African Union

Upscaling Biofortification in Africa: A Roadmap

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UPSCALING BIOFORTIFICATION IN AFRICA: A ROADMAP

The Challenge: Micronutrient Malnutrition in Africa

Micronutrient deficiency, which affects two billion people worldwide, leads to blindness, weakened immunity, stunted physical and cognitive development, haemorrhage during childbirth, and other serious health problems. This "hidden hunger" has seriously affected millions of women and children in Africa. Almost half of African children under five suffer from vitamin A deficiency; 60% suffer from anaemia, often caused by iron deficiency; and 25% are deficient in zinc. (These three micronutrients are identified by the WHO as among the most important for health). According to World Bank (2018), individual African countries lose several millions of dollars annually to vitamin and mineral deficiencies.

An Innovative Solution: Biofortification

A promising new approach to this problem is biofortification, which specifically targets smallholder farmers with limited access to diverse diets, commercially fortified foods or vitamin supplementation. Using conventional crop breeding techniques, more than 300 varieties of nutrient-rich staple food crops have been developed, tested or released in 60 countries around the world. These are called biofortified varieties. More than 50 million people in rural farm households are now growing and eating vitamin A cassava, maize and sweet potato; iron beans and millet; zinc maize, rice and wheat and other biofortified grain, legume and root/tuber crops. Peer-reviewed published evidence, much of it conducted in Africa, has demonstrated that biofortified foods reduce anaemia, diarrhoea and night blindness, and improve cognitive and physical performance. Data from Uganda shows that biofortification costs only $15 – $20 per Disability Adjusted Life Year (DALY) saved, making it a highly cost-effective, nutrition-sensitive agricultural intervention. (A detailed compendium of biofortification evidence, including links to studies, can be found here.) Biofortification has the potential to reduce demands on national health budgets and to contribute to national development, by improving the overall health and well-being of the population and their ability to contribute to economic development.

This document's main audience are policy makers and other stakeholders working in the 55 Member States of the African Union (AU). It serves the following two purposes:

1. It provides guidelines for the implementation of biofortification strategies for AU Member States (MS). These strategies are essential for achieving the national food and nutrition targets as detailed in the domestication of the Malabo Committments of 2014[1]; and
2. It forms part of the documents that will be included in the Framework for Biofortification in Africa consequent to the Continental Declaration by the African Union.

Africa Leads the Way

Today in Africa, a number of crops, including cassava, maize, sweet potato, beans and pearl millet, are being enriched with micronutrients such as vitamin A, iron and zinc. The first-ever large-scale deployment

[1] The Malabo Commitments of 2014 are the latest since the initial 2003 Comprehensive Africa Agriculture Development Programme (CAADP) commitments of the African Union. To measure progress on domestication, the AU set up a biennial review where these targets are monitored and reported on. The first of these was in 2018.

of a biofortified crop (vitamin A orange fleshed sweet potato in Mozambique and Uganda) laid foundation for the global biofortification movement today. National Agricultural Research Institutes (NARIs), working in collaboration with Consultative Group on International Agricultural Research (CGIAR) crop breeding centres, developed and released new crop varieties cross-bred with materials high in micronutrients with local varieties adapted to taste and preferences of the local population. An overwhelming amount of scientific evidence on the efficacy of biofortified crops has resulted in this expansion and led to recognition of leading scientists in this research area. To date:

- More than 100 varieties of nutrient-rich biofortified crops are in testing or have been released in 38 countries in Africa;
- Fourteen countries in Africa already include biofortification in their policies and programmemes;
- The 2016 World Food Prize was awarded to four biofortification pioneers, including three who have spent their careers in Africa; and
- Data from 6 countries in Africa[2], show that more than 6 million farm households were growing biofortified crop varieties by end of 2018. This represents nearly 70 percent of the global count.

Africa is the leading continent on testing, adoption and consumption of biofortified crops and foods.

Actions to Date – The African Union and Other Regional Partners

Positive momentum is increasing towards a continent-wide endorsement of this important nutrition-sensitive agricultural intervention. AU Member States continue to expand access to biofortification and to incorporate it into their policies, strategies, and investment plans; farmer input support programmes and other subsidy and procurement programmes; and health and nutrition programmes.

This achievement prompted the second meeting of the Specialized Technical Committee (STC) on Agriculture, Rural Development, Water and Environment – a policy organ of the African Union – held in early October 2017, to endorse biofortification as a strategy for improving nutrition, complementing industrial fortification, supplementation and dietary diversity, and contributing to the attainment of the Malabo targets for reducing stunting and underweight. The STC called for "AUC, NPCA and Development and Technical partners to work together to develop policy briefs leading to a Declaration on scaling up of biofortification in Africa within the context of development of sustainable food systems." It then requested the AU Commission's Department of Rural Economy and Agriculture (DREA) "to initiate a process for developing a framework for guiding the scale up of biofortification to cover more AU Member States, especially those with the potential for adopting and mainstreaming biofortification into their agribusiness and value chain development interventions." The STC Report was considered in the January 2018 Executive Council Meeting. The AUC/NEPAD Cost of Hunger in Africa Study (COHA), meeting in November 2018, included a recommendation that biofortification be promoted at AU and country level, as a contributing intervention for AU Member States to meet the Malabo Declaration target of a 10% reduction in stunting. The African Task Force on Food and Nutrition Development reviewed biofortification at their 2018 and 2019 meetings, as did the 2019 CAADP Partnership Meeting.

