken by individual producers who largely are small scale, so the quantities produced are still too low especially for large-scale agroprocessing. The majority of the producers sell their sweetpotato after hearing from their friends that the roots can be marketed or visiting the market themselves, and most producers do not have access to inputs or extension services for the crop (Mmasa and Msuya, 2012).

Marketing channels and retailers

The marketing channels for OFSP are largely the markets in the villages and nearby districts. According to farmers' FGDs, an average of 65% of the produced OFSP is marketed. At the point of retail, OFSP and white-fleshed sweetpotato varieties are sold for the same price and displayed side by side or in mixed batches (Temu et al., 2014), which is an indication that consumers are not aware of the differences between the varieties.

Sweetpotato vendors are few and are not organized in the business arena. They obtain sweetpotatoes directly from farmers. There are both urban and rural retailers of sweetpotato roots and processed products (Mmasa and Msuya, 2012). A small number of packaged OFSP products are sold in shops and supermarkets in urban centers such as Morogoro and Dar es Salaam, aimed at middle income and upper income consumers (Temu et al., 2014).

Processors

The processors of OFSP identified in the study were AFCO Investments, SUGECO and Matoborwa Company, which are small scale. The low demand for OFSP processed products, which is due to the lack of awareness about OFSP benefits among consumers, is one of the main constraints hindering its large-scale processing. Moreover, the lack of quality standards is an important constraint for large-scale processors of OFSP.

Transporters and traders

Transporters have a crucial role in ensuring that goods are moved and reach the intended market on time and in proper condition. The low quantity of OFSP roots produced by farmers and the poor roads in some areas are key constraints in OFSP value chain development.

Consumers

The OFSP value chain is driven by the demand for the crop and its products. The current consumption patterns at the household level show that OFSP is mostly consumed in the form of roots and rarely as processed products. Consumers have a vital role to play in scaling up the biofortified crops and their products. Awareness creation among consumers on the nutritional value of biofortified crops is necessary to ensure that their demand is high, which can trigger the productivity of the crops and attract processors to the value chain. The BNFB project should undertake awareness and sensitization initiatives to increase the consumption of biofortified crops and products.

4.1.4 Barriers preventing disadvantaged groups from accessing and benefitting from OFSP

The general community-related bottlenecks affecting access to biofortified crops and products with respect to the crops' seed systems, promotion, advocacy, and capacity building opportunities are summarized in Appendix 10. The bottlenecks specific to OFSP are discussed below.

Agronomical barriers

The barriers that prevent disadvantaged groups from accessing and benefiting from OFSP are more agronomical and social than economic. The production of OFSP is still low, with a national average of 3.2 t/ha (FAOSTAT, 2014) compared to a potential yield productivity of 20–40 t/ha. According to the farmers' FGDs, the main constraints that affect the production of OFSP include:

- **Limited availability of quality planting materials during the critical periods for planting:** OFSP vines for planting are largely produced by local research institutions, NGOs, farmers' groups and individual farmers. Bioscience Crop Solutions Ltd is the only private company that produces planting materials using tissue culture, specifically pre-basic seeds/vines, and it sells this to ARIs, which produce certified planting materials. NGOs and farmers receive planting materials from local research institutes to produce certified 2 planting materials. According to HKI (2012b), there is little interest or participation from the private sector in seed multiplication for sweetpotato in Tanzania and the EAC region. As a government agent, ASA is responsible for the production of seeds of low value crops if there is a demand from farmers. The situation analysis revealed that although the National Agricultural Policy of 2013 allows private seed companies to access new crop varieties developed by local ARIs, there is limited information on the mechanisms for these companies to do this.

- **Diseases and pests:** Viral disease incidences are higher when OFSP planting materials are recycled for successive seasons. Poor farmers may not be in a position to buy clean planting materials every cropping season and are likely to recycle vines. The incidence of sweetpotato weevil infestation increases as harvesting of the roots is delayed. Rural farmers may not be able to meet the costs associated with disease and pest control. Even when such farmers harvest the roots on time to avoid weevil damage, their ability to perform proper postharvest handling or value addition, or even utilize the harvest, is limited.

- **Drought stress** severely affects sweetpotato crop production, and disadvantaged groups are more vulnerable to this disaster. Worse still, these groups do not have access to land with irrigation. This is because such land is usually rented, making it unaffordable to many.

The shortage of planting materials, disease and pest infestation, and drought stress are correlated with economic barriers since disadvantaged and vulnerable groups are generally resource constrained and are unable to afford quality and expensive planting materials, expensive disease and pest control measures, or mechanisms for irrigation.

Social barriers

The social barriers limiting disadvantaged groups from accessing and benefiting from OFSP include limited access to land, theft of vines, preference for local varieties of sweetpotatoes and negative perceptions towards biofortified products, associated with the fear that they are genetically modified. Households with a shortage of land may not allocate land for OFSP because priority in allocating crop land is given to the main staples such as maize and beans. Vulnerable and disadvantaged groups including women have limited ownership of land resources owing to cultural barriers, including the requirement to change asset ownership upon marriage (HKI, 2012b).

The theft of vines was attributed to the shortage of OFSP vines during the peak season for crop planting. It was not clear during the study whether vulnerable groups were more likely to be victims of vine theft.

In some of the study areas such as the Lake zone, people preferred local varieties of sweetpotatoes to OFSP. Generally, varieties with low dry matter content (less than 30%) were not favored by consumers in the country (HKI, 2012b). Adults in Tanzania tend to prefer white-fleshed sweetpotatoes because they have higher dry matter content than OFSP (Waized et al., 2015). Vulnerable groups are more likely to consume the local sweetpotato varieties because their awareness of the nutritional value of OFSP is limited. To entice behavioral change in consumption preferences, the health benefits of OFSP varieties will need to be promoted heavily (HKI, 2012b).

The negative perception among people towards biofortified products is one of the main social barriers to accessing and benefiting from OFSP. The average quantity of OFSP consumed per household of 35.3% of the total production is low compared with the quantity marketed. Stakeholders in the study locations reported that there was a perception that OFSP products were meant for people with HIV/AIDS or those who were malnourished. This notion is one of the key challenges affecting OFSP consumption.

Economic and market barriers

Farmers considered certified seed to be expensive, and this is one of the main economic barriers to accessing OFSP for disadvantaged groups. OFSP vines are sold but vines of the landraces are recycled or obtained for free. Additionally, and according to the stakeholders consulted during the situation analysis, marketing of OFSP is affected by the small quantities produced, which limits the engagement of big traders and large-scale agroprocessors.

Data on the average yield and forms of OFSP root marketed by the households involved in the study are summarized in Appendix 11. The households marketed on average 62.7% of the total OFSP they produced. OFSP is marketed both unprocessed as raw roots, which sold for an average of Tsh 359.5 (USD 0.17) per kilogram, and in processed forms such as flour, crisps and chips. The products are sold largely within the villages growing the crop and nearby villages and district markets. According to the local researchers, NGOs, civil society organizations and private companies, the key constraints to private sector involvement in the OFSP value chain are the limited awareness among people on OFSP and the inadequate ability of local laboratories to analyze beta-carotene levels for the release of varieties. To traders, agroprocessors and private companies, inadequate capital to expand business, the low supplies of OFSP raw materials, sweetpotato perishability, and the low price of the processed OFSP products are the key constraints to private sector involvement in OFSP.

Capacity challenges

The RAC project built the capacity of SUA to conduct the ToT course on 'Everything you ever wanted to know about sweetpotato' (see section 4.1.2). A total of 15 key primary facilitators, 6 of whom were female, were trained. SUA trained 76 secondary facilitators, 29 of whom were female, through three ToT courses. Through a cascading training model, 18 step-down courses were conducted by the secondary facilitators, reaching a total of 2,899 trainees, 1,503 of whom were female. All these

change agents were trained between June 2012 and August 2014. From August 2014 until July 2017, SUA conducted only one course in 3 sessions, reaching a total of 34 ToTs, courtesy of funding from the VISTA project. Although SUA possesses the requisite technical capacity to conduct the ToT course, its administrative capability to independently organize, resource and run the course is uncertain.

SRI-Kibaha, Ukiriguru Research Institute and RECODA also have been playing an important role in training change agents for the various processes of the OFSP value chain. The capacity of these organizations was built through the RAC project. SRI-Kibaha is particularly strong on the entire value chain processes including breeding. Moreover, it possesses screen houses that contain pre-basic and basic OFSP seed. For organizations that require training of their staff, SUA and SRI-Kibaha are well placed to offer those services, albeit on a cost-recovery basis. RECODA is suited for training change agents at the tertiary or community level, who specifically are farmers and extensions. There is need for concerted efforts to build the capacities of more organizations like RECODA, which will be able to offer training services at the grassroots level.

Gender-related constraints

The gender analysis conducted on the production of OFSP in Tanzania by Mudege and Grant (2017) provides important information on the gender constraints affecting the production and consumption of the crop. For instance, men were more likely to face production constraints in OFSP than women were owing to women's higher involvement in sweetpotato farming, which allowed them better awareness on how to solve sweetpotato production constraints (Mudege and Grant, 2017). That study also found that women had the least productive land to cultivate sweetpotato and that men were unwilling to invest in sweetpotato because of its perceived lack of benefits and because they regarded it as a secondary and 'women's' crop. However, although women were more engaged in sweetpotato cultivation than were men, it was men who were often targeted with agronomic training. Moreover, women were unlikely to attend training events conducted outside the village owing to domestic demands (Mudege and Grant, 2017). This finding on training supports the conclusion drawn by RAC in its end of the project evaluation (RAC, 2015).

Mudege and Grant (2017) postulate that although medium-scale enterprises for sweetpotato vines were not well developed in Tanzania, women were more optimistic than men about marketing opportunities for sweetpotato vines and roots. This means that women were more likely than men to engage in OFSP production. However, owing to constraints in land ownership, women were unlikely to become medium-scale vine multipliers.

4.1.5 Recommendations on scaling up OFSP in Tanzania

- That OFSP is highly susceptible to diseases and pests was quite evident from the information gathered from the stakeholders consulted. The development of disease and pest-tolerant varieties for OFSP is a required intervention. Such an intervention will also contribute to addressing the challenge of the poor supply of planting materials.

- The low level of awareness and knowledge on biofortified products affects both the consumption and adoption of these crops. Promotion, training and awareness creation about biofortified crops and their products are some of the needed interventions that BNFB could contribute to. However, literature (see Waized et al., 2015, for example) suggests that interventions promoting biofortified crops, in particular OFSP, have been faced with tension in choosing between targeting the poorest farmers, who are the most vulnerable to undernutrition, and catalyzing commercial production of the crops. In innovation adoption, resource-poor farming households are considered as late adopters and are therefore not likely to rapidly adopt new biofortified crops. There is a clear need to identify the entry points for the effective promotion of biofortified crops in the target areas of BNFB project. In our opinion, using disadvantaged and vulnerable groups such as resource-poor farmers as an

entry point in the promotion of biofortified crops and products is inadequate and should be complemented with, for instance, commercial production and marketing of the crops and products.

- To address the gender-related constraints in OFSP production, Mudege and Grant (2017) propose that group businesses and market training for women farmers be explored as potential practical strategies. Strategies that adopt household approaches to farming as a business also are recommended to increase women's participation at that level.

- Marketing constraints of OFSP should be addressed for the whole value chain. The focus should be on awareness creation, promotion and advocacy for OFSP. There is a lack of standards of quality for processed OFSP, as the current TBS and TFDA standards for fortified processed products covering maize and wheat flour and other products do not include processed OFSP. This is a potential intervention area for BNFB. This issue is discussed in detail in section 4.5. A study in one intervention district established that commercial farmers who were supported by a project to multiply and disseminate planting materials stopped the work after the project funding ended, citing the lack of a local market as the reason (Waized et al., 2015). This underscores the need for increased awareness creation.

- Temu et al. (2014) provide practical recommendations on addressing some of the challenges facing the OFSP value chain. They say that attention should be given to retail and marketing interventions in order to increase the consumption of OFSP. One advantage of OFSP is that unlike other biofortified crops with hidden traits, it can be differentiated through color. Because of this attribute, Temu et al. (2014) recommend that retailers should be encouraged to sell OFSP and white-fleshed varieties separately and to provide information about the benefits of OFSP. Evidence (see Temu et al., 2014; Waized et al., 2015) indicates that these interventions lead to lasting change in the marketing of OFSP.

- In terms of capacity building, the commitment of SUA to sustain the ToT course on sweetpotato is uncertain. With more biofortified crops in its basket, BNFB should consider equipping/capacitating a center of excellence in Tanzania to train change agents on the entire continuum of biofortification, OFSP included. From the experience in Nigeria, partnering with a middle level college is less cumbersome and more promising for sustainability. Moreover, SRI-Kibaha, Ukiriguru Research Institute and RECODA are the only institutions known to have stepped down the ToT course. It is recommended that an ex post study be conducted to ascertain how many change agents stepped down the course, the reasons for success and the challenges facing the step-down cascading training model.

4.2 PVA maize

PVA maize (Photo credit – anonymous)

4.2.1 General production of maize in Tanzania

Maize accounts for 31% of the total staple food production in Tanzania, is the staple food for most Tanzanians and is largely produced by small-scale farmers. Up to 80% of all maize produced is consumed within the country. The volume consumed is approximately 7.1 million tons, and 125,773 tons is exported (Wilson & Lewis, 2015). Fig. 4 shows the main maize producing regions of Tanzania.

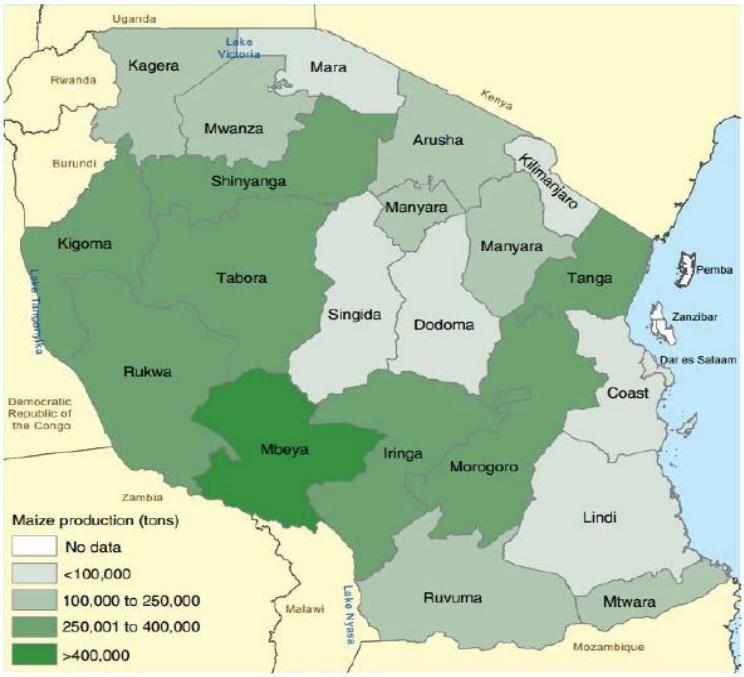

Figure 4: Maize producing areas in Tanzania

Source: Cochrane and D'Souza (2015)

According to FAOSTAT (2014) the area under maize cultivation increased from 2,600,341 ha in 2007 to 4,146,000 ha in 2014, and the quantities produced from 3,659,000 t in 2007 to 6,737,197 t in 2014 (Table 5).

