# Livelihoods and Food Security Programme

## Agriculture Productivity and Nutrition


# THE STATUS OF BIOFORTIFICATION IN ZIMBABWE

*This document has been produced with financial assistance from the United Kingdom, and with technical and implementation support from the Food and Agriculture Organization of the United Nations (FAO). The views expressed herein can in no way be taken to reflect the official opinion of the United Kingdom or of FAO.*

## Contents

## ACRONYMS

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| AGRITEX | Agricultural Research and Extension Department |
| APN | Agricultural Production and Nutrition |
| CADS | Cluster Agriculture Development Services |
| CBI | Crop Breeding Institute |
| CIAT | International Centre for Tropical Agriculture |
| CIMMYT | International Maize and Wheat Improvement Centre |
| DRSS | Department of Research and Specialist Services |
| FAO | Food and Agriculture Organization to the UN |
| FNC | Food and Nutrition Council |
| GE | Genetic engineering |
| HIV/AIDS | Human immunodeficiency virus/acquired immune deficiency syndrome |
| HRC | Horticultural Research Centre |
| IFPRI | International Food Policy Research Institute |
| LFSP | Livelihoods and Food Security Programme |
| MoHCC | Ministry of Health and Child Care |
| NGO | Non-governmental organization |
| OFSP | orange-fleshed sweet potato |
| PABRA | Pan Africa Bean Research Alliance |
| QPM | Quality Protein Maize |
| SAMP | Seeds and Markets Programme |
| SIRDC | Scientific and Industrial Research and Development Centre |
| UNICEF | United National Children's Fund |
| WFP | World Food Programme |
| WHO | World Health Organization |

## ACKNOWLEDGMENT

This paper was prepared for FAO by Anna Braizer and edited by Jannie Armstrong.

# Executive Summary

Biofortification, that is, the development of crops with enhanced levels of nutrients available for consumption, has become a central component of global multisectoral approaches to tackling malnutrition. To date, biofortification efforts in Zimbabwe and neighbouring countries have involved the promotion of Provitamin A maize, Quality Protein Maize (QPM), Orange Fleshed Sweet Potato (OFSP) and zinc and iron enriched beans. Due to overemphasis on crop breeding, Zimbabwean programmes lack co-ordination and are lagging behind neighbouring countries. Meanwhile, there are shortfalls in various aspects of efforts to promote biofortification, including farmer–led seed and crop production, consumption uptake, market development, monitoring and evaluation of nutrition impacts and most importantly, private sector engagement.

Output 4 of the APN, which sets out to increase demand for and consumption of, diversified nutritious food, can be supported through promotion of biofortified crops. However interventions must be developed with caution using a systems-approach with takes into account the complex problems, risks, and the key entry points and opportunities outlined in this report. Biofortification interventions through the APN must be guided by and compliment pre-existing holistic nutrition initiatives already established by government and NGOs. Zinc/iron enriched beans and Provitamin A maize show the most promise as crops for production, consumption and marketing in Zimbabwe.

**Intervention components through the APN**

1. Support the development of community-based biofortified seed production enterprises in partnership with breeders, private sector seed houses and NGOs.
2. Promote the production of biofortified crops in target communities through extension support from government and seed companies using sustainable intensification methods to reduce unfavourable environmental impacts.
3. With an emphasis on the commercial potential of biofortified crops, develop institutional market linkages involving contracts with farmers.
4. Mainstream markets for biofortified foods created through community based milling schemes and national scale food producers supported by a nation-wide advocacy campaign.
5. Promote consumption of biofortified foods through community based nutrition interventions supported by the government and NGOs.
6. Address post-harvest, milling and food preservation issues through technical support.
7. Engage a full time biofortification specialist for FAO Zimbabwe to manage the biofortification intervention.
8. FAO to facilitate stakeholder co-ordination and alert stakeholders to the risks involved in with biofortification, ensuring that the interests of smallholder farmers are represented.

# 1. Introduction

As part of the inception phase of the APN study was conducted to assess the present status and future potential of biofortification in Zimbabwe. Some 23 key informants from a wide range of sectors including crop breeders, nutritionists, private sector seed houses, food processors, NGO representatives, researchers and agricultural extension officers were interviewed. Additional information was solicited from biofortification working group presentations and from consulting a citizens' action group. Additional information was sought through a desk review of literature on biofortification. The data was analysed in the light of the study objective, which was to make recommendations as to how the APN component of the LFSP will promote the production and consumption of biofortified crops in Zimbabwe.

# 2. Problem Analysis

As part of the inception phase of the APN a study was conducted to assess the present status and future potential of biofortification in Zimbabwe. Some 23 key informants from a wide range of sectors including crop breeders, nutritionists, private sector seed houses, food processors, NGO representatives, researchers and agricultural extension officers were interviewed. Additional information was solicited from biofortification working group presentations and from consulting a citizens' action group. Additional information was sought through a desk review of literature on biofortification. The data was analysed in the light of the study objective, which was to make recommendations as to how the APN component of the LFSP will promote the production and consumption of biofortified crops in Zimbabwe.

## 2.1 Definition of Biofortification

Biofortification, that is, the development of crops with enhanced levels of nutrients available for consumption, has become a central component of global multisectoral approaches to tackling malnutrition. However, despite a strong international institutional backing, with CGIAR organisations promoting the breeding of biofortified crops and UN agencies including biofortification in their implementation strategies, international agreement on a definition of biofortification has been elusive (FAO/WHO, 2013). The implications of this are that without an accepted definition, what constitutes 'biofortified' is subject to interpretation and manipulation: biofortified crops developed through controversial methods (such as genetic engineering) could be promoted without revealing the technology used in their development. In a process driven by Zimbabwe and South Africa, the establishment of a definition for the term is being led by the international CODEX Alimentatirus Commission (administered by FAO and WHO). This ambiguity notwithstanding, for the purposes of this study, the discussion of biofortification will be restricted to the promotion of breeding, production and consumption of crops with increased nutrient levels developed through conventional breeding.

From the outset, it should be recognized that biofortification is distinct from food fortification, which involves adding nutrients to foods during processing. Food fortification can be carried out by food manufacturers, or it can be conducted at household level, whereby caretakers add micronutrient powders to food during preparation. As such, it constitutes a separate and distinct process which will be only lightly discussed in this paper.