[2] This data is for DR Congo, Nigeria, Rwanda, Uganda, Zambia and Zimbabwe. Such data is not available for several other African countries e.g. Angola, Mozambique, Ghana, Gambia, Kenya, South Africa, Niger, Tanzania, etc. where biofortified crops are being grown and consumed

The African Development Bank (AfDB) has included biofortification in its Multi-Sectoral Nutrition Action Plan (2018-2022), entitled "Harnessing 'Grey Matter Infrastructure' to Unlock the Human and Economic Potential of Africa: Catalyzing nutrition smart investments to support a 40% stunting reduction in Africa by 2025." The relevant section of the Action Plan reads as follows:

"Based on a thorough review of evidence, we have identified specific interventions in the five sectors that have the greatest impact on nutrition, and investments in these sectors can be leveraged to achieve a double bottom line for every dollar spent. Examples of nutrition smart interventions that can be incorporated into the Bank's pipeline and lending requests from regional members countries [include] biofortification - substituting micronutrient-poor staple food crops with varieties of biofortified nutrient-rich crops including high-iron beans, orange flesh sweet potato, yellow/golden cassava, quality protein maize, rice fortified with zinc, and biofortified pearl millet."

In partnership with CGIAR centres, the Forum for Agricultural Research in Africa (FARA) has promoted policy engagement and advocacy about biofortification at sub-regional and regional levels. Several CGIAR centers working in Africa, have contributed significantly to the development and delivery of biofortified crops, notably, the International Potato Center (CIP); the International Institute of Tropical Agriculture (IITA), which won the Africa Food Prize for 2018 for its innovative leadership in a broad array of agricultural innovations; the International Center for Tropical Agriculture (CIAT); the International Maize and Wheat Improvement Center (CIMMYT); the International Food Policy Research Institute (IFPRI); HarvestPlus; and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). The African Green Revolution Forum (AGRF) hosted by Rwanda in September 2018 featured two sessions that included biofortification as an important intervention in nutrition-sensitive agriculture. The Africa regional offices of the UN Food and Agriculture Organization (FAO) and World Food Programme (WFP) have also played a key role in championing biofortification. The FAO has recommended the inclusion of biofortification into National Agricultural Investment Plans (NAIPs) and National Agricultural Transformation Networks, while a conversation on the inclusion of biofortification indicators in the CAADP Biennial Review Scorecard and other nationally representative surveys such as the National Agriculture Surveys and the World Bank-led Living Standards Measurement Study, are at an advanced stage. The Global Panel on Agriculture and Food Systems for Nutrition, co-chaired by former President of Ghana, John Kufuor, has also endorsed biofortification.

Policy documents that highlight biofortification in Africa include the following:

- The African Journal of Food, Agriculture Nutrition and Development (AJFAND) special issue on biofortification;
- NOURISHED: How Africa Can Build a Future Free from Hunger and Malnutrition - the Malabo-Montpellier Panel;
- Cost of Hunger in Africa Studies;
- ReSAKSS (Regional Strategic Analysis and Knowledge Support System) - "Achieving a Nutrition Revolution in Africa" ; and
- Global Panel on Agriculture and Food Systems for Nutrition biofortification policy brief

Why Micronutrients?

As noted earlier, more than two billion people around the world suffer from "hidden hunger" or micronutrient deficiencies. They do not get enough micronutrients from the foods they eat in order to lead healthy, productive lives. The WHO has identified vitamin A, iron and zinc as particularly essential to good health and preventing illness and disability.

Vitamin A is essential for good vision and cell differentiation. Deficiency results in growth retardation, damage to mucous membranes, reproductive disorders, eye damage—and ultimately blindness. Children with vitamin A deficiency are often deficient in multiple micronutrients and are likely to be anaemic, have impaired growth, and be at increased risk of severe morbidity from common childhood infections such as diarrhoea and measles. Pregnant women with vitamin A deficiency may be at increased risk of mortality. Approximately 30 percent of preschool-age children are vitamin A deficient, and nearly 5.2 million preschool-age children suffer from night blindness. A 2013 Lancet article attributed 105,700 childhood deaths to vitamin A deficiency. Over 19 million pregnant women in developing countries are also vitamin A deficient, and 9.7 million are clinically night-blind.

Iron deficiency is the most common micronutrient challenge in the world. Poor diets lacking in iron limit brain development and learning capacity, hampering the potential of individuals and societies, generation after generation. The condition has damaging consequences, including impaired mental development and learning capacity, increased weakness and fatigue, and when it progresses to anaemia, adverse pregnancy outcomes. In low- and middle-income countries, roughly one in four women of reproductive age and two in five young children are anaemic due to iron deficiency.

Zinc is essential for healthy human growth and development, particularly during childhood, adolescence and pregnancy, when zinc requirements are relatively high. It is also required for normal functioning of the immune system. When deficient, children are more vulnerable to common infections like diarrhoea and pneumonia—the top two causes of death worldwide for children under 5 years old. Zinc deficiency is a significant cause of stunting (impaired linear growth) and impaired cognitive development. If stunting is not corrected prior to the second year of life, it can become irreversible and gravely impair development. Stunting can hinder a country's economic activity, potentially reducing GDP by as much as 12 percent. Stunting can be prevented by improving nutrition of women of childbearing age and young children, as well as improving sanitation.