Table 5: Trends of maize production in Tanzania from 2007 to 2014

Year	Area (ha)	Yields (t)	Productivity (t/ha)
2007	2,600,341	3,659,000	1.41
2008	3,980,970	5,440,710	1.37
2009	2,961,334	3,326,200	1.12
2010	3,050,710	4,733,070	1.55
2011	3,287,850	4,340,823	1.32
2012	4,118,117	5,104,248	1.24
2013	4,120,269	5,356,350	1.30
2014	4,146,000	6,737,197	1.62

Source: FAOSTAT (2014)

Despite the increased availability of improved maize seed in Tanzania, only an estimated 27% of the area under maize is planted with improved or certified seed (World Bank, 2012). The potential demand for maize seed in Tanzania is estimated to be 120,000 t per annum, and actual demand is estimated at 60,000 t. Only 28.6% of the maize seed in Tanzania is made available through the formal seed system (ESAFF, 2013). The main seed companies in Tanzania by market share include Pannar Seed (28%), SeedCo (26%), Suba Agro (9%), Kibo Seed (7%), Monsanto (6%), Highland Seed (6%) and ByTrade Tanzania Ltd (5%) (Lyimo et al., 2014).

4.2.2 Maize value chain

The main input suppliers for the maize sector in Tanzania are ARIs, seed companies and fertilizer retailers. Maize is produced mostly by small-scale individual farmers. There is little farmer organization in form of cooperatives. Few farmers have marketing strategies and most of them sell maize grain to local agents and brokers. Because of their small-scale production, as well as quality concerns, farmers are unable to sell their maize to the National Food Reserve Agency. According to the Southern Agricultural Growth Corridor of Tanzania (SAGCOT, n.d.), maize farmers sell about 70–80% of their total grain production.

Maize markets in Tanzania are divided into grain and flour markets (SAGCOT, n.d.). Most of the grain marketed by farmers is delivered to local collection hubs and then accumulated by traders who sell it to local, regional and urban markets. Export of maize is strictly regulated by the government, and Burundi, Congo, Kenya and Rwanda are the main markets for the grain. Some of the maize grain is sold also to processors and grain traders who accumulate and export it (for details on the grain value chain, see Wilson and Lewis (2015).

The milling capacity for maize flour in Tanzania has more than doubled over the last decade, with urban millers of medium capacity emerging strongly (SAGCOT, n.d.). Only a limited number of the larger roller mills produce high quality flour products, and all operate well below capacity. Small-scale hammer mills are what are mainly used throughout Tanzania to convert maize grain into low-cost flour (Lewis and Wilson, 2015).

The flour market is concentrated in urban centers, with the millers setting their prices based on production costs. Wholesalers are mainly concentrated around these millers. Supermarkets are the main retail outlets for milled products from the larger roller mills. The medium-size milling producers sell their products mostly through the shops and mini supermarkets often found within estates in urban centers.

4.2.3 PVA maize

Gannon et al. (2014) conducted a randomized controlled PVA maize efficacy trial among rural Zambian children[4] and found that the consumption of PVA maize improved their serum beta-carotene concentrations. They concluded that in that population when consumed as a staple, PVA maize was efficacious and could avoid the potential for hypervitaminosis.

CIMMYT is supporting research on and dissemination of PVA maize in Tanzania under the BNFB project. The release of two PVA maize varieties in Tanzania in 2016 by Meru Agro Company was done in collaboration with CIMMYT. The two varieties are Meru VAH517, with a beta-carotene level of 8 ppm, and Meru VAH519, with a beta-carotene level of 14 ppm. In terms of agronomic characteristics, both varieties have equal seed rates of 25 kg/ha, maturity period of 100–125 days, yield under managed drought of 3.6 t/ha, recommended elevation of 800–1200 m, average row number of 14–16, grain color of orange, and flint as the grain texture. However, they differ in yield, which is 7.5 t/ha for Meru VAH 517 and 5.9 t/ha for Meru VAH 519, and ear rots, which is 3.5% for Meru VAH 517 and 0.7% for Meru VAH 519.

TANSEED International Ltd received three PVA maize genotypes from CIMMYT–Zimbabwe and is bulking the seed for field evaluation. Other partners involved in the process of testing and evaluation of PVA maize include IFFA Seed Company and Multi Agroseed Main Supplier Ltd.

There is no commercial production of PVA maize seed in Tanzania at the moment as seeds of the parents of the PVA maize varieties Meru VAH517 and Meru VAH519 are currently being bulked by Meru Agro Company.

Constraints facing PVA maize

Several challenges could potentially affect PVA maize in Tanzania:

- **Low investment in research for PVA maize varieties:** Only two PVA maize varieties have been officially released in Tanzania. Before the advent of BNFB, there was almost no effort in testing and releasing of PVA maize. No breeding activities are being carried out in Tanzania for PVA maize. Without well-performing and desirable varieties, seed bulking and market development may not take root. These two factors are critical for increased grain production with corresponding increased adoption of certified seed.

- **Little differentiation between PVA maize and other orange or yellow maize varieties:** Lessons learned from the promotion of quality protein maize (QPM) indicate that farmers produced QPM grain with the anticipation of premium prices. However, since the quality attribute in QPM is hidden, grain traders were hesitant to pay such prices and offered market prices, which discouraged farmers. This challenge is likely to face PVA maize, as its beta-carotene content is a hidden trait and the orange color in the maize grain does not necessary indicate the presence of the micronutrient. The challenge already exists in Tanzania, where Charoen Pokphand Produce Ltd from Thailand has been promoting two yellow maize varieties, CP 201 and CP 808, sometimes labeling them as biofortified. But data from the National Release Committee indicate that these varieties were not released based on nutrition criteria but for animal feed. There were no data on their levels of beta-carotene showing that they were of PVA grade, and so we did not consider them biofortified. It is clear that the lack of differentiation of PVA maize from the other maize varieties and the

[4]Sampling 140 children, Gannon et al. (2014) found that after 6 months, with a 90% follow-up, serum beta-carotene was greater among the children in the orange maize group than among those in the white maize group. Moreover, the children's pupillary responsiveness increased significantly across all light stimuli. After adjustment for baseline differences, the children in the orange maize clusters had a 2.2 greater odds of improved pupillary function. In the context of that population, which was marginally deficient, regular biofortified maize consumption significantly increased serum beta-carotene concentrations. The researchers concluded that beta-carotene from maize was efficacious when consumed as a staple food in that population and could prevent the potential for hypervitaminosis.

historical preference of white kernel maize (Smale & Jayne 2003) are significant challenges for PVA maize in Tanzania.

- **Limited participation by processors and marketers:** Two other lessons learned in piloting QPM in Tanzania were that (1) owing to the uniqueness of QPM, its producers expected the giant grain buyers and processors such as Azam to join in, but there was little interest from these groups, and (2) QPM seed and grain production remained unpredictable and significantly low because of the unfavorable climatic changes, and this discouraged small and micro enterprises and large maize grain buyers. It is likely that PVA maize stakeholders will need to address these challenges to scale up the production and consumption of the crop.

- **Negative attitudes towards 'colored' maize varieties and maize products:** Tanzanians associate yellow colored maize with the relief food imported into the country to address famine in the 1980s. The yellow maize was nicknamed 'yanga', a name that is still blanketly used to refer to any yellow/orange maize varieties. To change this mindset for fast adoption of PVA maize, a lot of awareness creation is needed.

- **Capacity limitations:** Previous attempts to test products for micronutrients in Tanzania have been hampered by inadequacies in equipment and trained personnel. The food testing laboratories at SUA and TFNC are ill equipped for rigorous and modern scientific product testing. For instance, the testing of the Thai CP 201 and CP 808 varieties for beta-carotene content recently done at SUA produced unsatisfactory results. Additionally, there is no center of excellence for training technical experts on maize in Tanzania. Moreover, training manuals covering the entire maize value chain in Tanzania, particularly in Kiswahili, are not available.

Recommendations on scaling up of PVA maize

- The scaling up of PVA maize should focus on awareness creation, promotion and advocacy for the crop, involving all stakeholders in the value chain. Analysis of beta-carotene is required for the CP 201 and CP 808 varieties using recognized laboratories such the Biosciences Eastern and Central Africa laboratory in Nairobi or the HarvestPlus laboratory in Lusaka, Zambia, to assess if they meet biofortification criteria and are suitable for human consumption.[5] Once this is ascertained, Charoen Pokphand Produce Ltd should engage the National Release Committee to reclassify the two varieties.

- There is neither a center of excellence for training technical experts on maize nor manuals covering the entire maize value chain in Tanzania. BNFB should identify a national center of excellence to partner with to train primary facilitators on the PVA maize value chain, who will in turn step down the training following the RAC cascading model. The development of technical manuals covering the entire maize value chain would be a worthwhile investment. HarvestPlus has published a training guide on postharvest handling and processing of PVA maize in Zambia, and BNFB could leverage this effort and enhance the content, design the manual as a ToT manual, and translate it into Kiswahili for use in Tanzania.

- There are ongoing research efforts in Tanzania on PVA maize as a crop with high potential to address VAD. However, these efforts are still low in the research pipeline, partly due the complexities of the maize technologies and underinvestment. More efforts in research for new varieties and investments are needed to expedite the release of promising genotypes. Moreover, since the PVA maize quality attribute is hidden and its orange color may encounter resistance in a market accustomed to eating white maize, awareness creation and

[5] Supporting local institutions by providing them with better equipment and training is recommended as a better option (this is discussed under section 4.5).

promotion are critically needed. Using events such as Nane Nane shows and the mass media is particularly recommended to help shift attitudes. But the most important factor to pull the demand for PVA maize is the participation of large-scale maize millers and processors in PVA maize processing.

- Maize requires at least 3–4 seasons to generate large volumes of seed for commercial purposes. This is particularly challenging in instances where large quantities of parent material are needed. This constraint is compounded by the fact that the maize seed sector is predominantly private sector led, and the private seed companies are hesitant to invest resources in new technologies such as PVA maize. Key informant interviewees indicated that this challenge has been overcome elsewhere by supporting seed companies and commercial seed farmers with resources to multiply seed even as promotion efforts are conducted. AGRA has adopted this approach in Tanzania with commendable success. It is therefore recommended that BNFB partners support the seed companies with resources to multiply and avail sufficient quantities of PVA maize seed in Tanzania.

4.3 High iron and zinc beans

MAC 44 bean variety field at Selian Agricultural Research Institute (photo: Godfrey Mulongo)

4.3.1 General production status of beans in Tanzania

Beans are one of the major staples in Tanzania and account for up to 10% of the total staple crop production. Three zones, namely Lake, Southern and Northern, are the leading bean producers in Tanzania. Beans are used for both household consumption and as a cash crop. Tanzania is the largest bean producer in Africa with 1.5 million ha under the crop. The average production of beans is 1 million tons per year with an average productivity of 1 t/ha. Tanzania exports beans to about 10 countries in East and Sub-Saharan Africa. Fig. 5 shows the major beans producing areas.

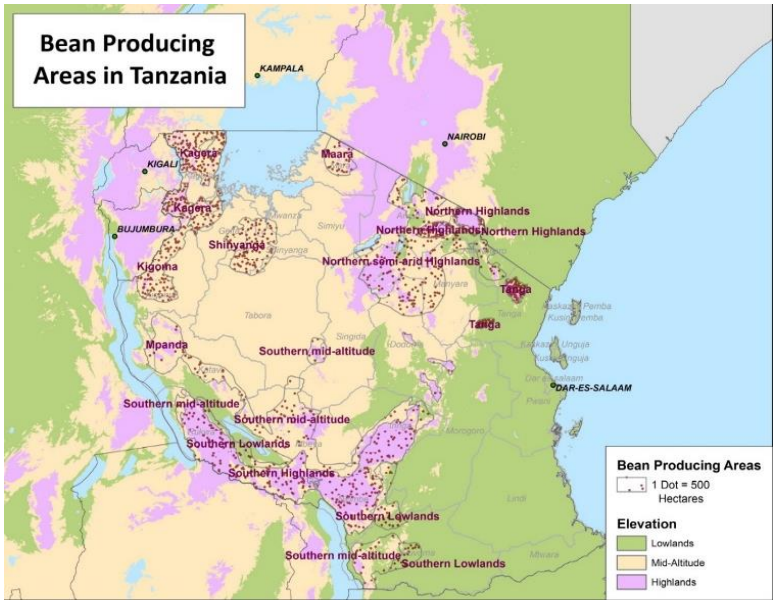

Figure 5: Bean producing areas in Tanzania

According to FAOSTAT (2014) the production of dry beans increased from 889,293 t in 2007 to 1,114,500 t in 2014 (Table 6).

Table 6: Trends of dry beans production in Tanzania from 2007 to 2014

Year	Area (ha)	Yields (t)	Productivity (t/ha)
2007	918,742	889,293	0.97
2008	749,540	570,750	0.76
2009	868,310	773,720	0.89
2010	1,208,690	867,530	0.72
2011	737,661	675,948	0.92
2012	1,265,404	1,199,267	0.95
2013	1,151,376	1,113,541	0.97
2014	1,134,394	1,114,500	0.98

Source: FAO (2014)

In terms of marketing, Korir et al. (n.d.) indicate that dry beans in Tanzania flow from the northern zone of the Tanzania hinterland into the regional market centers of Arusha and Moshi. From there the beans flow northwards to Nairobi through the Namanga border point and to Mombasa, Dar es Salaam and Zanzibar. Some 92.1% of the farmers produce dry beans for local markets, while 7.9% produce for export (Korir et al., n.d.). Wholesalers source their bean stocks for export from assemblers. The dominant marketing channel established for beans to flow through was from farmers to upcountry assemblers to wholesalers then to retailers and finally to consumers. Although the bean marketing system in Tanzania is generally efficient with bean market prices reflecting the production costs, producer participation is low (Korir et al., n.d.).

4.3.2 Efficacy of high iron and zinc beans

Haas et al. (2016) conducted a randomized controlled trial among a group of Rwandan women to determine the efficacy of high iron and zinc beans to improve iron status. The study established that the women in the high iron and zinc beans group, who consumed 14.5 ± 1.6 mg Fe/d, had significantly greater increases in hemoglobin (3.8 g/L), log serum ferritin (0.1 log µg/L) and BI (0.5 mg/kg) than those in the control group, who consumed 8.6 ± 0.8 mg of standard beans. In essence,

for every 1 g Fe consumed from beans over the 128 study days, there was a significant 4.2 g/L increase in hemoglobin ($P < 0.05$). The study concluded that consumption of iron-biofortified beans significantly improved the iron status in the treatment group.