## 2.2 Why Biofortification?

The main justification for the promotion of biofortification is as a means to address malnutrition (HarvestPlus, 2014). Micronutrient deficiency in children, including zinc, iron and Vitamin A, have been identified by WHO as causal in the problems of stunting, blindness, immune response suppression, impaired cognitive ability(HarvestPlus, 2014). In addition, in Zimbabwe, chronic malnutrition is a public health priority, with most districts in the country recording stunting levels above 30 percent (Zimbabwe National Nutrition Survey, 2010). Stunting is a complex problem with no single cause. The role played by micronutrients in stunting is recognized, but the interface between micro and macronutrients is not well understood (Souganidis, 2012).For these reasons, strategies to address stunting need to address both the immediate and underlying causes of malnutrition including both food and non-food components, including diet, child feeding practices, disease exposure and prevalence as well as socioeconomic factors such as poverty and education levels.

**Biofortification methods**

Methods of biofortification include: conventional plant breeding, increasing the levels of specific soil nutrients (notably zinc) for plant absorption, and the use of biotechnology such as genetic modification (GM). Conventional breeding methods are the most common and most widely accepted approach and as such will be the focus of this study. GM approaches to biofortification are controversial and are tightly controlled by legislation.1 GM is prohibited in Zimbabwe through a ministerial directive.

It is noted that at both global and national levels, Genetically Modified Organsims (GMO) are an emotive, politicized issue, and that there are strong opinions and partisanship on both sides of the debate. A criticism levelled of the promotion of biofortification in Zimbabwe has been that it will be used as a means to eventually introduce GM on a wider scale. This raises political, socio economic, environmental and health concerns with respect to the sustainability of small-holder farmer livelihoods as well as national food sovereignty (Johns and Eyzaguirre, 2007). These concerns were raised by respondents during this study, including academics, development workers and local seed company representatives. Many others consulted, notably crop breeders, felt that GM was an appropriate means to produce improved crop varieties and should be promoted in Zimbabwe. This lack of consensus is unlikely to be reconciled in the short or medium term. Nevertheless, the focus of this paper will remain on conventional methods of developing biofortified crops.

The process of developing biofortified crops through conventional crop breeding involves crossbreeding individual plants in order to produce new varieties (lines) with desirable traits (that is, increased levels of certain nutrients in the consumed parts of the plant). Vegetative reproductive material or seeds of these lines are then produced. With vegetatively reproduced plants, such as root and tuber crops, this material can be developed through tissue culture methods that increase production levels by producing high-yielding, disease-free planting material.

Biofortified seed-producing crops can be either hybrids (produced by crossing unrelated lines) or open pollinated varieties (produced by inbreeding related lines). Farmers can reproduce open pollinated varieties by retaining seed from previous seasons. Hybrid varieties must be purchased each season from a crop breeder. Once the initial breeder's seed have been produced for a biofortified crop they are then developed into foundation seed which can be sent to seed companies for sale to farmers. Foundation seed must be rigorously tested, verified and certified before it is released for sale.

The biofortification of staple foods, including maize, rice and wheat, has been advanced as a way to ensure the regular daily intake of micronutrients through consistent access to and consumption of enriched food staples, particularly in low-income households (Nestle et al, 2006). In Zimbabwe complementary foods are traditionally staple-based and thus the promotion of biofortified maize could directly target children aged 6-24 months. Proponents of biofortification see the method as a cost-effective way to reach undernourished populations in remote subsistence-farming communities (Nestle et al 2006 and Meenakshi, 2010). An advantage of biofortification over food fortification is that it can target rural communities which mainly consume food produced on the family farm rather than commercially processed food sourced from the market.

In terms of the Zimbabwean food basket, maize, the staple crop of southern Africa, is a good source of carbohydrates but lacks the important amino acids lysine and tryptophan that the body requires to make protein in the maize available for absorption (Pedersen and Eggum, 1983). In addition, maize contains only trace amounts of vitamins A, E and calcium. Many micronutrients contained in maize are lost during milling1 into the maize meal used to produce the staple food of Zimbabwe, sadza. Additional nutrient loss occurs during the storage and cooking of maize. Diets that depend on maize as the main source of energy can lead to deficiencies and, in extreme cases, pellagra (Latham, 1997). In order to obtain adequate nutrition, people eating a diet based on maize need to consume legumes or animal product-based foods regularly. In Zimbabwe poor households rarely achieve this diet.

[1] Including Thiamine, Riboflavin, Niacin, Pyridoxine, Foliate, Biotin, Calcium, Phosphorus, Zinc and Iron. Bauernfeind, J.C. and E. DeRitter, (1991). Cereal Grain products in Nutrient Addition to Foods. Bauernfeind, J.C. and P.A. Lachance (Eds). Food and Nutrition Press. Trumbull, CT.

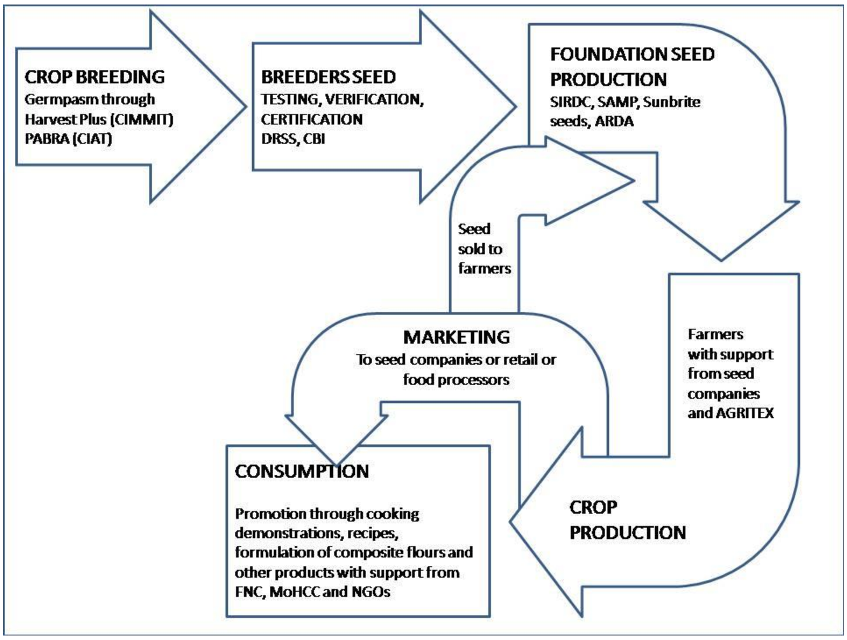
## 3. Biofortified crops in Zimbabwe and the region