Biofortification: Breeding for Improved Nutrition

Biofortification is an innovative, cost-effective, efficacious and sustainable way to fight micronutrient deficiency. In this food-based approach, staple food plants are bred for beneficial characteristics (yield attributes, other agronomic properties, consumer acceptance, and marketability) that match or outperform varieties farmers currently grow. In addition, biofortified varieties are bred for one or more of the following nutrition attributes:

- A **higher density of key micronutrients** in the edible plant parts, i.e., an improved ability of the plant to translocate and accumulate micronutrients extracted from the soil into the grain/tuber/root;
- A greater absolute **retention of those micronutrients during storage and cooking**; and

- A **higher bioavailable proportion** of micronutrients, i.e., the plant's ability to present the nutrients in forms that allow the human body to more efficiently assimilate them.

When consumed, biofortified foods provide a regular and safe source of micronutrients for all, including individuals who may not be reached by other types of micronutrient interventions.

The initial major fixed costs of developing these new biofortified varieties and determining effectiveness are covered by agricultural research programmes. Once these biofortified crops have been introduced nationally and in targeted communities, farmers are able to freely share the seeds, stems and vines for other farmers to plant; and grain, roots, and tubers for others in their communities to eat. Farmers can grow these crops to deliver better nutrition year after year with limited recurring costs, making biofortification a sustainable intervention for addressing micronutrient deficiency.

Biofortification Priority Index (BPI)

HarvestPlus, a non-profit CG based research programme dedicated to developing and delivering biofortified crops, developed country-crop-micronutrient-specific biofortification prioritization indices (BPIs) that rank countries according to their suitability for investment in biofortification interventions. BPIs combine sub-indices for production, consumption, and micronutrient deficiency, using country-level crop production and consumption data primarily from the FAO and iron, zinc, and vitamin A deficiency data from the WHO. These BPIs are calculated for seven staple crops that have been developed and for 128 countries in Africa, Asia, and Latin America and the Caribbean. For more information on the BPIs and determining an opportunity for biofortification, see this BPI website.

Biofortified Crops – the Nutritional Evidence to Date

Biofortified crops are designed to meet the nutritional needs of young children and women of childbearing age. Nutrients can be lost from the crop during storage, processing, or cooking. In addition, once the food is eaten, the body will only absorb some of the nutrients. To account for these losses, micronutrient target levels are set for each crop and assumptions are scientifically validated. Each newly released biofortified crop is rigorously tested to ensure it will improve the nutritional status of its target communities. Peer-reviewed clinical trial data have shown that biofortified crops reduce the prevalence and duration of diarrhoea; reduce anaemia, night blindness, and days spent with fever and pneumonia; and improve cognitive and physical performance.

Crop Breeding Pipeline

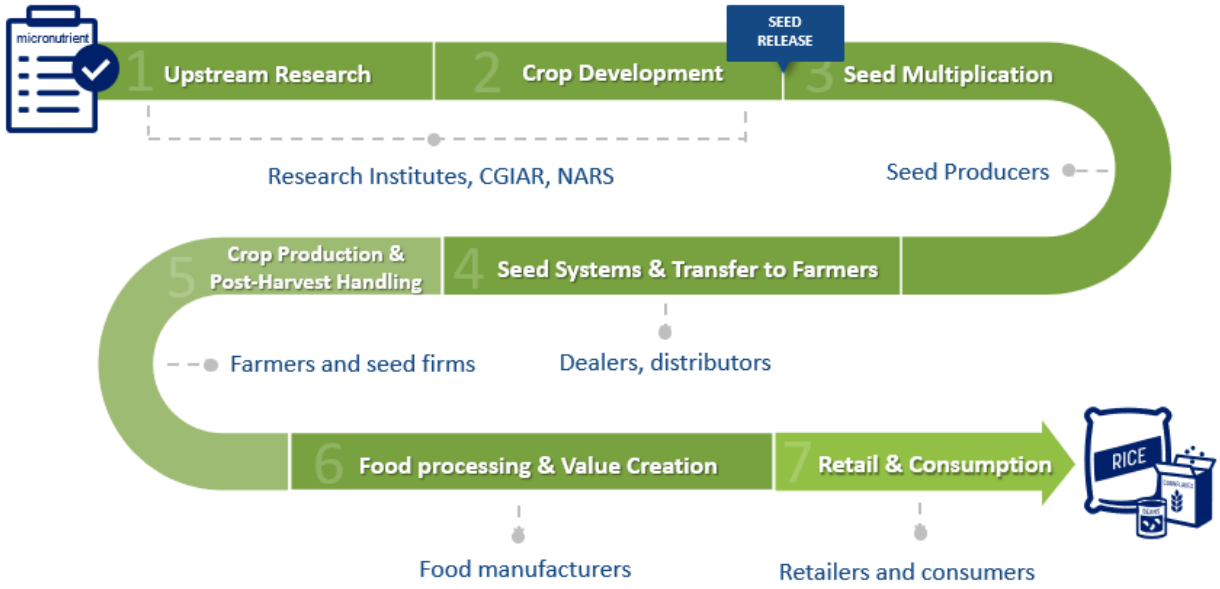
To date, national authorities have approved/released 119 varieties of biofortified staple food crops in 38 countries in Africa. Additional varieties are in the pipeline either being developed or tested. The major biofortified crop varieties released so far are iron beans, vitamin A cassava, vitamin A maize, iron pearl millet, and vitamin A sweet potato. These varieties are equally competitive on production, processing and consumption traits.

Biofortification Development and Delivery Pathway– A Roadmap for Implementation

A proven process has been developed for introducing biofortified crops over two decades of experience in developing and releasing biofortified crops on three continents. This roadmap reviews multiplication and distribution, as well as demand creation and advocacy activities. The following flow chart displays

types of activities that are needed along the biofortified crop value chain, with different actors investing in various parts of the value chain.