Another study by Luna et al. (2014) that investigated the relationship between changes in iron status and maximal oxygen uptake (VO2 max) after 5 months of consuming a high iron and zinc bean diet established that serum ferritin significantly increased in the high iron and zinc bean group. The median of the serum ferritin increase in the treatment group was 4.0 µg/L compared with 2.5 µg/L for the control group. VO2 max declined in both groups over the course of the intervention with no difference between the treatment and control groups. However, in the iron status component of the trial, which involved the participants with a ferritin increase of 15% or more drawn from the treatment and control groups, the treatment group had a significantly attenuated decline in VO2 max compared with the control group. The study concluded that the consumption of high iron and zinc beans significantly improved the iron status of the participants and that the improvements in iron status in the iron-biofortified group attenuated the decline in VO2 max.

4.3.3 High iron and zinc beans in Tanzania

CIAT is the facilitator of PABRA. PABRA is coordinated by a core team of CIAT scientists with the responsibility of developing and disseminating improved varieties of beans that are high yielding; nutritionally enhanced with iron and zinc; resistant to insect pests and diseases; tolerant to drought, heat and low soil fertility; and well suited for the market in terms of seed size and color.

According to the respondent from CIAT–Tanzania, high iron and zinc bean genotypes MAC44, a red mottled, mild altitude climber with 78–90 ppm of iron content, and RWV1129, a Kablanketi type with 78–90 ppm of iron content, have been introduced in Tanzania from Rwanda, Burundi and Uganda through the Eastern and Central Bean Research Network breeding system. These two genotypes yield 2027–3529.80 kg/ha and 1891.85–3398.29 kh/ha, respectively. They have been submitted to TOSCI and are undergoing DUS testing and NPTs and are expected to be released in the last quarter of 2017. A CIAT study on consumers' willingness to pay indicates that the acceptability of these biofortified beans by farmers and consumers is high due to their agronomic performance relating to yield and pest and disease tolerance, preference by consumers and marketability.

With the support of BNFB, multilocational trials for stability and adaptability for eight more high iron and zinc bean genotypes are going on. The genotypes are RWR 2154, KAB06 F2-8-36, KAB06F2-8-35, CODMLB 001, NGWANKUNGWANKU, CODMLB 033, SMC 18 and SMC17. CIAT partners in this work are ASA, Meru Agro Company in Arusha, Beula Company and Agri-seed Company in Mbeya, and local seed entrepreneurs in seed systems. CIAT provides training to farmers and researchers in collaboration with local agricultural research institutes, specifically ARI-Selian, ARI-Maruku and ARI-Uyole, as well as the Ministry of Agriculture, Livestock and Fisheries.

BNFB is the main actor implementing and investing in biofortified bean activities in Tanzania. There are other complementary initiatives particularly in the breeding of high iron and zinc beans, supported through PABRA such as HarvestPlus' breeding work at CIAT headquarters. The potential lines bred at CIAT are shared through the PABRA network. Moreover, through PABRA, the Southern African Development Community (SADC) countries share germplasm, including for high iron and zinc varieties released in these countries. Another effort supporting breeding is the Tropical Legume III initiative implemented by the International Crops Research Institute for the Semi-Arid Tropics and funded by the Bill & Melinda Gates Foundation.

4.3.4 Constraints facing biofortified beans

According to the respondents, the key constraints to private sector involvement in the high iron and zinc beans business is the low market demand for bean seeds. This is because bean is an open-pollinated crop and so its seeds can be reused by farmers for several years with little loss in yield or

quality. The low seed demand can be overcome by strategic demand creation, communication to both the bean and the food value chain actors and engagement with nutrition and health sector actors.

The varieties MAC44 and RWV1129 are climbers. This could pose significant agronomic challenges for farmers in Tanzania who are accustomed to growing the bush varieties.

Other constraints include low funding to local research institutes to conduct field evaluation of new varieties and lack of released bean varieties with high iron and zinc content.

4.3.5 Recommendations on scaling up high iron and zinc beans

No biofortified bean varieties are produced in the country at the moment, and none has been released. More effort is required to speed up research for new varieties. Additionally, farmers should be trained on appropriate agronomic practices for climbing bean varieties.

With biofortified beans being a new technology, education and awareness creation on the nutritional value of high iron and zinc beans in addressing iron deficiency are essential. Promotion and advocacy for the crop, particularly to unlock investments in it, are highly recommended.

4.4 Policy and investment environments for nutrition

This section deals with the prioritization of nutrition, specifically biofortification, in the national policy, legal and regulatory frameworks. It also identifies the national and international advocacy platforms and forums in Tanzania that are relevant for biofortification and makes recommendations on how BNFB can leverage their processes, and points to approaches on how to unlock investments for biofortification.

4.4.1 Prioritization of biofortification in national policy, legal and regulatory frameworks

A study conducted in 2012 by SUA entitled 'Nutrition policy mapping for Tanzania' (NPMT, 2012) revealed that most of the existing policies incorporated none to minimal content on nutrition matters. Only a few policies dealt with nutrition, especially those related to health, food and nutrition, agriculture, and child and community development. The issues that were most commonly addressed were related to food insecurity and diseases. Undernutrition was more frequently addressed than was overnutrition or emerging diet-related chronic diseases.

This situation analysis involved a review of literature and content analysis of various national policies, strategies and program documents of the Government of Tanzania to ascertain their inclusion of biofortification. A total of 33 policy documents and 12 strategies were reviewed. The review found that a number of national policies were formulated during the 1990s or after 2005. About 24% of the policies and strategies had a strong focus on nutrition and had some action-oriented policy commitments. The Agricultural Policy of 2013 and the Agricultural Sector Development Program of 2016 have a statement on biofortification (URT, 2016c).

The content review of the policy documents established that the National Agriculture Policy of 2013, the National Multisectoral Nutrition Action Plan (NMNAP) for July 2016–June 2021 (URT, 2016e) and the draft TFNC Strategic Plan support biofortification. The last two of these are fairly recent and benefitted from BNFB's input. The National Agricultural Policy of 2013 (URT, 2013) has policy statements related to biofortification but has neither a national strategy nor a program for its implementation. Although the Food and Nutrition Policy for Tanzania (URT, 2016d) does not expressly mention biofortification, it endorses nutrient-rich food crops. Consultations with TFNC revealed that efforts were underway to review the Tanzania Food and Nutrition Policy of 1992 to accommodate biofortification. Other policy documents that capture biofortification include the five-year strategy of the Ministry of Agriculture, Livestock and Fisheries (2016–2020) and the Agricultural Sector Development Programme Phase Two (ASDP-2) of 2016 (URT, 2016c). Biofortification appears

to have been given low priority, as ASDP-2 puts more emphasis on food security. BNFB needs to advocate for prioritization of biofortification in the resourcing and implementation of this program. The findings of the review of the national policies and strategies are summarized in Appendix 12.

As an important step in improving the coordination of nutrition in the country, the government has employed and deployed nutrition officers at regional and district levels. These officers are mandated with planning and facilitating the implementation of nutrition activities. To address the lack of data on the investments allocated and spent on nutrition activities in Tanzania, the Ministry of Finance, with the technical and financial support from UNICEF and the World Bank, instituted a public expenditure review on nutrition. INNOVEX Development Consulting Ltd was contracted by UNICEF to carry out the review. The purpose was to obtain baseline information on allocations and expenditures on nutrition against which progress would be assessed after the introduction of the budget line on nutrition in the financial year 2012/13.

According to the INNOVEX report (URT, 2014), the total nutrition investment at the national level over the three years from 2010 to 2013, excluding the resources allocated at the local councils, amounted to Tsh 78.6 billion (USD 35.8 million). The annual resource allocations were Tsh 17.8 billion (USD 8.2 million) for 2010/11, Tsh 27.5 (USD 12.6 million) for 2011/2012 and Tsh 33.2 billion (USD 15 million) for 2012/13. The nutrition sector budget allocation compared with the national GDP was 0.05% for 2010/11 and 0.06% for 2011/2012 and 2012/13. Also, in relation to the government total expenditure, the nutrition allocations were 0.15%, 0.20% and 0.22% for those years, respectively.

Whilst the implementation of the National Nutrition Strategy was estimated to cost Tsh 118.9 billion (USD 55 million) in 2011/12 and Tsh 145 billion (USD 67 million) in 2012/13, the actual resource allocations at the national level were only 23.1% of the estimates in 2011/12 and 22.9% in 2012/13. This shows a significant funding gap, which ultimately was responsible for the low success of the National Nutritional Strategy Implementation Plan for 2011–2016. Currently councils do not have earmarked funding for implementing nutrition interventions. The 15 local councils visited for the situation analysis had neither implemented the nutrition strategic plans nor undertaken nutritional surveys. Nutrition interventions were incorporated in the Medium-term Expenditure Framework on an ad hoc basis with a few selected interventions by sector. Ultimately, most of the interventions were not implemented owing to the lack of funds. The total nutrition resource allocation for the 15 councils covered in the study was Tsh 2.48 billion (USD 100,000) for a three-year period.

4.4.2 National and international advocacy platforms in Tanzania

BNFB intends to establish multisectoral technical and policy platforms as important forums to provide support, facilitate linkages and conduct advocacy for biofortification. The platforms will help spearhead the production and marketing of biofortified crops. It is therefore important that the project be aware of similar existing or associated initiatives. The key advocacy platforms in Tanzania are listed in Appendix 13. They include the Food and Nutrition Association of Tanzania (FONATA), the National Food Fortification Alliance (NFFA) and the Multisectoral Nutrition Technical Working Group. Other platforms that conduct advocacy in agriculture and nutrition are the Partnership for Nutrition in Tanzania (PANITA), the Agricultural Non-State Actors Forum (ANSAF), the Tanzania Agricultural Partnerships and Agriculture Coalition and PABRA. PABRA is made up of an international network of bean researchers, 29 national agricultural research institutions, and more than 350 partner organizations (see Appendix 13).

There are also steering committees for nutrition matters, for example the Councils Steering Committee on Nutrition, and special days are observed in the country to put a focus on nutrition, for example the Africa Day for Food and Nutrition Security (ADFNS). The Councils Steering Committee on Nutrition's meetings are chaired by the district executive director, while the secretary is the district or council nutrition officer. The objective of the Councils Steering Committee on Nutrition is

to ensure comprehensive and coordinated understanding and action in responding to nutrition challenges in the districts. The committee serves as a monitoring body for the councils in the implementation of the National Nutrition Strategy and the Tanzania Agriculture and Food Security Investment Plan.

At the 15th ordinary session of the African Union summit in Kampala, Uganda, in July 2010, the African Union Heads of State and Government made a declaration setting aside a day to be observed for nutrition, the Africa Day for Food and Nutrition Security. This decision was made in recognition of threat to the continent's population from the unacceptable and chronic crisis of hunger and malnutrition. The first ADFNS was observed in Lilongwe, Malawi, on 31 October 2010. Since then the day has been commemorated six times with the last editions taking place in Kampala, Uganda, from 28 to 30 October 2015 and Accra, Ghana, from 26 to 28 October 2016. The main purpose of ADFNS is to serve as a platform for rallying political and financial commitments at all levels to address contemporary challenges in food and nutrition insecurity. ADFNS provides a platform at national, regional and continental levels to share experience, knowledge and mutual learning, as well as to measure progress in ensuring food and nutritional security for all by governments and partners.

Tanzania is a signatory to several international treaties and declarations on agriculture and nutrition. These include the Comprehensive Africa Agriculture Development Programme (CAADP), which targets the enhancement of the role that non-state actors play in ensuring that agricultural transformation is made possible at the continental level, and the Malabo Declaration. During the African Union Summit in Malabo, Equatorial Guinea, in June 2014 the Heads of State and Government adopted a set of concrete agriculture goals to be attained by 2025. The Malabo Summit confirmed that agriculture needed to remain high on the development agenda of the continent and that it was a critical policy intervention area for African economic growth and poverty reduction. On 5 June 2011 Tanzania joined the SUN Movement. By that time the country had established the High-Level Steering Committee for Nutrition, which is convened in the Prime Minister's Office and involves multiple ministries and stakeholders. Tanzania has also created the Parliamentarian Group on Nutrition, which has drawn up an action plan for advocating for nutrition in parliamentary activities. Tanzania is a member of the UN REACH Partnership Initiative and the Global Alliance for Improving Nutrition (GAIN). GAIN works to improve agriculture and nutrition security through building alliances with stakeholders and representatives from every major sector in development. GAIN works with diverse partners, and specifically national governments, civil society, academic institutions, international bodies such as the UN, donors, foundations, consumer groups and local and international private sector companies in several countries including Tanzania.

4.4.3 Recommendations on the policy and investment environments for biofortification

Working through the multisectoral policy platform, BNFB should support existing nutrition advocacy initiatives in order for biofortification to be given a high priority in national budget allocation. Consultations with officials in the Ministry of Agriculture, Livestock and Fisheries, TFNC and the Prime Minister' Office revealed a number of weakness and challenges in promoting biofortification at the national level. The interventions proposed to address those weaknesses are shown in Table 7.

Table 7: Weaknesses in current resource allocation for biofortification by the government and proposed interventions

Challenges	Proposed interventions during policy review	Source of information
Lack of national programs on biofortification. Biofortification is just mentioned in national strategies, policies and plans but with low priority	Prioritize biofortification in ASDP-2	Ministry of Agriculture, Livestock and Fisheries
	Give biofortification priority in the National Multisectoral Nutrition Action Plan 2016–2022. Advocacy to ensure that it is incorporated into the implementation plans of the respective ministries, agencies should be given emphasis.	Tanzania Food and Nutrition Centre
Limited government budget on biofortification, while a significant portion of the budget is on nutrition	Prioritize the allocation of funds to support biofortification through the Multisectoral Nutrition Action Plan, 2016–2022.	Prime Minister's Office
	Prioritize allocation of funds to support biofortification in ASDP-2.	Ministry of Agriculture, Livestock and Fisheries
Limited awareness among politicians and government officials on biofortification	Enhance promotion of and awareness creation for biofortification.	Prime Minister's Office
Limited local capacity to spearhead biofortification efforts	Government to increase support to local ARIs to carry out field evaluation of new varieties and outreach programs on biofortification.	Ministry of Agriculture, Livestock and Fisheries
Lack of a national platform for advocacy on biofortification	BNFB should strengthen the National Food Fortification Alliance by integrating biofortification.	Tanzania Food and Nutrition Centre

4.5 Institutional capacity to scale up biofortification

This section is an appraisal of the institutional capacity gaps that need addressing to scale up biofortification.

4.5.1 Institutions involved in biofortification and their capacities

The important local institutions key to scaling up biofortification in Tanzania are the ARIs, TOSCI, TFDA, TFNC, seed producers and training institutions. A detailed assessment of each category is given below.

Local ARIs

Tanzania has ARIs in all agroecological zones of the country, and these could make research and field evaluation of new varieties of biofortified crops effective. The ARIs partner with other research and implementing partners to evaluate new varieties, including for biofortified crops. The key ARIs include SRI-Kibaha, ARI-Ukiriguru and ARI-Hombolo for OFSP; ARI-Uyole for OFSP and beans; ARI-Maruku and ARI-Selian for beans; and ARI-Ilonga for maize. The reducing public funding for research has constrained the activities of ARIs working on biofortified crops, particularly for training and transport and other facilitation expenses for field evaluation of new varieties. For instance, TOSCI's requirement that a new variety be evaluated in three agroecological zones in DUS testing and NPTs has implications for the transport and facilitation costs.