Globally, the name most commonly associated with biofortification is HarvestPlus, a programme co-ordinated by International Centre for Tropical Agriculture (CIAT) and the International Food Policy Research Institute (IFPRI). Launched in 2004 with funding from the Bill and Melinda Gates Foundation, the organization presents itself as "a leader in the global effort to end hidden hunger caused by the lack of essential vitamins and minerals in the diet, such as vitamin A, zinc, and iron" through work in nutrition and the development and promotion of the production and consumption of biofortified crops. In Africa, HarvestPlus targets several crops, including maize, cassava, beans and sweet potato.

Biofortification work in general in Zimbabwe and neighbouring countries, notably Zambia, Malawi and Mozambique, has involved the promotion of Provitamin A maize, quality protein maize (QPM), orange-fleshed sweet potato (OFSP), orange cassava and zinc and iron enriched beans. Crop breeding has been the emphasis, co-ordinated by the Department of Research and Specialist Services (DRSS) with support from International Maize and Wheat Improvement Centre (CIMMYT), HarvestPlus and the Pan Africa Bean Research Alliance (PABRA) through CIAT Malawi. The DRSS houses the Seed Services department, which is responsible for administering the legislation that governs the production, processing, labelling and marketing of certified seed in Zimbabwe. The Crop Breeding Institute (CBI) at DRSS has been responsible for the development of biofortified maize and bean varieties based on imported germplasm (genetic material). Other government research departments in the country have focused on developing OFSP and cassava varieties. Limited work on OFSP has also been carried out by Agri-Biotech, a local biotechnology company.

Increasing the available amounts (Bulking) of foundation seed has been done through the efforts of seed companies, NGOs and the national Scientific and Industrial Research and Development Centre (SIRDC). The Ministry of Health and Child Care (MoHCC) and the Food and Nutrition Council (FNC) as well as some NGOs have promoted the consumption of some biofortified crops to a limited extent, but this process has lacked coordination and monitoring has been weak. Figure 1 presents a value chain analysis showing the various stages in the development, production and promotion of biofortified crops in Zimbabwe with the most prominent organizations involved in direct implementation and support.

**Figure 1: The biofortified crop value chain in Zimbabwe**



### 3.11 Biofortified crop production

### 3.12 Iron/zinc enriched beans

Most biofortification work to date in Zimbabwe has involved the promotion of biofortified beans. Zimbabwe is one of the 29 member countries of PABRA, an African research organization supported by CIAT devoted to "improved nutrition and health, food security, a resilient production system able to recover rapidly from adverse effects of environmental stresses and market challenges and therefore contribute sustainably to better livelihoods and incomes of resource poor small holder families in Africa".[2]

PABRA collaborates with HarvestPlus on biofortified zinc and iron enriched beans and has released varieties in nine countries. The Zimbabwe bean project is co-ordinated by CIAT Malawi and involves several government departments including CBI, AGRITEX, the HIV/AIDS programme, the Food Science Department, the Biotechnology Research Institute and the FNC. In Zimbabwe, the NUA 45 variety was released in 2010 and two other varieties (Sweet Violet and Cherry) are at verification stage. NUA 45 uptake by farmers has been slow. Seed companies, the Agricultural Research and Extension Department (AGRITEX) and CBI respondents put this down to the fact that farmers and consumers are cautious about trying to grow unfamiliar new crops and are put off by the dark red colour of NUA45, which is a calima-type as opposed to a sugar bean. Beans in general are not a popular crop in Zimbabwe and are consumed less commonly than in other countries in the region.

The germplasm of the NUA 45 variety was imported from East Africa and was tested at DRSS and verified with researchers at SIRDC and the University of Zimbabwe before being distributed in 12 districts in 2011 through the FNC Healthy Harvest programme. Farmers were given the new variety through extension support by AGRITEX staff, who note that the beans are easy to grow, high yielding, disease resistant and early maturing (85–90 days) compared to conventional sugar bean varieties. A problem with the NUA 45 variety is pod shattering but the CBI believes that this can be overcome by training farmers to harvest the seed as the beans mature, although this adds an extra management and labour component to the production of the crop. AGRITEX surveys of producing households found that while some producing households do consume some of the beans, they are seen as a high value crop and producers prefer to sell them to institutions such as hospitals and boarding schools rather than consume them themselves.

Overall, Zimbabwe has made more progress than other countries in promoting NUA 45 by developing contracts with seed companies such as Zaka Super Seeds (supported by the NGO Seeds and Markets Programme [SAMP]) and Sandbrite Seeds to produce foundation seed. In the 2011–2012 season the Zaka Super Seeds exported 2308 kg to Zambia in support of the Concern Worldwide Realigning Agriculture to Improve Nutrition project, suggesting there is export demand for the seed.

### 3.13 Provitamin A maize

As a major staple crop that provides more than two-thirds of peoples' daily energy intake, (Muzhinigi *et al.,* 2008) maize is a strong potential conduit for biofortification in southern Africa. A maize variety has thus been developed over the last decade with an increased content of provitamin A, a substance which the body uses to manufacture true vitamin A (Ortiz-Monasterio, 2007).The variety being distributed to farmers in Southern Africa contains 7.5 ppm provitamin A, which is enough to provide 25 percent of the daily vitamin A needs of women and children.

### 3.14 The Zambian Experience

In 2012, HarvestPlus released three Provitamin A biofortified maize hybrids in Zambia and has since supported the free distribution of certified seed to 25,000 subsistence farmer households in three provinces. This distribution has been augmented by a consumption promotion campaign and a project to generate private-sector financing for strengthening the Provitamin A maize market in the country. Crop production is supported through partnerships with research and extension services, private seed companies, non-governmental organizations and community-based organizations in preparation for release.

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[2]Personal communication, Rodah Zulu, CIAT Malawi.