Fig 1: Supply Chain for Biofortified Crops



Agricultural Research/Crop Development

This requires leadership of National Agricultural Research Institutes (NARIs) in collaboration with regional, and/or international research centers to adopt and adapt appropriate crops and breeds/varieties for national purposes. The varieties of the crops mentioned (beans, pearl millet, cassava, maize and sweet potato), have been developed in this way in the 38 African countries. Moving forward, these varieties can serve as parental material in national breeding programmes to develop the next wave of biofortified varieties. A key process activity is to strengthen linkages between current research on new biofortified varieties to existing smallholder practices – through participatory varietal development and selection techniques. This way new varieties, are tested for their environmental adaptability, trait stability, agronomic and food quality traits in multi-locational on-farm and on-station trials, with active involvement of farmers/end users/processors/ agricultural extension workers/NGOs etc. Data is collected, compiled, analysed and a report written. Selected high performing varieties are then formally released for farmer production.

Agricultural Supply: Seed multiplication and distribution

The availability of good quality seed is the foundation for successful scaling up of biofortification. Depending on the existing seed systems in place for the crop of interest, seed multiplication can be done by public or private sector partners and it takes the following path: released varieties are licensed to seed companies or community-based multipliers; planting material (or “seed” as they are referred here) are multiplied; seed is packaged and delivered to distribution points (e.g., sub-national depots, agro-dealers, retailers, or development partner warehouses). An investment in multiplication should ensure that the seed system is well linked to a) the breeders who develop and identify new and more productive varieties

with traits sought by farmers and consumers; b) the availability of early generation seed is essential as this can be a bottleneck to the production of certified/quality declared seed; c) A robust seed quality regulatory system to ensure high seed quality; as well as d) the Extension and/or private distribution system for provision of information and training of the producers.

In developing sustainable markets for biofortified seed and grain/processed products, government investment, including subsidies, may be required in the introduction phase.

Demand creation, awareness raising along the value chain

This includes the development of a) messages on the production, nutrition and health benefits of biofortified crops/foods, b) promotional materials, and c) a strategy for dissemination of key messages. While demand creation and awareness campaigns should start early in the process, a careful balance with the seed production capacity and availability is important. A key starting point is to develop producer and consumer insights along each individual value chain – crucial for developing a value proposition for all those engaged, and the relevant promotional and advocacy messages and promotional materials. Evidence-based information should be shared with key stakeholders in the agriculture, nutrition, health, and education arenas in the public, private and social sectors, who will play a key role in integrating biofortification into their policies, programmes and commercial portfolios. One challenge facing the National Agricultural Research Institutes (NARIs) has been the funding limitations experienced in supporting extension agents while undertaking participatory breeding. To manage this challenge, one example can be seen in Ghana, which uses the Innovation Platform (IP) approach to build the capacity of the facilitators because such platforms have all the necessary stakeholders.

As biofortification gains traction, standards and guidelines for ensuring true-to type processed and unprocessed biofortified foods are essential and so are the policies to support the inclusion biofortification in existing and future public and civic sector-led seed and food distribution programmes. Successfully scaling up the delivery of biofortified crops requires a multi-sectorial approach working with both public and private sector partners across the value chain, from researchers, policy makers, private sector, farmers, and civil society organizations.

Marketing and Processing

Farmers will increase production of biofortified crops if there is a guaranteed market. Marketing campaigns are crucial to build demand, both for seed and for grain or processed products. Marketing campaigns build demand for the rural producer/consumer, boosting demand for biofortified seeds from public and private sources; accelerating farmer-to farmer diffusion; and triggering household consumption (a switch to biofortified food). For non-visible trait crops like iron beans and iron pearl millet, it is difficult for farmers and consumers to distinguish biofortified varieties from their non-biofortified counterparts. Effective branding is required to differentiate biofortified grains and other products on the market and to build consumer trust. Campaigns are also essential to create demand in urban areas for identified processed products and generate pull.

Depending on the biofortified crop and existing markets, liaising with private sector agro-processors to develop biofortified products for specific market segments can help create market demand. Products and advertising campaigns should be pretested prior to finalization and dissemination. The plan for active

investment in this phase should last for 3-5 years from the first large scale distribution of planting materials to farmers.

The level of adoption will affect the ability to scale up marketing and processing activities.

Aggregation

In upcoming/developing supply chains, aggregation can be a major bottleneck to scaling. This is typical for biofortified crops too. Timely supply of the quantity required by millers and processors – linking supply and demand – and establishing procurement systems, which allow identity preservation and quality control, must be considered in the delivery strategy. Aggregation routes may include linking the various actors: establishing digital platforms to link aggregators, processors and farmers to stimulate production and supply based on the actual communicated demand by processors; and developing large scale public and civic sector aggregation systems for food/grain distribution (which have a high potential to guarantee high demand levels and stimulate production and consumption. Each of these approaches are suitable for various country-crop scenarios. For example, it is more challenging for root crops, compared with grain crops, to become part of large-scale public and civic sector aggregation and distribution activities.

Processing and Retailing

Developing partnerships with food manufacturers of all sizes, but with focus on medium to large scale enterprises for economies of scale – (micro, small and medium size enterprises that can be supported through innovative financing facilities) and institutional and public sector food users/buyers to build new biofortified supply chains and or switch existing supply chains to the biofortified versions. Increased focus on consumer demand and need as the demand pull, and increasing investments in partnerships with/transfer of knowledge to food industry. Working with food retailers (local, national, regional and global) to stock and sell biofortified foods in retail environments. Key activities may include meetings and workshops with processing industry for building value propositions for businesses and consumers by understanding needs and interests from a demand-side perspective; facilitating aggregation; conducting joint awareness and promotional campaigns; collaborating on new product development, such as for school feeding programmes and the food industry; and assessing the nutritional value of these products.