TOSCI

TOSCI is responsible for the verification of new seed varieties for official release and certification of seeds produced for sale in Tanzania. According to the Seed Act, a breeder who wants to release a new variety must submit an application to TOSCI together with a seed sample, testing fees and two years of testing data. The new variety is then evaluated through NPTs. TOSCI puts the submitted variety through DUS testing and value for cultivation or use (VCU) tests. DUS testing is conducted for

two seasons and VCU testing for one season. When a variety has passed these tests, the NPT technical committee evaluates its test results and presents the findings to the National Variety Release Committee (NVRC). NVRC then evaluates the report from the NPT Technical Committee and makes a recommendation to the National Seed Committee for the release of the variety. The Ministry of Agriculture, Livestock and Fisheries' statistics on varieties release show rejection rates of 28.9% for 2015 and 15% for 2016.[6] After the National Seed Committee reviews the report, it sends the final recommendation to the Minister of Agriculture, Livestock and Fisheries for approval. The committees involved in variety release meet in session only once a year for the purpose of processing applications for seed release by developers.

Discussions with TOSCI during the situation analysis revealed that it faces a number of challenges in releasing, sampling and testing biofortified crop varieties. These challenges have affected its ability to enforce the measures for controlling the quality of the seed in the market, leading to the pervasiveness of fake and substandard seed. The presence of fake seeds is a disincentive for the farmers and others who wish to invest in certified seed. TOSCI's challenges are:

- Inadequacies in personnel to carry out all the functions prescribed in the seed law. The TOSCI employees in charge of variety testing are responsible also for conducting field inspections for seed certification and market quality control;

- Lack of a proper information technology system for the seed testing and certification functions that are under TOSCI's responsibility;

- The inadequacies in resources e.g. for the treatment of water, fertilizers and pesticides, and the untimely availability of resources for key stages in the testing process could impact TOSCI's ability to produce credible findings. Furthermore, TOSCI lacks the high-performance liquid chromatography (HPLC) machine used for testing crops for micronutrients.

- Inconsistency in budgetary disbursements, which often are also untimely, is a persistent problem, generating a large degree of uncertainty in TOSCI's ability to comply with the established schedules for variety testing.

The institutional constraints facing TOSCI and the proposed interventions to expedite the release of new varieties of biofortified crops in Tanzania are presented in Appendix 14.

TBS

TBS has developed standards of quality for fortified maize and wheat flour and sugars to which fortificants are added during processing. There are currently no standards for biofortified products. Consultations with TBS revealed that TBS was ready to develop standards for processed OFSP, PVA maize and high iron and zinc beans and their products as long as there was demand from processors. TBS standards of quality would increase confidence among processors, traders and consumers in the quality and safety of biofortified products. The main consideration in establishing these standards is the concentration of the micronutrient beta-carotene, iron or zinc present in the processed products. Unfortunately, there are no standard protocols on the quantities of micronutrients in unprocessed or processed products of OFSP, PVA maize and high iron and zinc beans grown in the different agroecological zones of Tanzania. TBS has capacity in human resources and facilities for testing for iron, zinc, beta-carotene, lysine and tryptophan, but it requires protocols for laboratory analysis of micronutrients and training of laboratory staff to conduct the tests. Moreover, as the

[6] In 2015, 42 applications were submitted to TOSCI for variety release, 23 for maize, 7 for groundnuts, 4 for paddy, 4 for sunflower and 4 for tea. Of these, 12 were deferred. In 2016, 41 applications were submitted for release, 3 for sweetpotato, 2 for beans, 16 for cashew nuts, 13 for maize, 3 for potato and 4 for paddy. Out of these, 6 were deferred.

processors indicated, the food safety inspection protocols of TBS and TFDA duplicate each other and thus are responsible for unnecessarily cumbersome, time-wasting and expensive procedures.

TFDA

One of TFDA's functions is to conduct the pre-marketing evaluation of regulated products to ensure that they meet the standards of quality, safety and effectiveness before they are registered or officially allowed in the market. TFDA requires data on the levels of micronutrient concentration, i.e. for beta-carotene, iron and zinc, during the pre-market laboratory analysis of biofortified products. This increases trust for the products among consumers, since it ensures that unprocessed and processed biofortified products meet the minimum standards. Consultations with TFDA showed that it had the capacity in human resources and facilities for testing for iron, zinc and beta-carotene, but not the protocols and skilled staff needed for laboratory testing of micronutrients.

TFNC

Over the years, TFNC has played a significant role in advocacy for good nutrition and nutrition-related initiatives. Because of its prominence in the nutrition arena, TFNC has been mandated to spearhead the implementation of the National Multi-sectorial Nutrition Action Plan for 2016–2021. However, the successful implementation of that role is currently encumbered by the lack of supportive political commitment and funding inadequacy. BNFB should work with nutrition champions to influence the government to allocate funds for scaling up biofortification.

Ministry of Education

Discussions with the Ministry of Education and the review of its documents revealed that biofortification is not entrenched in the national curriculum for basic education. There is therefore a need to engage the Ministry of Education actors to mainstream biofortification in the education system through the curriculum and its associated programs. Data indicate that the Tanzanian Institute of Education is in the process of finalizing a new national in-service teacher training (INSET) framework. Moreover, the Education Sector Development Plan (ESDP) (2016/17–2020/21) indicates that there are plans to establish a teachers' professional board to coordinate the functions of and formalize the teaching profession. This board, when created, will have the task of streamlining all professional teachers' education programs to meet the emerging needs of those teaching and training from preschools to higher education institutions. The ESDP document also indicates that Tanzania plans to strengthen school health and nutrition programs, particularly for school feeding. It is therefore recommended that (1) advocacy be conducted so that the new INSET framework incorporates nutrition and biofortification as critical elements, (2) an advocate on nutrition/biofortification be identified at the teacher professional board once it is established so that he or she can backstop the project's effort to mainstream biofortification in teacher training programs, and (3) advocacy efforts be geared towards the inclusion of biofortified crops in the school feeding programs currently under development.

National training institutions

The Ministry of Agriculture training institutes (MATIs) and tertiary level institutions such as the University of Dar es Salaam, University of Dodoma and Nelson Mandela Institute of Science and Technology have the potential to mainstream biofortification in their curricula and to provide training on it. However, these colleges and universities do not have biofortification in their curricula.

Being the main agricultural university in the country, SUA was assessed to determine its strength, opportunities, weakness and threats with respect to supporting biofortification. Interviews with SUA staff revealed that it had mainstreamed OFSP in its syllabus. The ex post study on RAC should help shed more light on this by determining the type of content that is covered. SUA possesses expertise in plant tissue culture, molecular biology, crop protection, agronomy and plant breeding, and laboratories for analysis of nutrients such as iron, zinc, lysine, tryptophan and beta-carotene. Its

weaknesses also were identified. For instance, it is not clear why the SUA laboratory returned highly contestable results for CP 201 and CP 808 maize varieties when it tested them for beta-carotene.[7] Another issue is that the SUA curriculum contains fortification and supplementation but not biofortification. A summary of the results of the assessment of SUA is given in Appendix 15.

The potential of the University of Dar es Salaam, University of Dodoma and Nelson Mandela Institute of Science and Technology to mainstream and support training on biofortification also was assessed and the results are summarized in Table 8. Although the capacities of middle level colleges were not assessed, it was considered unlikely that they would have entrenched biofortification by the mere fact that their higher level counterparts had not done so. Of importance for biofortification capacity building are MATI-Ilonga, MATI-Uyole, MATI-Ukiriguru, MATI-Tumbi, MATI Mtwara and the National Sugar Institute, which offer a wide range of agriculture related courses, namely a diploma in general agriculture, a diploma in crop production and a certificate in general agriculture. Appendix 16 lists the MATIs that could be targeted.

Table 8: Potential institutions for capacity building on biofortification

Institution	Possible areas of training	Potential areas of intervention on biofortification
University of Dar es Salaam	Crop production technologies, plant propagation and agribusiness	Link biofortification to agribusiness and health promotion along the whole value chain
University of Dodoma	Plant propagation and agribusiness	Promote biofortification along the whole value chain and focus interventions on the supply of good quality planting materials
Nelson Mandela Institute of Science and Technology	Plant molecular biology and biotechnology	Develop biofortified crop varieties with resistance to diseases and insect pests using marker assisted selection technology
MATIs	General agriculture and crop production	Agronomic practices for biofortified crops

4.5.2 Recommendations on building strong institutions

To build strong institutions to scale up biofortification in Tanzania, the following interventions are recommended:

- As the ARIs with the potential to scale up research projects for biofortified crops are constrained by funding, BNFB should build their capacity to mainstream biofortification in their research programs so that they can design, fundraise for, implement and monitor projects on biofortification.

- BNFB should work through its affiliates' laboratories such as those of HarvestPlus to support local institutions such as TFDA, SUA, TFNC and TBS to (1) develop and implement standards and controls for biofortified crops, specifically standards for the concentration levels of micronutrients beta-carotene, iron and zinc, and protocols for laboratory analysis of micronutrients, (2) train technical staff, and (3) get access to laboratory equipment for analysis of micronutrients locally. The Technical Committee of TBS requires data on the crops' micronutrient levels when developing the standards for biofortified products. Advocacy to harmonize the food safety inspection protocols of TBS and the TFDA is also recommended.

[7] The laboratory findings showed that at least one variety had beta-carotene content levels of 140 ug/g, which technically translates into 14,000 ug/100 g or to 14 mg/100 g dry weight basis. This is extremely high, considering that beta-carotene levels for the current biofortified maize varieties range from 7 ug/g to 21 ug/g dry weight basis.

- BNFB should assist local researchers to fast track the release of new varieties by using DUS testing and NPT reports from member states of East African Community (EAC) or SADC that have agreements with Tanzania for harmonization of seed policy and legislation.

- Other capacity gaps for SUA identified by the situation analysis include the fact that the training curriculum for the university contains fortification and supplementation but not biofortification. BNFB should find mechanisms to advocate for the inclusion of biofortification in the curricula of not just SUA but also the University of Dar es Salaam; University of Dodoma; Nelson Mandela Institute of Science and Technology; MATIs such as MATI-Ilonga, MATI-Uyole and MATI-Ukiriguru; and the national sugar institutes at Tumbi and Mtwara.

- SUA has integrated OFSP content in its syllabus, that is the material from the 'Everything you ever wanted to know about sweetpotato' course. It is recommended that BNFB conduct a follow-on assessment to ascertain this integration. Moreover, a follow-up of the SUA ToT course graduates is recommended to establish the extent to which they have stepped down the course.

- Advocacy should be conducted so that the new national INSET framework and the school feeding program proposed under the ESDP (2016/17–2020/21) incorporate biofortified crops. Moreover, an advocate on nutrition/biofortification should be identified at the teacher professional board, once it is established, so that he or she can backstop the project's efforts to mainstream biofortification in teacher training programs.

5. Conclusions and general recommendations on scaling up biofortification in Tanzania

Specific conclusions and recommendations have been made in each of the sections in this report. In addition to those, the following general conclusions and recommendations should be considered in scaling up biofortification:

- **Key actors in scaling up biofortified crops and patterns of consumption of biofortified crops and their products:** There are several actors in the biofortified value chain, but participation in the processing and consumption parts of the chain is limited. For instance, OFSP is largely consumed unprocessed as boiled roots in the villages that grow the crop and very little is consumed as processed products. BNFB should facilitate the participation of medium-scale and large-scale processors in the value chains of the biofortified crops. Drawing champions and advocates from the private sector to promote the processing of these products is recommended. Moreover, capacity building is also recommended for food processors on biofortification, especially on the standards for processed biofortified crop products, product labeling, and application of the protocols for laboratory analysis of micronutrients.

- **Barriers that prevent disadvantaged groups from accessing and benefiting from biofortification:** The situation analysis established that the barriers that prevent disadvantaged groups from benefiting from biofortification in Tanzania include (1) the lack and unaffordability of planting materials, (2) the slow adoption of the new technologies due to the lack of awareness about them, (3) the low prioritization of some of the crops, particularly OFSP, that renders them less competitive than the primary staples, especially in allocation of land for cultivation, and (4) social and cultural misconceptions about the crops. These bottlenecks affect both the consumption and adoption of biofortified crops. BNFB should engage in the promotion, training and awareness creation about biofortified crops

and products. Events such as Nane Nane agricultural shows and mass media campaigns are particularly recommended to help shift attitudes. Moreover, having media champions or advocates could boost support for these endeavors. For effective and accurate messaging, it is recommended that training on biofortification targeting media professionals and media advocates be undertaken by the project. BNFB should prepare training materials to facilitate this.

- **Current investment patterns in biofortification:** Funding for biofortification is limited, and therefore so are its programs. Moreover, PVA maize and high iron and zinc bean technologies are still low in the research pipeline, partly due to the complexities in the variety release guidelines and underinvestment. More efforts are needed in research for new varieties and in investments to expedite the release of promising genotypes. BNFB should assist local researchers to fast track the release of new varieties by engaging with TOSCI to allow DUS testing and NPT reports from any member state of EAC or SADC. For proper planning and decision-making on investing in biofortification there is need to develop investment guides for each biofortified crop for the nodes along its value chain. The investment guides need to provide details on what it would take to invest, how much to invest and how to invest in biofortified crops in order to fight hidden hunger. They should facilitate forecasting of the seed demand for the biofortified varieties. So far only the investment guides for OFSP that were developed by the RAC project exist. It is recommended that guides be developed for the other crops as well.

- **Government's funding priorities on nutrition and biofortification:** In the 2016/2017 national budget the agricultural sector ranked fourth in the allocation of government funding, coming after transport, education and health. Moreover, the proportion of the national budget allocated to agriculture has been declining, going from 7.3% in 2012 to 4.4% in the 2016/17 financial year. Similarly, the nutrition sector allocations have been low, standing at 0.15%, 0.20% and 0.22% of the government's total expenditure budget in 2010/11, 2011/2012 and 2012/13, respectively. These levels of budgetary allocation reflect the low priority agriculture and nutrition sectors are accorded. The Government of Tanzania has not been able to fulfill its commitment of allocating 10% of its national budget to the agriculture sector as required by the Malabo Declaration and the Maputo Protocol. Further, while the implementation of the National Nutrition Strategy was estimated to cost Tsh 118.9 billion (USD 55 million) in 2011/12 and Tsh 145 billion (USD 67 million) in 2012/13, the actual resource allocations at the national level were only 23.1% and 22.9%, respectively, of those estimates.