The government of Zambia has invested heavily in increasing maize production through an input support programme using electronic vouchers that allow farmers to purchase subsidized crop varieties of their choice, including Provitamin A maize. In addition, Zambia has been chosen as a pilot country for the AgResults initiative to build a market for new Provitamin A varieties of maize. AgResults will generate private-sector financing to strengthen the Provitamin A maize market in the country.

Nationally, the Zambian programme is implemented in partnership with government departments in the Ministries of Health, Agriculture and Livestock and Education; research institutions, the National Food and Nutrition Commission and the Micronutrient Malnutrition Taskforce as well as consumer groups and several private sector seed companies. HarvestPlus forecasts that by 2022, four million Zambians will be growing and consuming high-yielding, Provitamin A hybrids and open pollinated varieties.

### 3.15 The Zimbabwe experience

In Zimbabwe, the Provitamin A variety germplasm was introduced in 2013 in partnership with HarvestPlus through CIMMYT Mexico. Using this, the CBI aims to convert 20 varieties to Provitamin A varieties. One variety is currently undergoing verification and should be released in October 2014 or early 2015. HarvestPlus has plans to establish several demonstration plots with farmers and research centres in Zimbabwe, starting in the 2014/15 summer season.

In terms of production, CBI anticipates that the maize will perform on par with conventionally available hybrids in terms of yields, drought tolerance, disease resistance and nitrogen deficiency. Consultations with seed houses revealed great interest in marketing Provitamin A seed. The respondent from Agriseeds noted that biofortified varieties can provide seed companies with a market advantage because of their increased nutrient levels. Unlike legumes, maize seed is predominantly sold in hybrid form and is thus purchased on a large scale by farmers, making it a viable option for seed houses.

### 3.16 Quality Protein Maize (QPM)

CIMMYT Zimbabwe has been working on developing maize with enhanced levels of tryptophan and lysine for two decades. The result is known as Quality Protein Maize (QPM). Initial varieties had poor taste and texture but since the early 1990s the variety has improved. Its nutritional value is good and tests for lysine and tryptophan show that the levels of these amino acids, in the maize, are high. Two varieties have been released, the hybrid ZS261 and the open pollinated Obatanpa variety.

Both Agriseeds and the major food processing company, National Foods, consulted during this study showed interest in marketing QPM. A Seed Co respondent noted that the company has bred two QPM hybrids, SC527 and SC643, and is currently bulking SC643 in Zimbabwe, with the aim to start promoting it in 2014/15. This variety has already been released in Kenya.

### 3.17 Orange-fleshed sweet potatoes (OFSP)

OFSP varieties have been selected and grown traditionally in Zimbabwe for decades but new provitamin A-enriched varieties have been introduced in the last 10–15 years. The main promoters are government research stations including the Horticultural Research Centre (HRC) in Marondera and the Chiredzi research stations, both of which are developing virus-free propagating material for farmers using tissue culture methods. The HRC are supported by the National Biotechnology Authority, who is responsible for overseeing and regulating biotechnology activities in Zimbabwe.

In addition, the Biotechnology Research institute at SIRDC and Chinhoyi University of Technology are promoting virus-free OFSP production. Agri-Biotech has two orange-fleshed varieties but has found no demand for them and do not attempt to promote them, saying that the white varieties perform better.

A few NGOs are promoting OFSPs with farmers and communities through their nutrition interventions. Help Germany promotes the organic cultivation of tissue-cultured OFSPs that have been imported from South Africa. They report excellent yields that are even higher than those of white-fleshed varieties, working out to one bucket of sweet potatoes (which can be sold for between $10 and $12) from each metre of bed. Help Germany could not find enough good-quality local material and noted that local material that was claimed to be virus-free was in fact infected. From the South African stock farmers can take cuttings and grow the plants for three generations before they have to buy new material. Considerable work has been done on sweet potato promotion by Harvest Plus in neighbouring countries such as Malawi, Mozambique and Zambia.

## 4. Production constraints for biofortified crops in Zimbabwe

Progress has been slow in increasing seed to meet the demand, by promoters including government and NGO organisations, for biofortified beans and maize. A major bottleneck is the inadequate capacity of CBI to produce enough breeder seed, which must be produced through a rigorous, carefully monitored process to ensue purity. CBI has subcontracted some of NUA 45 bulking responsibilities to SIRDC, who hope to get 8 tons of NUA45 seed this harvest season (2014). However, AGRITEX estimates that they will need at least 40 tons per annum in order to cover all the districts it aims to include in the Zimbabwe bean programme.

Agriseeds and Seed Co respondents stated that there was no incentive for them to market legume seed since it is open pollinated and therefore farmers retain almost 100 percent of their own seed. This illustrates an important dimension of the introduction of biofortified crops: market imperative require that producers seeks means to make profits in the process, while the potential client base (that is, farmers) are attempting to keeps costs as low as possible. Ideally, legume seed should be purchased every 3 years because of yield degradation. Farmers complain that legume seed is prohibitively expensive. Small seed companies are selling NUA 45 foundation seed. The Sandbrite Seeds respondent stated that his company, which mainly sells seed to other seed houses for retail, cannot keep up with demand for NUA 45.

The respondent from SAMP noted that farmer uptake for the seed had been poor due to the lack of marketing, that creating demand is crucial for the sustainability of the seed. SAMP is supporting Zaka Super Seeds to embark on an aggressive marketing programme, building on the success of a maize promotion programme in Lesotho. To facilitate marketing, SAMP has recognized the need for a business development unit as well as a pro-poor marketing strategy that works towards developing markets for seed and crops in target communities.

During maize production there is a danger that orange maize may hybridize with the white maize being grown on the same farm if sufficient space is not kept between fields growing different varieties. Because QPM grain is hard to distinguish from other maize it is also hard to distinguish on the market. This has to be closely monitored. In a study on biofortification, Johns and Eyzaguirre (2007) note that the recessive nature of the increased lysine and tryptophan trait in QPM and the fact that its presence is not visible to farmers or consumers means that for purity reasons, the entire maize breeding population needs to be replaced with QPM. In addition it must be isolated from other maize if it is to be successfully promoted. For this reason farmers must also obtain certified seed rather than trying to retain open-pollinated varieties. The researchers note that these constraints may limit its usefulness to small-scale farmers. There is also the danger of contamination by other maize varieties during storage and packaging. Provitamin A maize, because of its colour, is easier to manage from this point of view.