Integrating Biofortification into Government Policies and Programmes

Biofortification's success rests on the participation of all relevant sectors, including research, government, academia, private sector, farmers, civil society organizations and consumers. The following is an illustrative list of national government policies that should integrate biofortification to ensure its mainstreaming and scaling. (Note: regional policymaking bodies like Regional Economic Communities (RECs) can also play a key role, such as regulatory harmonization and seed standards that are crucial for facilitating the movement of seed across borders.)

Policies:

- National Development Plan
- National Agricultural Investment Plan (or it's equivalent for CAADP implementation)
- National Extension Services Policy
- Food and Nutrition Security Policy

- Fortification Policy
- School Feeding Policy
- Early Childhood Development Policy
- Anaemia/stunting policies
- Regulations/standards
- Seed certification policies and standards (especially for open-pollinated and vegetatively propagated crops)

Programmes:

- Fortification, subsidy and procurement programmes, including farmer input support programmes
- School meals
- Agricultural extension programmes
- Community health, incl. ante-and post-natal counseling; infant/young child feeding; etc.
- Biofortification literacy in school and university curricula

Which partners can help?

While the nature and number of partnerships will differ according to local circumstance, the following are partners that have previously been essential in the development and delivery of biofortified crops:

- CGIAR centers, including HarvestPlus – crop development, technical assistance
- UN Agencies: FAO, IFAD, UNICEF, WFP – technical support to governments and inclusion in relevant programmes, such as school meals; local and regional procurement; training; knowledge resourcing and sharing platforms; and project formulation
- Ministry of Agriculture – crop development, seed multiplication, extension services, awareness creation (via demonstration plots, farmer field days)
- Ministry of Health – policy support, messaging and training materials, inclusion into community health services
- National Agricultural Research Institutes (NARIs)
- Private sector and/or state seed companies – seed multiplication and distribution, independent crop development, awareness creation (via demonstration plots, farmer field days)
- NGOs/CBOs – seed multiplication and distribution, farmer and community training
- Agro-dealers – seed distribution and basic farmer training
- National universities – variety development, baseline research, food product development, agricultural curriculum
- Continental and regional research (FARA, CCARDESA, ASARECA, etc.)
- Regional Economic Communities (ECOWAS, SADC, EAC, IGAD, etc.)

- Traders both public and private – linking biofortified crops to urban markets
- National standards organisations – quality control and regulation
- Processors – food product development, marketing
- Media – awareness raising, marketing
- Scaling Up Nutrition - inclusion of biofortification in government nutrition planning

The introduction of biofortified crops will involve multi-sector collaboration within the government, including Ministries of Agriculture, Health, Education and Finance. Off-takers will need to be identified to stimulate initial demand. The private sector will also play a key role in terms of seed marketing and distribution, milling, and food processing. Farmer organizations and other civil society groups will also play a key role in accelerating access for farmers. Introduction and scaling will follow these phases:

Increased uptake by producers and consumers

- Create public awareness of benefits of biofortified crops
    - Ministry of Health nutrition awareness campaigns
    - Community outreach/sensitization meetings
    - Identify lead mothers and other respected community figures as early adopters and change agents who can motivate others
    - Media campaigns
- Popularize new varieties at farmer level
    - Work with existing farmer organizations at village level
    - Identify lead farmers as early adopters/change agents who can motivate and influence others
    - Training of trainers, including agricultural extension agents
    - Farmer field days, including agrodealers and retailers
    - Demo plots
    - Agricultural expos
    - Seed distribution – demo packets
    - Home and community gardens
- Increase availability of seed and grain
    - Multiplication and distribution through public and private partners
    - Farmer-to-farmer distribution

Create sustainable value chain

- Motivate private seed and consumer product companies towards commercialization for relevant crops (e.g., maize)
- Increased mainstreaming among private seed and grain companies

Mainstreaming biofortification in policy

- Include biofortification in national and sub-national nutrition, health, education, and agriculture policies and programmes

Monitoring, Evaluation and Learning (MEL)

A robust MEL is required to understand implementation progress and the impact of biofortification at national and continental levels. A clear biofortification impact pathway and theory of change (ToC) should be the basis for determining the results that will be achieved and what needs to be measured and reported. A set of common/aligned set of indicators is essential to enable aggregation across geographies/countries. CGIAR's HarvestPlus and partners have developed a robust MEL toolkit for biofortification that includes a biofortification ToC, set of indicators and the methods and tools for collecting data. Using these, a body of evidence on the progress, adoption, effectiveness and impact of biofortification has been generated. This has been key for developing behaviour change communication materials and for informing delivery strategy and policy direction. These tools and methods can be adopted and adapted by biofortification stakeholders at national and continental level. While project and programme level MEL systems have been and will continue to be useful, integrating data collection for biofortification into existing national level data collection systems is cost effective and sustainable. Examples of large-scale national surveys into which biofortification indicators can be integrated are: National Agriculture Surveys; Living Standards Measurement Surveys Integrated Survey on Agriculture (LSMS-ISA). Data from these can feed into national and continental level scorecards e.g. the CAADP Biennial Review Scorecard; the AfDB led Commitment to Nutrition Scorecard etc. A strategic starting point is to integrate biofortification into national and continental level plans e.g. the NAIPs and the CAADP Results framework or related plans. This will create the need and appetite for measuring progress and impact of biofortification. It is imperative that biofortification indicators are aligned to global nutrition indicators for ease of data collection and aggregation.