  It is recommended that more funding be directed towards national programs on biofortification. But even with the low funding, the government's commitment to nutrition programs is notable. For instance, for the fiscal period of 2016/17–2018/19, the government allocated Tsh 5.75 billion (USD 2.7 million) to support nutrition programs in 82 districts. It is recommended that BNFB advocate to the regions and districts so that some of these resources are allocated specifically to biofortification programs. Potential donors that BNFB could approach to increase investment in biofortification are USAID, DFID/UK Aid, Irish Aid, Monsanto Fund and McKnight Foundation. Advocacy among decision-makers will be important to improve prioritization of and budget allocation for biofortification interventions. Biofortification champions and advocates should advocate for more funding through the Ministry of Agriculture, Livestock and Fisheries for increased production of biofortified crops and their processed products. Finally, BNFB should build the capacity of strategic local councils, community-based organizations, faith-based organizations and other civil society organizations to design fundable projects through the 'Project planning, implementation, monitoring and evaluation' course designed under the RAC project.

- **Institutional and structural bottlenecks to address in order to unlock the value chain for biofortified crops in the country:** The value chain for biofortified crops is affected by the limited physical and human capacity, e.g. in agronomic skills. Other constraints include crop pests and diseases, poor access to inputs such as quality planting materials, and lack of a wide array of officially released varieties. Institutional capacity gaps also exist. The situation analysis identified specific capacity gaps in institutions such as TOSCI, TBS, TFDA, TFNC and SUA that are necessary to address in order to scale up biofortification in the country. It is recommended that the project prioritize filling those gaps and supporting the access to quality seed, among other mechanisms, to unlock the value chain of biofortified crops. It is important to provide support to facilitate the release of more crop varieties through the relevant institutions and channels. The project should align its work with that of institutions such as TBS and TFDA to provide technical support on the development of standards for processed products.

- **Strengthening the national breeding programs for biofortified crops:** There is need to strengthen the national breeding programs for biofortified crops so that appropriate varieties that are market led are developed, released and disseminated expeditiously. To achieve this, the project needs to advocate for more resources to support this goal and engage with TOSCI, the NPT Technical Committee, NVRC and the National Seed Committee so that protocols that prioritize the development and release of biofortified crops are introduced. Other practical mechanisms to strengthen the breeding programs include (1) developing crop-specific strategies for screening potential promising lines and germplasm, (2) providing stable and continuous funding for the breeding work, (3) screening and testing potential lines in stations and on farms, (4) continuous capacity building for young scientists on technical skills, which could be in long or short tailor-made courses such as the AGRA-supported courses for sweetpotato, and (5) providing equipment for modern breeding methods such as marker-assisted selection and genomic selection. In addition, breeders require sensitization and awareness creation on the need to include and prioritize biofortified crops in their agenda. Moreover, the introduction of breeding for biofortified crops in the university/college curricula is a worthwhile long-term strategy.

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Appendices

Appendix 1: Respondents in the key informant interviews

Name of respondent	Institution	Email address	Telephone number
Heneriko Kulembeka	ARI Ukiriguru		
Caresma J. Chuwa	ARI Ukiriguru		
Mariana Hermes	ARI Ukiriguru		
Adventina Babu	ARI Ukiriguru		
Dr George Tryphone	SUA	muhatry@gmail.com	(+255) 754-018531
Dr Anna Temu	SUGECO	aatemu@gmail.com	
Peter Mutisya	Multi Agroseed Main Supplier Ltd	peternmutisya@gmail.com	(+255) 767 068980 (+255) 715 068980
Isaka Mashauri	TANSEED International		(+255) 784352412
Dr Zubeda Mduruma	Aminata Quality Seeds and Consultant Ltd	zubedamduruma@yahoo.co.uk	(+255) 782853342 (+255) 753632802
Wilfred Mushobozi	Bioscience Crop Solution Lab	w.mushobozi@ecoagriconsult.com	(+255) 754 282 182
S. Erick	Charoen Pokphand Ltd		(+255) 754 367 419
Mr Peter Mutisya	Multi-Agro Trading Ltd	peternmutisya@gmail.com	
Papias H. Bingwa	Selian ARI	hongera1984@yahoo.com	(+255) 685-886762
Rose Ubwe	Selian ARI	roseubwe@yahoo.com	(+255) 783-494173 (+255) 719-269188
Michael Kilango	ARI-Uyole	michaelkilango@yahoo.com	(+255) 754-512167
J. George	CRISPO Processing Industry, Iringa		(+255) 754-886799 (+255) 715-886799
Dominick Ringo	RECODA	ed@recoda.or.tz	(+255) 768-224 052
John Msemwa	TOSCI		(+255) 756 591 674
John K. Kigwinya	ARI-Uyole	kigwinyakalaye@gmail.com	(+255) 783-380902 (+255) 753-174720
Dr Kido Mtunda	ARI-Kibaha	kjmtunda09@yahoo.co.uk	(+255) 715-466201
Dr Madgalena Willium	ARI-Maruku		(+255) 782-288391
Richard Kasuga	MALF	rykasuga@yahoo.com	(+255) 769-239946
Dr Elifatio Towo	TFNC	eetowo@gmail.com	
Coletha Salimbo	TFDA	colletas@hotmail.com	(+255) 784-542-104
Lilyan Gabo	TBS	lyngebo@yahoo.com	(+255) 755-260000
Rogers Wanyama	WFP		(+255) 686-923598
Janeth Said	USAID	jsaidi@usaid.gov	(+255) 755-355393
Ibrahimu	UNICEF	asanga@unicef.org	(+255) 687-276600
Neema Rwebangira	ANSAF	nrwebangira@gmail.com	(+255) 716-573196
Mohamedi Hamisi	Trader (DSM, Mabibo)		(+255) 718-215313
Habiri Shabani	Trader (DSM, Mabibo)		(+255) 719-375656
Ramadhani Ally	Trader (DSM, Manzese)		(+255) 713-984182
Fred Grant	CIP		(+255) 759-184827
Mr George Kaishozi	HKI		(+255) 782-444 304
Pauline Kisanga	COUNSENUTH	md@counsenuth-tz.org	(+255) 682-892386
Dr Tumaini Mkindo	PANITA		(+255) 719-676646
Obey Asery Nkya	PMO		(+255) 756-772852
Peter Mapunda	Tanzania Home Economics and Association	pimaps900@yahoo.com	(+255) 759-390714
Virginia De Kuyt	EU	Virginie.de-kuyt@eeas.europa.eu	
Ms J. Mkindi	Tanzania Horticultural Association		(+255) 754-306878

Appendix 2: Policy and strategic documents reviewed

Policy documents	Strategies/initiatives	Acts and regulations
• The National Agriculture Policy of 2013 (URT, 2013) • The National Science and Technology Policy for Tanzania of 1996 (URT, 1996b) • Child Development Policy Second Edition of 2008 (URT, 2008) • Food and Nutrition Policy for Tanzania July 2016 (URT, 2016d). • National Health Policy of 2007 (URT, 2007a) • Community Development Policy of 1996 (URT, 1996a) • Biotechnology Policy of 2010 (URT, 2010) • Education Policy (2014) and its Sector Development Programme (URT, 2014b)	• National Nutrition Strategy of 2011/2012 - 2015/2016 (URT, 2011) • National Multisectoral Nutrition Action Plan (NMNAP) (July 2016–June 2021)- (URT, 2016e) • Health Sector Strategic Plan III (2009–2015)- (URT, 2009) • Agricultural Sector Development Strategy Phase Two (ASDS-II) of 2014 (URT, 2014a) • Agricultural Sector Development Programme Phase Two (ASDP-II) of 2016 (URT, 2016c).	Seeds Act No. 18 of 2003 (URT, 2003) and its Seeds Regulations GN No.37 of 2007 (URT, 2007b)

Appendix 3: Project documents reviewed

- BNFB inception Workshop report, 16–18 March 2016 (Arusha, Tanzania)
- BNFB monitoring, evaluation and learning plan: Draft, August 2016
- BNFB project description, 2015
- BNFB bi-annual report: November 2015–June 2016
- Reaching Agents of Change (RAC): Achievements. (Flyer). Tanzania, September 2014
- Reaching Agents of Change (RAC): Advocacy and communication strategy (Final version)
- Reaching Agents of Change (RAC): Project achievements overall. September 2014
- Reaching Agents of Change (RAC) : Situation analysis report
- Learning the Smart Way: Lessons learned by the Reaching Agents of Change Project (RAC) 2015

Appendix 4: Stakeholder groups consulted in key informant interviews

Group of stakeholders	Institutions	Representatives
BNFB project partners	CIP, CIMMYT, CIAT	3
Policy-makers and decision-makers	TFNC, MALF, PMO	4
Development partners	USAID, UNICEF, WFP, EU	4
Civil society organizations	CONSENUTH, HKI, PANITA, AFRICARE, ANSAF, Tanzania Home Economics Association, Tanzania Horticultural Association	7
Food processors	Charoen Pokphand Produce (T) Ltd, Bakhresa, Nutri Products Co. Ltd, CRISPO	4
Food regulators	TBS and TFDA	2
Agricultural research and training institutions	SUA, ARI Ukiriguru, ARI-Uyole, ARI-Kibaha, ARI-Maruku and ARI-Selian	6
Seed companies	Crop Bioscience Solutions Ltd., Aminata Seed Co, Multi Agro Trading Company, SUA-SUGECO, TANSEED International Ltd	5
Variety release regulators	TOSCI	1

Appendix 5: FGD participants

Appendix 5a: Composition of the participants

District	Village	Participants		Representation	Crop of interest
		Male	Female		
Handeni	Msogera	6	4	Farmers	PVA maize
Mufindi	Igomaa	6	6	Farmers, extension officer (1)	OFSP
Iringa Rural	Kalenga	6	7	Farmers, extension officer (1)	OFSP
Mbozi	Ihanda	7	3	Farmers, extension officer (1)	OFSP
Gairo	Madege	2	11	Farmers	OFSP
Ukerewe	Musozi	1	4	Farmers	OFSP
	Malegea	2	2	Farmers	OFSP
Ilemela	Nyafla	0	9	Farmers	OFSP
Misungwi	Mwasonge	4	7	Farmers	OFSP
Arumeru	Tengeru		2	Farmer and processor	OFSP
Mkuranga	Matanzi	6	8	Farmers	OFSP
Bukoba	Balairuba	4	5	Farmers	OFSP
Total		**44**	**67**		

Appendix 5b: Farmers involved in FGDs in the Southern Zone

Respondent	Village/district	Crop
Musa Mwaluko (Bwana Shamba)*	Igomaa/Mufindi	OFSP
Joyce Lugusi	Igomaa/Mufindi	OFSP
Alua Punge	Igomaa/Mufindi	OFSP
Goodluck Mbate	Igomaa/Mufindi	OFSP
Jesca Chibwana	Igomaa/Mufindi	OFSP
Greyson Mgonsa	Igomaa/Mufindi	OFSP
Rajabu Kadege	Igomaa/Mufindi	OFSP
Slyvester Msimbwa	Igomaa/Mufindi	OFSP
Majorino Gugami	Igomaa/Mufindi	OFSP
Christina Mavika	Igomaa/Mufindi	OFSP
Janeth Chaula	Igomaa/Mufindi	OFSP
Betita Manga	Igomaa/Mufindi	OFSP
Aisha Mawale (Bibi Mifugo)*	Ihanda/Mbozi	OFSP
Omary A. Msyani	Ihanda/Mbozi	OFSP
Ester Mwogha	Ihanda/Mbozi	OFSP
Raphael Mahenge	Ihanda/Mbozi	OFSP
Peter Mtafya	Ihanda/Mbozi	OFSP
Flaison Mwogha	Ihanda/Mbozi	OFSP
Herman Kilindu	Ihanda/Mbozi	OFSP
Agnes Sanga	Ihanda/Mbozi	OFSP
Imanuel Fiyabo	Ihanda/Mbozi	OFSP
Said Sembeye	Ihanda/Mbozi	OFSP
Faustina Mhaganga	Kalenga/Iringa Rural	OFSP
Nuru Mhavile	Kalenga/Iringa Rural	OFSP
Eleuteli Mkini	Kalenga/Iringa Rural	OFSP
Zena Mnyatule	Kalenga/Iringa Rural	OFSP
Richard Kainovera	Kalenga/Iringa Rural	OFSP
Reah Ibrahimu	Kalenga/Iringa Rural	OFSP
Venancia Pugili	Kalenga/Iringa Rural	OFSP
Jumanne Mbatta	Kalenga/Iringa Rural	OFSP
Godfrey Missana	Kalenga/Iringa Rural	OFSP
Neema Magaho	Kalenga/Iringa Rural	OFSP
Yunus Mwangali	Kalenga/Iringa Rural	OFSP
Letisia Nungu	Kalenga/Iringa Rural	OFSP

*= Contact person

Appendix 5c: Farmers involved in FGDs in the Lake Zone

Respondent	Village/district	Crop of interest
Avelina Ihoyelo	Musozi/Ukerewe	OFSP
Bernadeta Costantine	Musozi/Ukerewe	OFSP
Meleciana Mafwele	Musozi/Ukerewe	OFSP
Eliza Didas	Musozi/Ukerewe	OFSP
Barongo Mazebele	Musozi/Ukerewe	OFSP
Roman Kakuru	Malegea/Ukerewe	OFSP
Siwema Costantine	Malegea/Ukerewe	OFSP
Alex Chota	Malegea/Ukerewe	OFSP
Silvia Patrick	Malegea/Ukerewe	OFSP
Scolastica Lufaili	Nyafla/Ilemera	OFSP
Mariam Nigembe	Nyafla/Ilemera	OFSP
Esta Vicent	Nyafla/Ilemera	OFSP
Roza Nyelema	Nyafla/Ilemera	OFSP
Gaudensia Buzengano	Nyafla/Ilemera	OFSP
Anna Paulo	Nyafla/Ilemera	OFSP
Suzan Samson	Nyafla/Ilemera	OFSP
Anisia Sammwel	Nyafla/Ilemera	OFSP
Lucia Malonja	Nyafla/Ilemera	OFSP
Anastazia Kakinda	Mwasonge/Misungwi	OFSP
Elizabeth Silvesta	Mwasonge/Misungwi	OFSP
Suzana John	Mwasonge/Misungwi	OFSP
Prisca Nekison	Mwasonge/Misungwi	OFSP
Velediana Stephano	Mwasonge/Misungwi	OFSP
Maria Mchele	Mwasonge/Misungwi	OFSP
Mwanaid Ramadi	Mwasonge/Misungwi	OFSP
Joseph Petro	Mwasonge/Misungwi	OFSP
Paul Elikana	Mwasonge/Misungwi	OFSP
Daud Nkaguna	Mwasonge/Misungwi	OFSP
Felician Marco	Mwasonge/Misungwi	OFSP