Additionally, QPM suffers from a yield differential and cannot compete with local varieties, which can make it hard to market. Neither of the released varieties of QPM have taken off commercially locally, firstly due to the yield and secondly because of concerns about the market. No real effort has been made to promote it. Although there is a potential for QPM as stock feed, no one has managed to convince the companies of its potential. Thus, there is no link between the seed supplier and the output market.

For OFSP, the main production constraint is that sweet potatoes are prone to viruses, which can dramatically reduce their productivity. Unless the local producers can improve their tissue culture technique, farmers may not be able to realise the high yields reported by Help Germany. Importing plant material from South Africa is not sustainable.

## 5. Consumption of biofortified crops in Zimbabwe

The promotion of the consumption of biofortified crops has lagged behind breeding and production efforts and little data has been collected on actual consumption patterns. No clearly structured or co-ordinated implementation strategy for biofortified food promotion as a nutrition intervention could be identified in the course of this research.

## 5.1 Iron/zinc-rich bean consumption

Baseline surveys conducted by PABRA in Zambia and Tanzania, backed up with reports from Zimbabwean nutritionists, show that families have limited preparation methods for beans; either boiling them on their own, or together with maize. This form of cooking does not enhance the bland flavour of the beans nor is it suitable for feeding children aged 6–23 months because of its hard texture. Children in this age group are usually fed on bean broth since they are not able to chew whole cooked beans. Thus, these children do not get the full nutritional benefit (protein, energy and micronutrient) of consuming beans.

By processing these products, including soaking or roasting, the bioavailability (extent to which the food's nutrient load is available to the body) of iron, zinc and protein is increased through either the removal or inactivation of anti-nutrition factors (including polyphenols and phytic acid, which affect iron and zinc absorption and bioavailability). In addition, roasting improves the shelf-life of the bean flour and enhances the flavour. In Malawi, bean consumption in rural households is promoted through NGOs. Biofortified bean-based products and recipes for snacks, soups and sauces, complementary foods and composite flour have been developed to encourage consumption. The bean-based composite flour, which can be used for making complementary foods, has been field tested in all PABRA countries and it was liked by programme participants. Industrial production of this flour has been tested in Uganda and the product was also tested in schools and at community level.

Preliminary results from PABRA in Zimbabwe show that beans are a good vehicle for biofortification and plans are being developed to use it in school feeding supplementary programmes. In Zimbabwe the FNC has begun promoting NUA 45 in 12 districts through the Healthy Harvest programme but according to the local PABRA programme officer, the consumption promotion roll-out has been slow and involves low numbers of households. PABRA are interested in pioneering a nationwide programme to promote production and consumption of the bean but are not certain that the FNC have the capacity to do so. PABRA are currently investigating other options through local NGOs such as Cluster Agriculture Development Services (CADS), which promotes improved nutrition through value addition and agricultural diversification. CADS also have experience in the research and development of composite flour that includes cereal, legume and baobab powder mixtures. CADS are keen to promote NUA45 through their programmes in two districts.

Meanwhile, the DRSS HIV/AIDS programme promotes NUA45 with small groups of vulnerable households in several districts including Hwedza, Goromonzi and Rusape. In support of this the Food Science Department at DRSS is working on developing recipes for a wide range of biofortified bean-based products and composite bean/maize flour for dissemination with target communities. The HIV/AIDS programme head noted that groups which have tried the beans report that they enjoy the taste and were pleased to see that they double in size when boiled.

## 5.2 Provitamin A maize consumption

Studies on the impact of Provitamin A promotion in Zambia has shown that there is good consumer uptake, and that some consumers will pay a premium for it when it is promoted and packaged with nutrition information. A major Zambian milling company, Star Millers conducted a trial to package and distribute Provitamin A maize meal through retail outlets in Lusaka. A study of the trial found that within two months of putting the product on supermarket shelves in Lusaka, 37 percent of Provitamin A maize was bought by consumers (Zulu, O. 2013). This rate was slower that purchases for white maize meal but was considered by the study to be fast for a new product and 42 percent of retailers who participated placed second orders for the orange maize meal. Both millers and retailers noted that with more consumer awareness and product promotion, uptake could be even greater and the study concluded that that given the initial consumer response, orange maize meal can become a permanent product line as long as consumers are informed about its added health benefits. It should be noted that no similar trials have been conducted in rural communities. Even so, studies by Meenakshi, et al. (2010), show that orange maize is likely to be acceptable in rural communities as well as urban ones. School feeding programmes, through the World Food Programme (WFP), have also shown progress on the acceptability of orange maize by schoolchildren.

To some extent, the bright colour of Provitamin A maize could be construed as an advantage. From a marketing perspective it distinguishes the product as well as the seed. In addition, there is less likelihood of contamination or impurities caused by mixing it with other varieties. The Zambian roll-out strategy includes laboratory studies to measure the nutrient retention in both the crops and foods. Studies have also been conducted to determine the bio efficacy (the extent to which the nutrient can be used by the body) of provitamin A-rich maize to improve human vitamin A status and have proved effective (Muzhingi et al., 2011).

The programme in Zambia has also measured the improvement in nutritional status of target populations using an effectiveness trial. The results will be published at the end of March 2014, but at an earlier meeting in Harare, HarvestPlus representatives indicated that the analysis shows there is a positive increase in vitamin A levels in children between 5–7 years of age who were consuming food containing Provitamin A maize. It is important to note however, that the maize used in the study was the 15 ppm maize not the 7.5 ppm Provitamin A maize that is being grown in Zambia. Thus the maize being tested for efficacy is not the same as that being grown by farmers, which calls into question the validity of the results of the Harvest Plus study.

In Zimbabwe the CBI is raising awareness of their variety through the National Nutrition Department in the Ministry of Health. The CBI respondents noted that in Zimbabwe there are at present no trials to show the nutritional performance of Provitamin A maize in terms of bioavailability or efficacy.