Appendix A - Case Study - Zambia - Vitamin A Maize

Scaling Accomplishments: After 8 years of crop breeding research[3] and crop development and delivery, nearly **300,000 households[4] were growing vitamin A maize seed by the end of 2018, covering 55 out of 110 districts**. Latest varieties contain 73% of target values of vitamin A, which will provide up to 25%+ of daily needs when regularly consumed per meal.

3 first-wave (2012) and 3 second-wave (2015) varieties

- 300,000 farm households growing
- 5 companies commercializing seed
- 10 millers buying and milling grain

Early Learning: Zambians generally eat food made from white maize. Initial formative research revealed that a stigma can be attached to yellow maize, which is considered to be poor quality and reminds Zambians of the food aid delivered during the famine era. Thus, vitamin A maize was bred to be orange. Consumer acceptance studies conducted with the prototypes of the first orange varieties confirmed that **orange maize is indeed perceived as different** and not confused with yellow maize. It **has the potential to compete with white maize** even without nutritional benefit information, although nutritional information provides strong leverage.

Scaling Drivers and Approaches: The Zambia maize market context is characterized by a strong commercial market for hybrid maize seed, comprising 80% of maize grown in Zambia. The market is also diverse, with over 200 released white maize varieties. The most popular maize variety is planted by no more than 10% of farmers. Publicity of good results from efficacy studies of adoption and steady increase of vitamin A orange maize uptake in Zambia has led to its introduction in neighbouring countries and beyond. Seed companies are selling vitamin A maize seed in Zimbabwe, Malawi, DR Congo, Botswana and Angola. Many rural households grow their own maize for consumption and sell the surplus, making them the biggest contributors to the national reserves of grain. Large millers produce for the broad consumer market; medium sized commercial millers and community mills serve farming households. Based on the results of seed and grain (i.e., maize that is eaten, not planted), value chain assessments, network mapping, and crop situation analyses, as well as through monitoring and learning activities, a multi-pronged approach with primary and secondary drivers has been used to scale up vitamin A orange maize in Zambia.

Primary – *Commercial seed and grain market development:*

- **Technical assistance for seed production and distribution** – Since vitamin A orange maize is a new product, partners worked closely with private seed companies to introduce orange maize in their

[3] Crop Development Partners: International Wheat and Maize Center (CIMMYT) and, Zambia Agricultural Research Institute (ZARI)

[4] Households reached are not cumulative because some farmers will repeat-buy seed over years. This value therefore refers to households growing which is cumulative and has been adjusted for repeat buy and other factors like diffusion and dis-adoption

product lines and to de-risk the companies' investments as much as possible. To this end, Partners provided the seed companies with parental seed supply and information/training on the use, further development and evaluation of orange maize technology. We also trained agro-dealers – as the final points of sale - in providing farmers with nutritional and agronomic information about orange maize.

- **Identifying and incentivizing demand "pull mechanisms" along the value chain** - For example, the World Bank-funded AgResults project provided medium to large scale maize millers with volume-indexed cash incentives to process vitamin A orange maize flour for urban markets. At inception of the programme, 87 emergent farmers were contracted to provide initial raw material for industry. Subsequent research showed that farmers would be more likely to adopt orange maize if there was a buyer for any surplus harvest. These incentivized millers provided farmers with an orange maize grain market, thereby stimulating adoption of orange maize at the farmer end. Moreover, increasing consumption of orange maize by urban dwellers was also found to stimulate the consumption of orange maize by rural consumers.

Secondary – *Awareness raising.* Two additional strategies were essential to strengthen and expand the commercial sector led approach.

- **Demand creation through awareness campaigns** – Partners invested in various marketing activities to generate demand for vitamin A orange maize seed and grain. Most were targeted at rural households, such as farmer field days, where farmers visit lead farmers' vitamin A orange maize fields to learn about agronomic properties and proof of competitive advantage in yield levels in comparison with the white varieties. Farmers also learn that vitamin A orange maize is climate smart (growing in low, medium and high rainfall areas) and drought, disease and pest tolerant. Other approaches include participating in or watching community dramas on the importance of vitamin A in household health and the role of orange maize in providing vitamin A, as well as tasting of food and drinks made with orange maize and contrasting with yellow 's colour, taste and aroma. Other demand creation strategies targeted at rural households included agri-exhibitions, and information education communication through community radio stations, schools and health clinics (under 5 children and antenatal departments). Promotion campaigns (e.g., pop songs, TV/radio programmes, tasting orange maize products in retail markets) were targeted at urban and peri-urban consumers to generate demand along the value chain.

Scaling Snapshot – Supporting Commercial Seed Company Engagement for Scaled up Distribution: The private seed companies that were assigned the first three orange maize varieties had a combined market share of over 50% in the maize seed industry. Zambia Seed Company (ZamSeed) sells to the government as the largest buyer of biofortified maize seed. Other seed companies sell to commercial and smallholder farmers through their extensive network of agro-dealer outlets in the country. While commercialization is the responsibility of private seed companies, the CGIAR has provided technical assistance vis-à-vis seed parental supply, improving distribution systems, advising on pack sizes, and conducting promotions to enhance seed access by farmers. The CGIAR is also working with agro-dealers to strengthen their nutrition knowledge and improve their ability to serve as agronomic advisers to farmers. CGIAR's HarvestPlus also developed training manuals and conducted training programmes for agricultural staff; other agriculture and nutrition-sensitive organisations, such as World Vision and Programme Against Malnutrition; and farmers on the complete value chain - agronomy, post-harvest management, nutrition benefits, utilization, and market linkage provision to farmers.