Appendix 5d: Farmers involved in FGDs in the Lake Zone

Respondent	Village/district	Crop of interest
Agness Mayunga	Ibingo/Shinyanga Rural	Quality protein maize
Steven Kanongu	Ibingo/Shinyanga Rural	Quality protein maize
Kulwa Charles	Ibingo/Shinyanga Rural	Quality protein maize
Silvin Gombo	Ibingo/Shinyanga Rural	Quality protein maize
Henry Sweya	Ibingo/Shinyanga Rural	Quality protein maize
Mandalu Masanyigwa	Ibingo/Shinyanga Rural	Quality protein maize
Rebecca Samwel	Ibingo/Shinyanga Rural	Quality protein maize
Elizabeth Julius	Ibingo/Shinyanga Rural	Quality protein maize
Naomi Matoboki	Ibingo/Shinyanga Rural	Quality protein maize
Kuleha Ndamo	Ibingo/Shinyanga Rural	Quality protein maize
Elizabeth Izengo	Ibingo/Shinyanga Rural	Quality protein maize
Rahel Mwaja	Ibingo/Shinyanga Rural	Quality protein maize
Hamisa Bernard	Ibingo/Shinyanga Rural	Quality protein maize
Paschal Mabula	Ibingo/Shinyanga Rural	Quality protein maize

Appendix 5e: Farmers involved in FGDs in the Eastern Zone

Name respondent	Village/district	Crop of interest
Ally Mbalika	Matanzi/Mkuranga	OFSP
Zena Elembende	Matanzi/Mkuranga	OFSP
Mwajabu Liyele	Matanzi/Mkuranga	OFSP
Zabibu Kumbawene	Matanzi/Mkuranga	OFSP
Nuru Kunja	Matanzi/Mkuranga	OFSP
Zaina Kilembe	Matanzi/Mkuranga	OFSP
Rehema Lipanjaga	Matanzi/Mkuranga	OFSP
Mohamedi Lindunga	Matanzi/Mkuranga	OFSP
Hemed Kipaye	Matanzi/Mkuranga	OFSP
Masudi Maichagange	Matanzi/Mkuranga	OFSP
Jumanne Bozi	Matanzi/Mkuranga	OFSP
Halima Mangosongo	Matanzi/Mkuranga	OFSP
Ally Lwambo	Matanzi/Mkuranga	OFSP
Mwajuma Namkeleja	Matanzi/Mkuranga	OFSP
Betueri R. Massawe	Mungushi /Hai	Quality protein maize
Geoffrey A. Swai	Mungushi /Hai	Quality protein maize
Latipha B. Tarimo	Mungushi /Hai	Quality protein maize
Amina S. tarimo	Mungushi /Hai	Quality protein maize
Delvina R. Massawe	Mungushi /Hai	Quality protein maize
Judith G. Urassa	Mungushi /Hai	Quality protein maize
Janeth B. Massawe	Mungushi /Hai	Quality protein maize
Bashir S. Tarimo	Mungushi /Hai	Quality protein maize
Irene R. Kessy	Mungushi /Hai	Quality protein maize
Rose Matiko Ubwe	Mungushi /Hai	Quality protein maize
Emanuel Semindu	Ibuti/Gairo	Quality protein maize
Mwamini Masala	Ibuti/Gairo	Quality protein maize
Loi Godlick	Ibuti/Gairo	Quality protein maize
Olivia Mpolela	Ibuti/Gairo	Quality protein maize
Penina Magota	Ibuti/Gairo	Quality protein maize
Rudia Elikana	Ibuti/Gairo	Quality protein maize
Gloria Sebogo	Ibuti/Gairo	Quality protein maize
Gerald Mhando	Ibuti/Gairo	Quality protein maize
Yohana Mkola	Ibuti/Gairo	Quality protein maize
Angelina Hendry	Ibuti/Gairo	Quality protein maize
Agnes Chiduo	Ibuti/Gairo	Quality protein maize
Neli Ezron	Ibuti/Gairo	Quality protein maize
Castori Komba	Madege/Gairo	OFSP
Mwajabu Almasi	Madege/Gairo	OFSP
Mwajabu Mhando	Madege/Gairo	OFSP
Zainabu Mwenjuma	Madege/Gairo	OFSP
Aziza Issa	Madege/Gairo	OFSP

Name respondent	Village/district	Crop of interest
Ziada Frank	Madege/Gairo	OFSP
Hadijah Said	Madege/Gairo	OFSP
Hadijah Ally	Madege/Gairo	OFSP
Mwajabu Ally	Madege/Gairo	OFSP
Mohamed Zuberi	Madege/Gairo	OFSP
Halima Makuli	Madege/Gairo	OFSP
Rehema Saidi	Madege/Gairo	OFSP
Mariamu Saileni	Madege/Gairo	OFSP
Omari Mvungi	Mkanyageni/Muheza	Quality protein maize
Hamida Othmani	Mkanyageni/Muheza	Quality protein maize
Mwanaidi Rajabu	Mkanyageni/Muheza	Quality protein maize
Hamidu Ally	Mkanyageni/Muheza	Quality protein maize
Mama Anna	Mkanyageni/Muheza	Quality protein maize
George Lucas	Mkanyageni/Muheza	Quality protein maize
Agnes Ramadhan	Mkanyageni/Muheza	Quality protein maize
Omary Mfaume	Mkanyageni/Muheza	Quality protein maize
Ashura Rajabu	Mkanyageni/Muheza	Quality protein maize
Ally Idrisa	Mkanyageni/Muheza	Quality protein maize
Saad Twaha	Msogera/Handeni	Orange maize
Salehe Amduni	Msogera/Handeni	Orange maize
Abdallah Omari	Msogera/Handeni	Orange maize
Aziza Juma	Msogera/Handeni	Orange maize
Latifah Hamduni	Msogera/Handeni	Orange maize
Tatu Ismail	Msogera/Handeni	Orange maize
Khadija Juma	Msogera/Handeni	Orange maize
Musa Hassan	Msogera/Handeni	Orange maize
Mohammed Twaha	Msogera/Handeni	Orange maize
Jumanne Suleiman	Msogera/Handeni	Orange maize

Appendix 6: Trends in annual sweetpotato production and productivity in Tanzania

Year	Area under cultivation (ha)	Total yield (tons/year)	Yield productivity (tons/ha)
2007	450,000	1,322,000	2.9
2008	460,000	1,379,000	2.9
2009	465,000	1,381,120	2.9
2010	480,000	1,381,120	2.9
2011	480,000	1,392,000	2.9
2012	699,073	3,573,302	5.1
2013	651,216	3,018,175	4.6
2014	788,603	3,470,304	4.4
Average	**506,333.5**	**1,786,474.25**	**3.24**

Source: FAOSTAT (2014)

Appendix 7: Production status of OFSP in Tanzania according to farmers' FGDs

Village/district	Varieties grown by farmers	Min. and max. area (ha/household)	Min. and max. yield (tons/ha household)	Households per village	Households growing OFSP per village
Igomaa/Mufindi	Kabode, Mataya, Kiegea, Ejumula, Kakamega	0.1–1.62	17.29-19.76	560	100
Tengeru/Arusha	Jewel, Mataya, Kabode	0.81	2.49	1186	1
Balairuba/Bukoba	Kabode, Kakamega Ejumula, Jewel	0. 08–0.16	1.48	588	30
Madege/Gairo	Kabode, Mataya, Kiegeya, Kakamega, Ejumula	0.1–1.62	6.18	382	22
Malegea/Ukerewe	Kabode, Ejumula, Jewel, Carrot Dar	0.4– 0.81	2.47-4.94	805	19
Nyafla/Ilemela	Kabode, Ejumula, Jewel	0.1–0.2	0.62–1.85	758	24
Matanzi/Mkuranga	Kabode, Kiegea, Mataya	0.1–0.2	1.24	308	146
Mwasonge/Misungwi	Kabode, Ejumula,Jewel	0.2–0.61	3.71–11.12	615	300
Total				**5202**	**642**

Appendix 8: Volumes and forms of OFSP consumed by households producing it

Village-District	Yield consumed by household (%)	Forms of products consumed
Igomaa/Mufindi	20	Cooked roots
Ihanda/Mbozi	40	Cooked roots
Tengeru/Arusha	2	Cooked roots, crisps, buns and spaghetti
Balairuba/Bukoba	33	Cooked roots, buns and chips
Madege/Gairo	25	Cooked roots, buns, chips, crisps, porridge, bread, chapati and spaghetti
Malegea/Ukerewe	50	Cooked roots, flour, chips, buns, porridge and juice
Nyafla/Ilemela	40	Cooked roots, flour, chips, buns, porridge and juice
Matanzi/Mkuranga	75	Cooked roots
Mwasonge/Misungwi	33	Cooked roots, chips and buns
Average	**35.3**	

Source: FGD data

Appendix 9: Study areas

Biofortified crop	Agricultural zone	Region	District/municipality	Key stakeholders in the production value chain
QP maize	Eastern	Tanga	Tanga Municipality	Aminata Quality Ltd
			Muheza District	Farmers
		Morogoro	Morogoro Municipality	TANSEED International Ltd, TOSCI
			Gairo District	Farmers (Gairo District)
		Dar es Salaam	Dar es Salaam City	BNFB, government ministries/departments, development partners, processors, traders, consumers
	Northern	Arusha	Arusha Municipality	Selian Agricultural Research Institute, Multi-Agro Trading
		Kilimanjaro	Hai District	Farmers (Hai district)
	Lake Victoria	Shinyanga	Shinyanga Rural District	Farmers (Shinyanga Rural district)
PVA maize	Eastern	Tanga	Tanga Municipality	Charoen Pokphand Produce (T) Ltd
			Handeni District	Farmers (Handeni District)
		Morogoro	Morogoro Municipality	TANSEED International Ltd, TOSCI
		Dar es Salaam	Dar es Salaam City	BNFB, government ministries/departments, development partners, processors, Consumers
OFSP	Eastern	Morogoro	Morogoro Municipality	SUGECO
			Gairo District	Farmers (Gairo District)
		Coast	Kibaha Township	ARI-Kibaha
			Mkuranga District	Farmers (Mkuranga)
		Dar es Salaam	Dar es Salaam City	BNFB, government ministries/departments, development partners, processors, consumers
	Northern	Arusha	Arusha Municipality	TAHA, , Crop Bioscience Solution Lab
	Lake Victoria	Mwanza		ARI-Ukiriguru
			Ilemela District Ukerewe District Misungwi District	Farmers (Ukerewe, Ilemela, Misungwi Districts)
		Kagera	Bukoba District	ARI-Maruku, Farmers
	Southern Highlands	Mbeya	Mbeya Council	ARI-Uyole
			Bukoba District	Farmers
		Iringa	Mufindi District Iringa Rural District	Farmers (Mufindi and Iringa Rural Districts)
Iron/zinc beans	Northern	Arusha	Arusha Municipality	Selian Research Institute, Farmers
	Southern Highlands	Mbeya	Mbeya Municipality	ARI-Uyole, Farmers
	Eastern	Dar es Salaam	Dar es Salaam City	BNFB, Government Ministries/Departments, Development Partners, Processors, Consumers
		Morogoro	Morogoro Municipal	SUA

Appendix 10: Community bottlenecks to access to biofortified crops and products and priority interventions

Parameter	Bottleneck	Priority interventions
Seed systems	Shortage of high quality OFSP planting materials. This is caused by lack of interest among private companies to invest in OFSP vine multiplication.	As a government agent, ASA is responsible for multiplication of crops that are not very attractive to private companies. ASA, local ARIs and village vine multipliers should be supported to increase production of vines.
	The use of certified vines to reduce viral diseases in every planting season makes OFSP vines more expensive (USD 566 per ha) than vines of the traditional varieties, which are recycled year after year.	Support breeders to produce virus-resistant varieties of sweetpotato to enable farmers to recycle planting materials.
	Seeds of yellow maize variety CP 201 are more expensive than those of the open pollinated (OP) white maize varieties. For instance, seeds of variety CP 201 are sold at TSh 9,000 per kg compared to TSh 6,000 per kg for the OP local varieties produced in Tanzania. In addition, CP 201 is a F1 hybrid, which means that farmers cannot recycle the seeds.	The government is currently providing subsidies on maize seed. It is recommended that such subsidies be directed to yellow maize or biofortified maize so that resource-poor farmers can have access to it.
	Beans are open pollinated and thus their seeds can be recycled. As result, bean seed business is no very attractive for investments by private seed companies. However, ARI-Uyole produces bean seed for business.	Support local ARIs (e.g. ARI-Uyole & ARI-Maruku) to increase production of certified 1 and 2 seeds and farmers to increase production of quality declared seeds (QDS) of high iron/zinc beans.
Promotion	Currently promotion of OFSP is conducted through farmers' training and field days within villages that implement its projects. Promotion activities such as field days should involve all actors in the value chain.	Involve all actors in the value chain in farmers' field days, national agricultural exhibitions (Nane Nane) and Dar es Salaam International Trade Fair (Saba Saba).
	Lack of awareness on biofortified crops and products among the majority of community members.	Create awareness through meetings, factual films and training.
	Misperception among some people in the Lake zone that OFSP is useful for people with malnutrition and HIV/AIDS.	Increase sensitization of community members on the nutritional value of biofortified crops and products.
	Wrong perception among community members that biofortified crop/products are GMOs.	Create awareness and sensitization for the general public on biofortified crops.
Advocacy	Limited awareness among community members on their rights to quality food.	Provision of civic education on the right to quality food such as biofortified products.
		Use of powerful and influential politicians to incorporate biofortification in relevant national policies, strategies and programs.
	Periodic and irregular change in political leadership negatively affects advocacy.	NA
Institutional capacity building and training opportunities	Short-term trainings on biofortification were provided by several projects such as RAC. VISTA project is also providing training on biofortification. However, there are no local training institutes in Tanzania that provide training on biofortification, which limits the capacity to spearhead biofortification.	There is a need to incorporate biofortification as a topic within the plant breeding course. Biofortification can also be incorporated as a topic under food biotechnology or food processing courses. These courses are offered at Sokoine University of Agriculture.
Individual capacity building and training opportunities	There is limited knowledge among individuals on biofortified crops and nutritional value of biofortified products.	There is a need to have several approaches to make individuals aware of biofortified crops and their nutritional value through TV programs, thematic workshops with a focus on farmers and primary and secondary schools.