### 5.3 QPM consumption

Considerable work has been done on understanding modes of consumption of QPM. For example, children recovering from severe malnutrition were fed QPM in clinical studies in several countries in Latin America. The results showed that consuming QPM maize increased the proportion of protein available for utilization by the body (cited in Akalu et al. 2010). Studies of undernourished children in India, Ghana and Ethiopia also had positive results indicating that QPM has potential as a treatment for stunting (cited in Akalu et al. 2010).

A meta-analysis of community-based studies on the effect of QPM consumption on child growth found that replacing conventional maize with QPM leads to a 9 percent increase in the rate of growth for height and a 12 percent increase in weight growth in infants and young children exhibiting mild to moderate undernutrition (Gunaratna, et al. 2010). The study in Ethiopia published in 2010 showed that QPM can have a significant effect on child growth. However the conclusion to this study cautions that a “biofortified crop such as QPM, which is improved in only one nutritional trait, is not a complete food and cannot meet all of an individual’s nutritional needs. Although these studies indicate that QPM can have a significant nutritional impact in this region, it is also important to increase children’s access to and consumption of a more diverse diet” (Akalu et al., 2010).

### 5.4 OFSP consumption

Although not a major staple crop, sweet potatoes are eaten in Zimbabwe, usually as a snack. During the economic decline from 2004–2009, they became more widely grown and consumed as an alternative to bread in urban areas. A United National Children’s Fund (UNICEF) nutritionist consulted during this study, noted that OFSP can play an important role as a complementary food since its soft texture means that it can be mashed and consumed by small children.

## 6. Constraints to the consumption of biofortified crops

Consumption of beans in general is low in Zimbabwe. This was noted by a number of respondents. The 2013 ZIM VAC rural assessment reports that people eat beans on average only three times per fortnight. Eating beans is hindered by people’s perceptions. Respondents noted that bean varieties distributed by NGOs during 2008 as part of food aid were not palatable and have put people off. In addition, people who had to eat beans at boarding school as children have bad associations with the food. On the whole, beans are generally perceived in Zimbabwe as low status food and have a commensurately low market value.

There is need for considerable education on NUA45, which is said to be very palatable by those who have eaten it. Consumption of biofortified beans, Provitamin A maize and OFSP is hindered by the different colours and differences in taste and texture. However most respondents (who also had a vested interest in promoting biofortification) felt that these issues could be overcome through promotion. Follow up and monitoring of the programme in Zimbabwe appears to be weak. Reports and documentation on the nutrition aspect of the PABRA programme were not available. In addition, the design of a rigorous monitoring tool for collecting consumption data did not seem to have been developed.

To intervene effectively in consumption, with effective, nutrition outcomes, data collection must be rigorous to establish whether or not target groups have increased their consumption of biofortified food in amounts and at frequencies, and how that has contributed to their improved nutrition status. In addition, there needs to be a cost-benefit analysis to determine whether food fortification may be a more economical way to improve consumption of micronutrients. In the absence of precise findings for Zimbabwe, the following findings from Malawi are offered for indicative use.

### 6.1 Lesson learned in Malawi

- Training in food processing and legume consumption has helped farmers to understand that legumes play an important role in human nutrition and health and consumption has increased. Farmers now appreciate the importance of not selling all their nutritious food but aim to keep some for themselves and their children.
- Extension advice, geared towards women and school-based nutrition programmes needs a focus on nutrition awareness and education to promote the consumption of beans.
- A strategy to produce small packs for distributing beans would be useful when new products are rolled out and for the urban poor who make daily purchases for their own household needs.
- Households appreciate the new recipes. Porridge prepared from composite flour (maize meal–bean blend flour) is more favoured by children than the locally cooked porridge from maize flour only
- Several studies reviewed alluded to consumer resistance to the consumption of Provitamin A maize in both Zambia and Zimbabwe due to the association with yellow maize varieties distributed as drought relief rations or used as livestock feed. However, these studies also show that this barrier can be overcome through consumer education (Muzhingi *et al.* 2008).

A study by Burt et al. in 2010 notes that “extreme caution is needed to maintain [provitamin A] levels in maize during handling and storage.” For this reason it is important to begin an intervention with a biofortified variety which already has a high level of vitamin A. Currently maize varieties with the target level of 15ppm have not been developed with yields which are comparable to conventional maize hybrids. In other words, additional agricultural research is needed prior to attaining the desired load of micronutrients in the maize. For this reason Provitamin A maize cannot be seen as a single source of vitamin A and should only be promoted as a supplement in conjunction with other vitamin A rich foods.

## 7. Marketing of biofortified crops

Consultations with a representative from National Foods suggested an interest in the company marketing products manufactured from biofortified crops, specifically in piloting biofortified maize products in small 2 kg packages to test consumer interest. The spokesman also voiced an interest in developing a baby porridge mix using Provitamin A maize.

The National Foods respondent noted that Zimbabwean consumers are suspicious of food that contains ‘unnatural’ additives such as fortified maize meal. Market surveys conducted by the company found that 22 percent of consumers said they would not eat fortified food (i.e which has micronutrients added to it). This was of particular concern, given the implementation of the forthcoming food fortification strategy in which the Ministry of Health will require all food producers to fortify selected products, including maize meal. The respondent felt that products made from biofortified food crops would be more acceptable than fortified foods because they would be perceived as being more natural.

In Zimbabwe researchers have done experiments with stockfeed, adding different amounts of QPM as a mix with poultry feed concentrate. In these studies savings on feedstock were recorded, and there was no reduction in broiler performance. This suggests that QPM has a potential in small-scale poultry schemes and family feeding at community level. In South Africa a considerable effort was made to promote QPM for livestock feed but farmers found that it was cheaper to buy lysine to add to feed.

## 8. Opportunity analysis

It is clear that the promotion of the production and consumption of biofortified crops in southern Africa is well underway. Malawi and Zambia, with considerable support from PABRA and HarvestPlus, have been market leaders while efforts in Zimbabwe have lagged, lacking co-ordination and support. Despite this lack of support, it is noteworthy how many organizations across multiple disciplines in Zimbabwe are involved in biofortification and the strong growth potential reported by all research participants.