- **Commercialization of vitamin A orange maize –** Demand for vitamin A orange maize is steadily increasing, and both large- and small-scale processors are either including the vitamin A orange maize products in their existing production line of white maize products, or entirely coming up with new products. At least 30 companies are making various products; mealie meal, grits, samp (maize rice), porridge or drink mix (vitamin A orange maize mixed with soy bean and pearl millet), instant porridge (90% orange maize mixed with moringa leaves) and snacks (corn puffs and corn chips). **Collaboration with civil society organizations to ensure inclusive reach** - In many rural areas, maize farmers recycle their own seed (about 25% in any one season) and do not have access to government inputs programmes and/or to agro-dealers to acquire hybrid seeds annually. Many of these are female headed, poorer households located in the most marginalized areas of the country. To reach these households, various local and international civil society organizations have received seed and training on the nutritional and agronomic properties of orange maize to then transmit to the farmers with whom they work.

- **Foundational –** The Government of Zambia has made excellent progress in including orange maize in both input subsidy and grain procurement programmes. The government is the biggest facilitator of hybrid maize seed acquisition and one of the biggest buyers of maize grain. The Government of Zambia sees orange maize as a viable strategy for alleviating vitamin A deficiency in this country, and has included it in the National Food and Nutrition Strategic Plan.

Appendix B - Case Study - Rwanda – Iron Beans

Upscaling Accomplishments: After over a decade of crop breeding research[5] and 6 years of crop development and delivery, by the end of 2018, **a cumulative total of** 5,000 metric tons of iron bean seeds had been delivered and nearly 800,000 farming households were growing iron beans resulting in 4 million people in these households consuming them)**.** The latest varieties contain up to 94% of target values of iron, which will provide up to 50% of daily needs when regularly consumed.

4 first wave (2010) and 6 second wave (2012) varieties

- 420,000 farming households reached
- 29% of all farmers have planted iron beans
- > 300 partners (private sector, gov't, civil society)

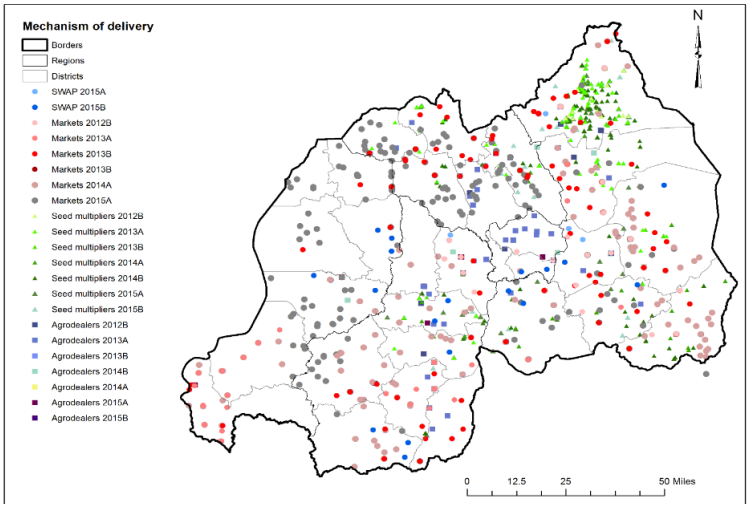
Early Learning: Assessments showed that some biofortified bean varieties were significantly more productive than non-biofortified varieties, which has been an important factor in farmer acceptance. This was partly due to crop attributes as well as the increased support some farmers received from partner agencies.

"Before, when I was growing the indigenous variety, I could hardly harvest 1 ton, but now I harvest 3 tons of iron-rich beans from the same 5 acres of land." ~ Shiragahinda Augustin, Farmer from Northern Province

Upscaling Drivers and Approaches: Beans of various types are grown throughout the country and eaten as the staple crop. Beans for consumption (known as "grain") are typically sold in bulk in local markets, with some supermarket purchases. The scaling strategy and drivers are summarized below:

Primary – *Farmer outreach*: To reach the maximum number of farmers with iron bean seed, they were targeted with **direct marketing** at local markets through specifically trained sellers and sold through farmer **cooperatives** and **agro-dealers**. To widen seed distribution to hard-to-reach farmers, innovative delivery models also played an important role. The **payback system,** through which farmers receive iron bean seed and "pay back" a portion of the harvest to the programme, also functions as a conduit for seed multiplication. A **seed swap,** through

Upscaling Snapshot – National Level Coverage by Method:



[5] Crop development partners: Rwanda Agriculture Board (RAB) and the International Center for Tropical Agriculture (CIAT)

which farmers are given an opportunity to trade in their local bean varieties for iron bean ones, gradually "flushes out" the less nutritious varieties. The figure below shows the delivery mechanisms used across regions and seasons.

Secondary – *Seed sector development:*
Local and regional seed companies have multiplied bean seed, and government seed inspectors have been trained to certify biofortified seed. Extension workers, farmer-based cooperatives, seed multipliers and agro-dealers have also been trained on the yield advantages of growing seed rather than grain. To address the short- to medium- term bottlenecks in seed supply, partners also launched a new seed class, "Declared Quality Seed" (DQS) or Certified II seed, which is produced from certified seed and is priced between certified seed and grain, bridging a price gap for farmers who are inclined to plant recycled grain rather than purchase certified seed.
Consumer awareness and demand creation: To complement the seed supply push activities, several consumer awareness and demand creation activities have also been undertaken. These include extensive **field demonstrations, farmer field days and community agriculture shows**, as well as creative marketing campaigns, including radio talk shows, songs and jingles[6], using locally renowned musicians and journalists as spokespeople.