Appendix 11: Volume and forms of OFSP marketed by households producing OFSP, according to farmers' FGDs

Village/District	Yield marketed (%)	Forms of OFSP products marketed	Unit	Selling price (Tsh)
Igomaa/Mufindi	80	Raw roots	18 kg bucket	10,000
Ihanda/Mbozi	60	Raw roots	18 kg bucket	5,000
Tengeru/Arusha	80	Raw roots	54 kg bag	15,000
Balairuba /Bukoba	66	Raw roots	1 kg	530
		Buns	1 pc	250
		Chips	1 plate	500
Madege/Gairo	75	Raw roots	18 kg bucket	10,000
Malegea/Ukerewe	50	Raw roots	1 kg	500
Nyafla/Ilemela	60	Raw roots	1 kg	1,000
		Flour	1 kg	2,000
		Chips	1 food plate	1,000
		Buns	1 bun	100
		Juice	250 ml	300
Matanzi/Mkuranga	25	Raw roots	54 kg bag	15,000
Mwasonge/Misungwi	67	Raw roots	1 kg	1,000
		Chips	1 kg	1,200
		Flour	1 kg	2,200
Average	**62.7**			

Appendix 12: Biofortification content in the national policies and strategies

Policy/ strategy	Description of policy/strategy	Areas of biofortification or related areas covered	Gaps in the policy document	Recommendations/ implications for the advocacy strategy
The National Agriculture Policy of 2013 (URT, 2013)	To enhance production, productivity, competitiveness and profitability of the agricultural sector.	To promote production and utilization of crops with high nutrient content in areas experiencing nutritional problems.	The high nutrient crops promoted in the policy statement can include biofortified crops.	The policy should integrate biofortification in the promotion of production and utilization of crops with high nutrient content in areas experiencing nutritional problems.
Agricultural Sector Development Strategy (ASDS) Phase II (2014) (URT, 2014a)	The goal of ASDS-2 is to contribute to national economic growth, reduced rural poverty and improved food security and nutrition.	The policy mentions maize and beans as examples of biofortified crops.	There is low priority on biofortified crops in the strategy.	Integrate biofortified crops in ASDS-2 as staples and influence the government to promote them as both staple and nutritious crops.
Agricultural Sector Development Programme Phase Two (ASDP-2) of 2016 (URT, 2016c).	The goal of ASDP-2 is to contribute to the national economic growth, reduced rural poverty and improved food security and nutrition.	ASDP-2 contributes to improved rural nutrition by promoting breeding of high quality crops and food safety, although for the proposed priority value chains, the scope remains relatively limited, e.g. it focuses on quality protein maize and enriched rice varieties.	Low priority is given to biofortified crops in the strategy.	Integrate biofortified crops in ASDP-2 as staples and influence the government to allocate a budget for them as both staple and nutritious crops.
Seeds Act No. 18 of 2003 (URT, 2003) and its Seeds Regulations GN No.37 of 2007 (URT, 2007b)	This act and its regulations provide an institutional framework for agricultural seed quality assurance through registration of seed dealers; variety release; variety registration and deregistration; and seed classification, standards, marking and labeling, certification, and sampling and testing.	None	There are no special regulations on variety release, registration and deregistration, marking and labeling, or seed certification for biofortified crops.	The National Seed Committee is required to advise the minister of approvals of new plant varieties. The implications of this are not clearly stipulated. The regulatory powers of the minister are too wide, which may interfere with the statutory functions of TOSCI. BNFB may take advantage of the power of the minister to influence the release of new varieties and scale up biofortification.
National Science and Technology Policy for Tanzania of 1996 (URT, 1996b)	This policy is a tool to develop and manage science and technology in a manner consistent with the physical and human endowment of Tanzania. This policy is a means to organize and sustain science and technology capacity that is realistic, efficient and productive.	The second bullet in section 21 (p. 13) under Agricultural Research promotes breeding for higher yielding and more nutritious crop varieties of staple foods such as maize, banana, rice, wheat, sorghum, millet, tropical root and tuber crops, and vegetables.	There is no strategy or program to support breeding of more nutritious crops, including biofortified crops.	The policy is currently under review and should integrate biofortification as part of the breeding processes for more nutritious crop varieties.

Policy/ strategy	Description of policy/strategy	Areas of biofortification or related areas covered	Gaps in the policy document	Recommendations/ implications for the advocacy strategy
Food and Nutrition Policy for Tanzania, July 2016 (URT, 2016d).	This policy provides an opportunity for critically re-examining the factors responsible for malnutrition among vulnerable groups. It aims at contributing to renewed commitment and focus to address critical issues basic to improving the nutritional status of the community.	None	The policy is not yet finalized for endorsement.	BNFB should engage with the policy-makers to review and provide input on biofortification interventions.
National Multisectoral Nutrition Action Plan (NMNAP) (July 2016–June 2021) (URT, 2016e)	NMNAP's broad goal is to accelerate scaling up of high impact multisectoral nutrition-specific and nutrition-sensitive interventions and creating an enabling environment for improved nutrition for a healthy and wealthy nation, with special focus on the most vulnerable groups.	Promotion and multiplication of seeds, seedlings and cuttings of nutrient rich varieties (PVA maize, high iron beans, OFSP, cassava and vitamin A rich bananas) and distribute to farmers.	NMNAP promotes biofortification by promoting micronutrient-rich varieties such as OFSP, but it does not say who should multiply the seeds of these plants for farmers.	The multisectoral nutrition action implementation plan accommodates promotion of biofortification interventions as a complementary effort to increasing vitamin and mineral intake.
Child Development Policy of 2008 (URT, 2008)	The main goal of this policy is to ensure that children develop and lead a good life as their basic right to development, protection and participation in matters that concern them, including nutrition, which is essential to all human beings.	The policy is silent on biofortification but its section 35 of chapter 3 insists that children's developmental stages must be taken care of, for which the essential needs include nutrition.	The policy should include statements that insist on provision of essential nutrients for children and pregnant women by utilization of biofortified food crops and products.	The policy, which is currently under review, should integrate biofortification as a part of the package for provision of essential nutrients to children and pregnant mothers.
National Health Policy of 2007 (URT, 2007a)	The main aim of this policy is to reduce the burden of diseases and maternal and infant mortality and increase life expectancy through the provision of adequate and equitable maternal and child health services and provision of adequate nutrition.	None	The policy promotes provision of adequate nutrition to children but does not promote the use of biofortified products.	The policy, which is currently under review, should integrate biofortification as a part of the promotion of adequate nutrition.
Health Sector Strategic Plan III (2009–2015) – (URT, 2009)	This policy aims at strengthening the capacity for management of acute malnutrition.	None	The strategy should provide for implementation programs promoting the utilization of biofortified food crops and products by children and pregnant women.	During the implementation of this strategic plan, the ministry could be advised to include the promotion of the consumption of biofortified food crops by children, pregnant women and lactating mothers in order to achieve the main goal of reducing malnutrition.

Policy/ strategy	Description of policy/strategy	Areas of biofortification or related areas covered	Gaps in the policy document	Recommendations/ implications for the advocacy strategy
Community Development Policy of 1996 (URT, 1996a)	This policy promotes income improvement and use of wealth to improve the welfare of Tanzanians.	None	The policy promotes production and income improvement and the use wealth to improve people's welfare, but it does not specifically mention nutrition.	The policy, which is currently under review, should integrate biofortification as part of the actions to improve people's income and welfare.
Biotechnology Policy of 2010 (URT, 2010)	This policy aims to ensure that Tanzania has the capacity and capability to capture the proven benefits arising from health, agriculture, industry and environmental applications of biotechnology while protecting and sustaining the safety of the community and the environment.	Section 4.6 (Priority areas for biotechnology) emphasizes the objective to "develop new varieties of high quality and high yielding, pest resistant plants and animals".	The policy does not mention biofortification but it promotes the development of new crop varieties of high quality and high yield.	The policy should integrate biofortification as part of the processes for the development of new crop varieties of high quality and high yield.
Education Policy (2014) and its Sector Development Programme (URT, 2014b)	The Education Sector Development Programme 2008–2017, section 3.4 on Equity of Access to Quality Education has as one of its priority actions for access to quality education the introduction of school feeding schemes, albeit at the community's expense.	None	The Education Sector Development Program 2008–2017 promotes equity of access to quality education through the introduction of school feeding schemes, among other actions.	The Education Sector Program should integrate consumption of biofortified products as part of school feeding schemes.
Education Sector Development Plan (2016/17–2020/21)	ESDP is based on the priorities of the Tanzanian government as set out in the Tanzania Development Vision 2025, the National Five-Year Development Plan 2016/17–2020/21 and the Education and Training Policy of 2014.	None	This plan mentions the need for school feeding programs and good nutrition for better learning outcomes. However, it fails to provide details on how this can be achieved or operationalized.	ESDP indicates that TIE is in the process of finalizing a new INSET framework and that there are plans to establish a teachers' professional board to coordinate and formalize the teaching profession. The plan also proposes school feeding programs. Advocacy to entrench biofortification in the national INSET framework and the school feeding program is proposed.

Appendix 13: National and international platforms working in Tanzania

Name	Main roles
National advocacy platform	
Agriculture Coalition	The Agriculture Coalition is a partnership of Oxfam in Tanzania, ANSAF, TGNP, Action Aid Tanzania and the Policy Forum and aims to strengthen engagement, analysis and advocacy on issues around the national budget processes in Tanzania.
ANSAF	ANSAF is a member-led forum for non-state actors to discuss and work towards solutions to improve the agriculture sector in the interest of men and women currently living in poverty. ANSAF develops common positions and joint action plans toward influencing policies and practices that hinder the development of the agriculture sector and promotes proven and innovative practices within the sector for wider uptake and consideration by farmers, policy-makers and other stakeholders.
Food and Nutrition Association of Tanzania (FONATA)	FONATA is an association that incorporates food scientists and nutritionists. It arranges meetings, workshops and conferences where issues of food and nutrition are exchanged. FONATA is hosted by the Tanzania Food and Nutrition Centre, which is mandated to oversee the nutrition agenda in the country. The objectives of FONATA are to promote information exchange on food and nutrition and to form a forum for consultation in areas related to food and nutrition.
High Level Steering Committee for Nutrition	The High Level Steering Committee is led and chaired by the permanent secretary in the Prime Minister's Office. Its membership includes permanent secretaries of the government ministries from the Prime Minister's Office – RALG; the ministries of health and social welfare, agriculture food security and cooperatives, livestock and fisheries, water, education and vocational training, industry and trade, natural resources and tourism, and community development, gender and children; the East African Community; the Executive Secretary of the Planning Commission; development partners UNICEF, USAID and Irish Aid; private sector; SUA; faith-based organizations (TEC and National Muslim Council of Tanzania) and NGOs. The chair may decide to invite to the meetings other relevant heads of ministerial departments, organizations or external experts. The objective of this committee is to ensure comprehensive and coordinated understanding and action in responding to the nutrition challenges in Tanzania. It serves as the interministerial monitoring body of the National Nutrition Strategy and the Tanzania Agriculture and Food Security Investment Plan. It meets every six months and on ad-hoc basis if required. Each ministry and agency represented reports on progress towards the key milestones on nutrition, activities undertaken and their results and activities planned for the next six months.
Joint Multisectoral Nutrition Review Meetings	After three years of implementation of the National Nutrition Strategy, the High Level Steering Committee on Nutrition convened the first of the joint multisectoral nutrition reviews of the National Nutrition Strategy (2011/12–2015/16) at the Julius Nyerere International Convention Centre in Dar es Salaam in 2014. The event was hosted by the Prime Ministers' Office as chair of the High-Level Steering Committee on Nutrition and organized by the Ministry of Health and Social Welfare through the Tanzania Food and Nutrition Centre. Support for such reviews is normally sought from development partners such as UN-REACH, Irish Aid, USAID/FHI 360, UNICEF, WHO and WFP. The outcomes of the reviews are normally expected to guide the implementation of the National Nutrition Strategy and the design of future strategies. The primary objectives of the joint review meetings are to review, analyze and document progress, challenges and lessons learned from the years of the National Nutrition Strategy's implementation.

Name	Main roles
Multisectoral Nutrition Technical Working Group	In recognition of the need for concerted efforts to address malnutrition, a Multisectoral Nutrition Technical Working Group was formed to facilitate policy and technical dialogue across all relevant sectors in Tanzania. The overall aims of the technical group are to provide advisory support on nutrition to key sectors and to monitor the performance of nutrition initiatives against the goals, objectives and targets in the sector's strategies and policies and the National Strategy for Growth and Poverty Reduction (MKUKUTA). The working group, which meets every three months, is composed of the managing director of TFNC, who serves as the chairperson, and the TFNC director of policy and planning, who serves as the deputy. The director of National Food Security is the co-chair of TWG on nutrition. TFNC also serves as the secretariat, with support from the chair and the co-chair of the Development Partners Group on Nutrition. Other members include representatives from the government, development partners, NGOs, the private sector and civil society organizations. Membership is composed of institutions, which designate a focal person who is expected to participate actively in the activities of the group.
National Food Fortification Alliance	NFFA was established in 2003 to oversee the implementation of food fortification initiatives in Tanzania. NFFA draws members from public and private sectors, academia, NGOs, and multisectoral and bilateral organizations. The alliance was formed as an advisory body for the program on food fortification in Tanzania with the roles of overseeing the implementation and monitoring of fortification initiatives and providing advice for their implementation.
Partnership for Nutrition in Tanzania (PANITA)	PANITA provides technical expertise to support the SUN Movement, including on the development of implementation guidelines and resource sourcing for programs and providing advice on policy. PANITA is a member of Tanzania's Multisectoral Nutrition Technical Working Group. PANITA works collaboratively with nutrition champions from the Parliamentary Group for Nutrition, Food Security and Children's Rights.
Policy Forum	The Policy Forum is a multisectoral policy advocacy platform in Tanzania aimed at influencing policy processes to enhance poverty reduction, equity and democratization and increase informed civil society participation in decisions and actions. It is a network of 74 civil society organizations. It seeks to influence policy processes for enhanced governance, accountable use of public resources and effective protection of human rights. So far it has no explicit nutrition agenda. BNFB advocacy and stakeholder linkages initiative can booster the potential of the platform to adopt nutrition and embrace biofortification.
Tanzania Agricultural Partnerships (TAP)	TAP consists of public institutions, private companies and national and international organizations and is coordinated by the Agricultural Council of Tanzania (ACT). TAP mainly works on rice and maize value chains and is currently working towards including value chains for sunflower and cassava. It aims to reduce rural poverty by delivering appropriate agricultural inputs and improving output markets for Tanzanian farmers.
Tanzania Gender Networking Programme (TGNP)	TGNP is a civil society actor that promotes gender equality and women's empowerment through policy advocacy and mainstreaming of gender in Tanzanian policies and laws.
International and regional advocacy platforms	
Amsterdam Initiative Against Malnutrition (AIM)	Launched in 2009, AIM aims to bring its partners together to find innovative and sustainable solutions to address malnutrition. The initiative currently focuses on Ethiopia, Kenya, South Africa and Tanzania. Among its other activities are the work to boost the local production and distribution of micronutrient powder.
Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA)	ASARECA is a not-for-profit subregional organization of the national agricultural research systems of 11 member countries including Tanzania. ASARECA brings together scientists from the national agricultural research institutions of the member countries, national agricultural extension service providers and other strategic development-oriented partners to generate, share and promote knowledge and innovations to solve common challenges facing agriculture in the member countries.