### 8.1 Current trends in biofortification

A recent catalyst for the promotion of biofortification comes from the Ministry of Health Nutrition Unit, through the formation of a biofortification working group. The momentum for this has been built through Zimbabwe's offer to draft a discussion paper and project document with South Africa for the international Codex Alimentarius Commission on biofortification. This process will be supported by HarvestPlus, with a workshop due to be held in June 2014. To pave the way for this, a meeting was held in Harare with working group members and representatives from HarvestPlus, who voiced surprise at the existing levels of expertise in biofortification in Zimbabwe. It is possible that through this process some investment will come from international organizations to support the Zimbabwean biofortification movement.

The working group meetings also highlighted key shortfalls in the biofortification value chain, notably:

- Several organizations are working on breeding biofortified crops but few are promoting their consumption or creating markets.
- The only organization actively promoting consumption of biofortified crops, the FNC, does not appear to have developed structured monitoring mechanisms to follow up changes in consumption patterns or efficacy. In addition, they do not appear to be giving clear information to their target group on how often and how much of the biofortified food needs to be consumed in order to have an impact.
- A lack of co-ordination and communication among stakeholders.
- There has been very poor engagement of the private sector both in terms of seed production and product marketing. The private sector appears to be largely unaware of biofortification or its potential.
- There is poor representation of the needs and concerns of smallholder farmers in the working group.

### 8.2 Controversial trends in biofortification

A concern that arose from the biofortification working group meetings is the danger of the biofortification promotion movement being used as a stalking horse for the promotion of GE and GMO. There is a possibility that the promotion of biofortification could be the basis for relaxing Zimbabwe's current ban on GE. At the working group meeting, crop breeders and biotechnology members appeared to be lobbying the government to relax restrictions on GE. Others, both locally and globally, have voiced a suspicion of the role of HarvestPlus in facilitating the process of developing a definition for biofortification through the Codex Alimentarius Commission process (Alliance for Natural Health, 2014). HarvestPlus, through IFPRI, are partly funded by CropLife International a lobbying group that represent major producers of transgenic crops, including Monsanto. These issues are discussed further in section 3 under risks.

### 8.3 Key points of entry

#### *8.31 Creating a demand*

A first step in supporting existing biofortification interventions in Zimbabwe would involve creating a demand among project target groups for biofortified crops both for consumption, because of their nutritional benefits and also as potentially marketable commodities (including seed, unprocessed food crops and processed products). This must be developed through a participatory process working with farmers, especially women, and community stakeholders in the project target areas.

An effective way to create a demand for food is through developing markets with institutions where there is a captive audience, such as Provitamin A promotion by WFP in school feeding programmes in Zambia. In Zimbabwe institutional markets could include boarding schools, hospitals and clinics in the project districts. All have large populations that require constant supplies of cheap, safe, nutritious food. Since all these establishments are also controlled by government, it would be possible to support the programme with a Ministry of Health directive that biofortified foods should be introduced onto menus, replacing conventional maize with Provitamin A maize or QPM and conventional sugar beans with NUA 45. The Hospital Food Services Department in the Ministry of Health were consulted on this idea and gave positive feedback. Additionally, WFP could be approached to pilot the use of Provitamin A maize in their feeding programmes in Zimbabwe. Due to the time constraints of this study this idea could not be explored with WFP but it is an avenue which could be pursued through the APN.

### *8.32 Improving breeder seed supply*

Building the capacity of CBI to produce more breeder seed would involve improving relationships with private sector seed houses. Lessons learned from SAMP will be important. Regular stakeholder forums at district level will be required for information exchange, sharing innovations and lessons learned and monitoring in order for the project to develop through an iterative process.

A viable mode for disseminating seed could be adapted from the Pfunduza programme being implemented by Foundations for Farming in which farmers can purchase small ($25) packages of inputs including seed, fertilizer and instruction booklets on how to develop intensive plots whose size is directly related to producing adequate food for an average family for a year. Through the APN, packs could contain biofortified bean and maize seed and would be accompanied by training programmes, based on the Farmer Field School approach, along the lines of the Healthy Harvest programme already being implemented.

Supply chains for biofortified products could be developed through engaging farmers in the project districts to develop contracts to produce biofortified products for the aforementioned institutions. This idea builds on a concept note that was developed with Technoserve in Zambia, which proposed that farmers could grow Provitamin A maize to supply local school feeding programmes. If the farmers are assured of markets then they will have greater incentive to produce biofortified crops. Production could be supported by trained AGRITEX extension officers.

Once grown, the maize could be milled at local hammer milling enterprises supported by the project. Again, this builds on the experiences of Technoserve which has run a successful 2.5 year project in Mozambique involving developing franchise-linked community milling enterprises which have grain storage facilities to ensure that the surplus can be contained in whole-grain form for increased product availability and sustainability. These grain processors are given technical support in safe and effective grain-processing practices and business management training. If replicated in the APN project, this could also help to address some of the post-harvest issues associated with Provitamin A maize.

### *8.33 Improving consumption*

Any such programming should be linked to a nutrition education intervention which could be linked to the same institutions which are receiving the biofortified products through institutional feeding. Such behaviour-change programmes should focus on improved maternal, infant and young child feeding and could be linked to production of biofortified products if land and labour were available. Appropriate complementary foods using biofortified crops in addition to other nutritious, locally available foods, could be promoted though cooking demonstrations. The emphasis on dietary diversification as opposed to dependence on biofortified crops must be emphasised.

This nutrition education programme would need to be monitored in collaboration with the Ministry of Health and should be linked to studies on bioavailability (how the body is able to absorb nutrients from biofortified crops) and bio efficacy (whether the nutrients absorbed actually have an impact on nutrition). Such a programme should compliment or feed international agriculture and health interventions such as Healthy Harvest, which has been in effect since 2006. Healthy Harvest clubs established at schools and health facilities and supported by AGRITEX, village health workers, teachers and environmental health technicians could serve as local level conduits for the project. Water and sanitation issues, home food processing and food safety issues could also be addressed through these clubs, providing synergies with other outputs of the APN.

### *8.34 Increased marketing*

National food processors and retailers can be engaged in a pilot project to develop products manufactured from biofortified foods, including composite flour and weaning foods. This programme would be supported thorough a nationwide advocacy programme including radio and TV promotion and other forms of media.