Foundational – The Government of Rwanda has demonstrated strong leadership to promote biofortification, as evident from the inclusion of biofortification in several government policy documents including the Ministry of Agriculture and Animal Resources' National Food and Nutrition Policy and its Strategic Plan for the Transformation of Agriculture in Rwanda.

[6] see e.g., https://www.youtube.com/watch?v=fo6449Rd3I0

APPENDIX C: FREQUENTLY ASKED QUESTIONS ABOUT BIOFORTIFICATION

What is biofortification?
Biofortification is the process of breeding food crops that are rich in bioavailable micronutrients, such as vitamin A, zinc, and iron. These crops are "biofortified" by loading higher levels of minerals and vitamins in their seeds and roots during growth. Through biofortification, scientists can provide farmers with crop varieties that provide essential micronutrients and can naturally reduce anaemia, cognitive impairment, disease, and other malnutrition-related health problems that affect billions of people.

How is biofortification a cost-effective approach?
Unlike the continual financial outlays required for supplementation and fortification programmes, a one-time investment in breeding-based solutions can yield biofortified crops to grow and be consumed year after year to reduce malnutrition in entire populations around the world for years to come. It is this multiplier aspect of biofortification across time and distance that makes it so cost-effective in reducing malnutrition.

Is biofortification a replacement for supplementation and fortification interventions?
No, biofortification is complementary to these nutritional interventions. Biofortification is more rural-based, while supplementation and fortification tend to be more urban-based. Biofortification is one solution among many interventions that are needed to solve the complex problem of micronutrient malnutrition. Among these interventions biofortification is considered one of the most cost-effective interventions for countries to employ in combating micronutrient malnutrition[7].

Does biofortification require genetic engineering?
No, all of the biofortified crops released in Africa to date have been developed using conventional plant breeding. The CGIAR biofortification methods for the continent exploit natural variations existing within the crops. Plant breeders identify parent varieties with high vitamin or mineral levels, and then cross (male and female) varieties over several generations to produce plants that have the desired nutrient and agronomic traits. These crops are then released by national partners in compliance with existing laws and regulations.

In which countries have biofortified crops been released?
Crops are available or in testing in 60 countries – please see this map on this website for details.

Do biofortified foods affect consumer preferences?
Not in the case of zinc, which does not affect the colour or taste of rice.

How are farmers included in the biofortification process?
Farmers' needs are accounted for as crops are being developed, and farmers participate in trials to test and select the best varieties. Biofortified seeds and propagation materials are then made available through extension programmes, market mechanisms or by programmes targeting nutritionally vulnerable communities and smallholder farmers.

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[7] Meenakshi, J. V., Nancy, J., Manyong, V., De Groote, H., Javelosa, J., Yanggen, D., Naher, F., Garcia, J., Gonzalez, C., and Meng, E. 2010. How cost-effective is biofortification in combating micronutrient malnutrition? An ex ante assessment. World Development, 38(1), 64–75.

Will farmers have to buy biofortified seed every year?
No. In most cases, they will not. Most food crops in the developing world are not hybrids. Non-hybrids include wheat, rice, open pollinated maize, sweet potato (roots and vines), and cassava (cuttings). These can be saved, shared, and replanted.

Whom does biofortification target?
People who eat large amounts of staple foods daily and do not have a diverse diet. A diverse diet would include micronutrient-rich foods such as fruits, vegetables, and animal products. These foods may be unavailable (seasonal), or available but too expensive to buy regularly or not at all.

Do biofortified crops deplete the soil of nutrients?
No, the additional quantity of nutrients taken from the soil by biofortified crops is minute.

Does biofortification also improve agronomic properties of crops?
Yes, plants need micronutrients to grow and be healthy, just like people. Micronutrient-rich seeds show greater seedling vigour, and the resulting crops are more productive. All biofortified varieties are agronomically competitive with or better than the varieties farmers already grow.

Which population groups will benefit from biofortification?
Preschool children (more than 2 years old), adolescents, and adults will benefit - in particular, pregnant and lactating women.

Can crops biofortified with vitamin A, zinc, or iron cause toxicity?
No, the amounts of micronutrients that is bred into crops are too low to cause toxicity (but the amounts are sufficient to improve nutrition), and their uptake is regulated by the body.

Do we want to replace all crops with biofortified varieties?
No, the aim is not to replace all the crop varieties so that biodiversity is maintained. This way we will not lose the gains made in other improved crop varieties. Biofortification builds on existing breeds that have other desired traits such as high yield, disease-resistance, drought tolerance etc.

APPENDIX D: CHECKLIST FOR INTRODUCTION

Below is a chart derived from the International Potato Center's (CIP) Investment Guide for vitamin A orange-fleshed sweet potato, which can be found with other valuable training and implementation materials here. It could be used as a template to guide specific actions by various actors in the biofortification value chain.

Decision Points Along Value Chain	**Organization(s)**	**Action**
Current interventions that address stunting		
Current interventions that address micronutrient deficiency		
Role of crop in diet		
Availability of biofortified crop		
Technical capacity to implement biofortified crop programme		
Sources of biofortified planting material		
Multiplication of seed/stems/vines		
Distribution of planting material		
Farmers 'ability to adopt new crop (agronomic skills, etc.)		
Marketing of new variety		
Nutritional understanding, awareness and behaviour change		
Monitoring of food-based approaches to addressing micronutrient deficiency		
Inclusion of biofortified ingredients in food products		