Name	Main roles
Business Platform for Nutrition Research	Launched in mid-2013, the Business Platform for Nutrition Research aims to utilize the research capacities of global businesses to help define, fund and disseminate new research to improve nutrition in the developing world.
Coalition of CAADP Non-Sate Actors	CAADP targets the enhancement of the role that non-state actors play in ensuring that agricultural transformation is made possible at the continental level. In the light of that fact, CAADP non-state actors' coalitions are being established at the continental level to enhance the coherence of efforts being undertaken by non-state actors and improve their coordination. This will support CAADP pillar programs to achieve the goals of agriculture productivity growth, inter-regional food trade, poverty reduction and economic growth.
East African Farmers' Federation (EAFF)	EAFF aims to promote regional integration of farmers in eastern Africa. It has the objectives of ensuring food and sustainable livelihoods for family farmers, creating a surplus for export markets, creating and adding value to products for industrial use, generating social security and solidarity in communities, ensuring equitable access to productive resources, and fostering sustainable management of natural resources.
GAIN Nordic Partnership	GAIN Nordic Partnership is a multisector platform with the desire to facilitate the implementation of a scalable and inclusive business model that enhances the nutritional value of food in developing countries. The partnership works to ensure the availability of affordable nutritious and safe products to poor consumers and vulnerable groups.
Global Alliance for Improving Nutrition (GAIN)	GAIN works to improve agriculture and nutrition security through building alliances with stakeholders and representatives from every major sector in development. GAIN works with diverse partners, specifically from the national government, civil society, academic institutions, international bodies such as the United Nations, donors, foundations, consumer groups, and local and international private sector companies in several countries including Tanzania.
Pan-Africa Bean Research Alliance (PABRA)	PABRA is made up of an international network of bean researchers, 29 national agricultural research institutions and more than 350 partner organizations. As a result of PABRA's interventions, more farming families have access to improved and marketable bean varieties, new crop management techniques, micronutrient-rich, bean-based products, niche market varieties and products, and bean-related skills and knowledge that help to increase incomes and boost food and nutrition security.
Sun Business Network	Launched by WFP and GAIN in 2010, the Sun Business Network aims to promote business engagement in the SUN movement.
SUN Movement	On 5 June 2011 the United Republic of Tanzania joined the SUN Movement through a letter of commitment from former President H.E. Jakaya Kikwete. At that time Tanzania had established the High-Level Steering Committee for Nutrition, which is convened by the Prime Minister's Office and involves multiple ministries and stakeholders. Tanzania has also established the Parliamentarian Group on Nutrition, which has drawn up an action plan for advocating for nutrition in parliament. Tanzania had also joined the UN REACH Partnership Initiative.
Forum for Agricultural Research in Africa (FARA)	FARA is the apex continental organization responsible for coordinating and advocating for agricultural research for development. FARA serves as the technical arm of the African Union Commission on matters concerning agricultural science, technology and innovation.
Tropical Agriculture Platform (TAP)	TAP helps countries to strengthen their national capacity for agricultural innovation. Ultimately, small farmers, small and medium-size agribusinesses and consumers are the beneficiaries of TAP's activities. TAP aims to increase farmers' income, food security and nutrition, and environmental sustainability.

Appendix 14: Institutional challenges in releasing new varieties of biofortified crops in Tanzania

Category of challenge	Institutional challenges	Proposed interventions
Technical	TOSCI has limited capacity of human resources and laboratory equipment for analysis of micronutrients. Usually the institute sends samples for analysis to local laboratories such as TFDA. These local laboratories require standards for biofortified crops such as for minimum levels of micronutrients and protocols for laboratory analysis of micronutrients. They also require equipment such as infrared spectrophotometers and skilled personnel to analyze micronutrients.	BNFB should work through its affiliates' laboratories such as those at Harvest-Plus to support local institutions such as TFDA, SUA and TBS in setting standards for biofortified crops, establishing standard levels of micronutrients in products, developing protocols for laboratory analysis of micronutrients, training technical staff, and providing laboratory equipment for analysis of micronutrients locally.
Financial	TOSCI charges USD 500 for conducting one DUS test and USD 600 for conducting one NPT per variety in at least three geographical sites. Funding is inadequate to visit all the trial sites since they are in the Northern, Southern, Eastern and Central zones, which are agroecologically far apart.	BNFB partners should support TOSCI financially to conduct DUS testing and NPTs in order to fast track the release of the varieties in the pipeline.
Structural	The National Seed Committee is required to advise the minister on the approval of plant varieties but this is not stipulated clearly. Similarly, the regulatory powers of the minister under the current seed law are too wide and may interfere with the statutory functions of TOSCI.	BNFB may leverage the power of the minister in influencing the release of new varieties. This can be done by inviting the minister or permanent secretary as a guest of honor at BNFB project meetings and workshops. So far the BNFB team is engaged in a discussion with TOSCI to explore the possibilities of fast tracking the release of biofortified crop varieties.

Source: Data from key informants and FGDs

Appendix 15: SUA capacity assessment for biofortification

Area of capacity development	SUA Department of Crop Science and Horticulture	SUA Department of Food Science and Nutrition
Training		
Strengths	Strong expertise in plant tissue culture, molecular biology, crop protection, agronomy and plant breeding	Presence of training on food technology, food biotechnology, nutrition and consumer sciences; strong expertise in these areas; and existence of teaching venues
Weakness	Inadequate number of technicians for practical training and lack of biofortification content in the training curriculum	Training curriculum contains fortification and supplementation but does not cover biofortification
Opportunities	Expertise in plant tissue culture, molecular biology, crop protection, agronomy and plant breeding is useful for capacity development in biofortification	Available expertise in food technology, food biotechnology, nutrition, and consumer sciences is useful for training in biofortification
Facilities		
Strengths	Equipment and facilities are available for tissue culture, molecular biology, seed health, plant pathology studies, nursery production, greenhouses, water reservoirs and drip irrigated farms	Laboratories are available for analysis of nutrients such as iron, zinc, lysine, tryptophan and beta-carotene
Weakness	Unreliable electricity supply and lack of standby generators and solar power for electricity	Unreliable electricity supply and lack of standby generators and solar power for electricity
Opportunities	The department can support training of farmers on biofortification, laboratory analysis of micronutrients, production of OFSP through vitro propagation, and disease diagnosis and management	The department can support training of food processors on biofortification and laboratory analysis of micronutrients
Training manuals		
Strengths	Expertise is available to develop manuals in areas related biofortification, specifically plant tissue culture, crop protection, agronomy, plant propagation and postharvest management	Trained personnel are available in food technology, food biotechnology, nutrition and consumer sciences for the development of training manuals on biofortification
Weakness	Low motivation among staff to develop training manuals as these do not count for promotion to high ranks	Low motivation among staff to develop training manuals as these do not count for promotion to high ranks
Opportunities	The department can support development of training manuals in various areas of biofortification	The department can support development training manuals in biofortification with respect to food technology, food biotechnology, nutrition and consumer sciences

Source: Data from key informants

Appendix 16: Middle level MATIs

Institute	Courses for 2017/2018	Address
MATI Ilonga	• Diploma in General Agriculture (NTA Level 6 (Upgrade) • Diploma in General Agriculture (NTA Level 5–6) • Diploma in Food Production and Nutrition (NTA Level 5-6 • Certificate in General Agriculture (NTA Level 4–5)	P.O. Box 66, Kilosa
MATI Mlingano	• Diploma in Agro mechanization (NTA Level 5–6)	P.O. Box 5051, Tanga
MATI Uyole	• Diploma in General Agriculture (NTA Level 6 (Upgrade) • Diploma in General Agriculture (NTA Level 5–6) • Diploma in Crop Production (NTA Level 5–6) • Certificate in General Agriculture (NTA Level 4–5)	P.O. Box 2292, Mbeya
MATI Ukiriguru	• Diploma in General Agriculture (NTA Level 6 (Upgrade) • Diploma in General Agriculture (NTA Level 5–6) • Certificate in General Agriculture (NTA Level 4–5) • Diploma in Crop Production (NTA Level 5–6)	P.O. BOX 1434, Mwanza
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Appendix 17: Checklist for consultations and FGDs for key stakeholders

SITAN SPECIFIC OBJECTIVE 1: Use available data and other information to accurately identify key actors in scaling up biofortified crops, and trends and patterns of consumption of biofortified crops and their products, disaggregated by relevant segments of the country and of the population

1.0 Research and seed systems of biofortified crops

1.1 Description of the seed system in Tanzania

i. Maize (general, quality protein maize and pro-vitamin A maize)

ii. Beans (general and then focus on high iron and zinc beans)

iii. Sweetpotatoes (general and then focus on OFSP)

1.2 Identify seed systems stakeholders and key players for each crop

i. Characterization and profiling of the existing seed market

ii. Understanding the existing sources of planting material

iii. Understanding the existing distribution channels and sub-channels of planting materials

1.3 Varieties and farmers-preference

i. List of existing crop varieties

ii. List of already officially released biofortified varieties

iii. Nutritional composition of the variety (e.g. vitamin A, iron, zinc, lysine and tryptophan)

iv. List of farmer-preferred varieties (biofortified and conventional) with reasons

1.4 Research in biofortified crops

i. Who are the major players in research on biofortified crops?

ii. Who is doing what in biofortification?

iii. Mapping of seed production and supply

iv. Private vs. public sector involvement in seed systems by crop

v. Quantities of seed/planting material produced and supplied to farmers

vi. Categories (certified, truthful labeled etc.) of seed supplied

1.5 Varieties under development for release

i. What are the varieties in the pipeline and current stage and biochemical composition?

ii. Which researcher is spearheading the release process for each variety?

1.6 What are the gaps that ought to be addressed to expedite the release of the pipeline varieties?

i. Institutional capacity (TOSCI)

ii. Policies, laws and regulations

iii. Financial

iv. For each of the above, give recommendations

2. Agronomy of biofortified crops

2.1 Performance of biofortified crop varieties

i. Time to maturity

ii. Adaptation

iii. Area under production

iv. Yield per unit area and per year

v. Quality

2.2 Pests and diseases

i. Resistance and or susceptibility to diseases and insect pests

ii. If susceptible to disease or insect pests, mention them?

2.3 Input supply system and use

i. Which fertilizers are used in production of each biofortified crop?

ii. Which pesticides are used in production of each biofortified crop?

iii. Are certified seeds used for production of each biofortified crop?

3. Cookability and Sensory attributes of biofortified crop varieties

i. Cookability (time spent and texture of cooked product

ii. Sensory attributes (aroma, taste, smell and appearance)

4. Postharvest storage and progressing of biofortified crops (SUGECO)

i. Postharvest storage (current and potential)

ii. Processing and value addition (itemize products)

iii. List of processors (current and potential)

iv. Mapping of value chain players

5. Marketing of biofortified crops

i. Local and export demand of biofortified crops and products

ii. Local and export supply of biofortified crops and products

iii. Mapping of market channels and market accessibility

SITAN SPECIFIC OBJECTIVE 2: Identify and analyze the barriers and bottlenecks that prevent disadvantaged groups from accessing and benefiting from biofortification, including the social/cultural, political and economic conditions that result in shortfalls in the creation of an enabling environment for the scaling up of biofortification.

1. **Disaggregation of disadvantaged groups actually consuming of biofortified crops, frequency of consumption and quantities consumed**.

   i. Male-female involvement and roles in producing the crops

   ii. Quantity consumed at the household level vs. quantity sold

   iii. Quantity consumed by under-fives

   iv. Quantity consumed by females aged 15–49 years

   v. List of barriers to scaling up of biofortified crops (social, traditional, economic, political, dietary and culinary requirements, agronomic, storability and farming practices disaggregated by disadvantaged groups above).

   vi. Enhancers of scaling up of biofortified crops (social, traditional, economic, political, dietary and culinary requirements, agronomic, storability and farming practices disaggregated by disadvantaged groups above).

2. **Existing alternative sources of micronutrients of interest other than biofortified crops**

   i. List of alternative sources of vitamin A

   ii. List of alternative sources of iron and zinc

   iii. List of alternative sources of proteins

3. What are the awareness levels for hidden hunger in general and biofortified crops in particular?

SITAN SPECIFIC OBJECTIVE 3: Assess the current investment pattern in biofortification and main donors to approach and to unlock increased investments in biofortification.

i. Itemize previous and current donors who fund biofortification?

ii. Who are the main funders in biofortification in the country?

iii. Which areas of biofortification do they support (crop research, labs and human recourses and advocacy)?

iv. Mention potential donors who might be interested in funding biofortification and in which areas of support (crop research, laboratories and human recourses and advocacy).

4. SITAN SPECIFIC OBJECTIVE 4: Analyze the extent to which biofortification is prioritized in national policies, laws, strategies, plans and budgets. This would include an analysis of the extent to which there is an enabling environment for the realization of the scaling up consumption including the promotion of positive social norms and behaviors, organization of services, institutional capacities at national, subnational and community levels.

i. What are the current investment/resource allocation patterns by government as far as agriculture and nutrition sectors are concerned?

ii. What are the current investment/resource allocation patterns by government in biofortification (consider both ministries responsible for agriculture and health)?

iii. Assess private sector involvement and investment in biofortification (research, seed production, production, processing and marketing)

iv. What are the key constraints to private sector investment in biofortification and how can they be addressed?

5. **SITAN SPECIFIC OBJECTIVE 5:** Analyze government (and its agencies) policy and funding priorities as far as nutrition and biofortification are concerned.

1. Policy environment

i. What are policy documents and government strategic plans that prioritize biofortification within the agricultural, health, education and nutrition sectors (See findings from review of policies and strategies)

ii. What programs on biofortification have been developed as a result of the policies above?

iii. Who are the key actors and sponsors (government, international donor, etc.) of these programs?

iv. What is the level of success and weaknesses of the programs on biofortification?

v. What are the current policy documents and government strategic plans that the government is working on within the agricultural and nutrition sectors? (Indicate the status of completion and the focus of each)

vi. Who are the major stakeholders (individuals and institutions) spearheading the process above?

vii. What do you recommend as mechanisms to overcome the barriers above?

SITAN SPECIFIC OBJECTIVE 6: Analyze current institutional and structural bottlenecks to address the value chain for the biofortified crops in the country (varietal release policies/criteria, and the biofortified varieties currently in the pipeline for release).

i. What are the institutional and structural bottlenecks to address the value chain for the biofortified crops (consider the varietal release policies/criteria and policies, infrastructure, personnel etc.)?

ii. What do you recommend as mechanisms to overcome the institutional and structural barriers above?

SITAN SPECIFIC OBJECTIVE 7: Assess the needs of the population/communities, bottlenecks/gaps to be addressed and prioritize interventions that need to be implemented (advocacy, promotion, seed systems and institutional and individual capacity building and training opportunities).

iii. What are the needs for adoption of biofortified crops (prioritize them)?

i. What bottlenecks/gaps should be addressed to enhance adoption/scaling-up of biofortified crops?

- Seed systems
- Social/cultural
- Economical
- Political
- Agronomical
- Storage practices and storability
- Farming practices
- Dietary and culinary
- Institutional/individual capacity
- Advocacy
- Promotion

3. What interventions should be implemented in order to address the above bottlenecks?

Building Nutritious Food Baskets

The Building Nutritious Food Baskets: Scaling up Biofortified Crops for Nutrition Security seeks to reduce hidden hunger by catalyzing sustainable investment for the production and utilization of biofortified crops (Orange-fleshed sweetpotato (OFSP); vitamin A (yellow) cassava, vitamin A (orange) maize and high iron/zinc beans) at scale. The project is implemented in **Nigeria** and **Tanzania**, to demonstrate how biofortified crops can be scaled up through a multi-crop ("food basket") approach. BNFB draws on complementary expertise for scaling up through a partnership between CGIAR centers and programs, regional organizations and other public and private sector agencies to create a movement that will eventually reach the target populations. BNFB's hypothesis is that scaling up is dependent on supportive policy environment, strong institutional capacities and availability of proven technologies.