## 9. Risk analysis

As part of this study, concerns about the outcomes of promoting biofortification in Zimbabwe were discussed through an email forum through the FoodMatters Zimbabwe group (March 2014). FoodMatters has over 160 members from development, the media, academia and the private sector. The concerns voices by respondents from this group via email are summarized below. As these points represent the individual opinions of FoodMatters members, the veracity of claims cannot be verified, but there are nonetheless included here as illustration of the serious interest and depth of feeling surrounding the topic of biofortification.

- There is concern over biofortification being promoted by multinational companies such as DuPont, Pioneer and Monsanto. Major support for HarvestPlus comes from the Bill and Melinda Gates Foundation which supports GE initiatives. This in turn supports the suggestion that the promotion of biofortification will be manipulated to allow transgenic organisms into Zimbabwe.
- The perceived need for biofortification is closely linked to the narrative that Zimbabwe's agriculture is failing and the food insecurity is a major issue. In fact, it is the insecurity of institutional and service conditions for farming that are the problem. This being the case, biofortification, whether local or not, only paves the way for money to be allocated to biotechnology, instead of to local infrastructure, thus facilitating the entrance of multinational biotechnology companies into Zimbabwe.
- The development of biofortified crops is a process dominated by scientists and often fails to include the participation of farmers.
- There is concern over how much such programs actually cost and who would pay for them. Investment could be better directed towards encouraging people to grow and eat more nutritious food which is already available in local communities, rather than investing in breeding, growing and consuming biofortified ones.
- The evidence in terms of the tangible and proven health improvements resulting from biofortified crops is unconvincing.
- Malnutrition and vitamin deficiencies in Zimbabwe are linked to the distribution of and access to resources, the deterioration of national infrastructure of silos, transport and markets; together with a critical lack of operating credit and access to the basic services that would secure national production in the small farm sector and improved access to food for people in all parts of the country. The promotion of biofortified crops will not address any of these issues.
- The climate and natural conditions in Zimbabwe favour the production of most types of fruit, vegetables, nuts and oil seed that small farmers have produced for generations and would satisfy a balanced and nutritious diet.
- Most Zimbabwean consumers have no real understanding of how the food they eat gets into the supermarket. They do not know what they are eating and are susceptible to corporate public relation promotions from the biotechnology industry.

These concerns echo global debates around biofortification in whole and in part. A 2007 paper by Johns and Eyzaguirre, notes that "biofortification as a strategy has tended to fall within the group of centralized, technological, single-factor solutions that have often failed to achieve their promise because of inadequate attention to the social, cultural and economic processes that underpin food systems and diets." Johns and Eyzaguirre argue that because biofortification focuses on micronutrients it addresses a symptom, rather than the many and complex causes of malnutrition, and is appropriate only in situations where the promotion of increased dietary diversity is not possible. The paper questions whether issues on bioavailability and "the need to promote synergistic food combinations such as those recognizing the role of fat in vitamin A absorption" are adequately tackled in biofortification promotion programmes. In promotion of consumption, the paper warns that, since dietary preferences are based on choice of foodstuff (including cultural, economic and aesthetic factors), rather than their nutrient content, the promotion of nutrient benefits is insufficient to ensure the consumption or markets for biofortified crops

Finally, the same authors further note that biofortification programme outcomes could disadvantage small-scale farmers through the cost of certified seed of biofortified crops. A focus on staples leads not only to dietary simplification, exacerbating nutrition problems but also has the same environmental consequences associated with commercialized cropping, including the loss of biodiversity, which ultimately feeds back into dietary simplification. Alternatively, if biofortified crops have only small potential niche markets then they may become too expensive for small farmers to produce and too costly for the undernourished communities that most need to buy them. Johns and Eyzaguirre ask how concerns on the privatization of seed by transnational companies will be addressed. The risks that are specific to the possible APN entry points are outlined in Table 1.

Table 1: APN component risk framework

| Risk type | Potential Impact on Project | Risk management/mitigation measure | WHO | BY WHEN |
|---|---|---|---|---|
| **Inadequate nutrition outcome** | Moderate | Design and implement an effective nutrition strategy involving research institutions and capacitated nutrition promotion organizations. Include a strong focus on dietary diversity, water and sanitation and appropriate infant and young child feeding practices. Ensure effective participatory information dissemination and M and E mechanisms, including a robust baseline. Integrate into national nutrition strategies. | FAO/implementing partners, MoHCC and research partners such as Zvitambo and NUST | Year 1 1st quarter |
| **Lack of consumption of crops** | Moderae | Develop a strong, multisectoral promotional mechanism including behaviour change and communication tools including the mass media. Ensure backing from the Ministry of Health and private sector food manufacturers. | FAO/implementing partners, MoHCC, food manufacturers, The media | Year 1 3rd quarter |
| **Lack of markets for crops and seed** | Substantial | Develop community-based seed markets based on pro-poor market models. Develop rigorous M and E mechanisms. Involve private sector. | FAO/implementing partners, seed companies | Year 2 |
| **High production costs/poor market price for biofortified crops** | Moderate | Ensure the promotion of locally adapted varieties. Discourage focus on only a few cash crops. Encourage biodiversity. Capacity-build extension agents to provide good back-up to farmers and encourage low input, climate-smart sustainable intensification methods.[3] | FAO/implementing partners, extension agencies | Year 2 |
| **Lack of seed for farmers** | Substantial | Ensure private sector buy-in coupled with strong drive to develop consumer demand for seed and product. | FAO/implementing partners, seed producers | Year 2 |
| **Negative environmental impacts** | Substantial | Encourage biodiversity and conservation of natural resource base. Capacity-build extension agents to provide good back-up to farmers and encourage low input, climate-smart sustainable intensification methods. | FAO/implementing partners, extension agents | Year 2 |
| **Creating a backdoor for transgenics** | Substantial | Facilitate stakeholder co-ordination and support stakeholders to understand the complete range of dangers involved in promoting biofortification and GE, including any hidden agendas of the multinational organizations promoting them. | FAO/biofortification working group | Year 1 |

## 10. Strategic partnerships

Because of the complexities associated with nutrition interventions and the risks associated with promoting biofortification outlined above, the success of an implementation programme will depend on taking a holistic systems approach. Co-ordination and facilitating dialogue between different sectoral stakeholders will be a key role for FAO. Table 2 lists the most important partners who need to be involved at different stages, their strengths and their role.

[3] Montpellier Panel (2013) Sustainable intensification: a new paradigm for African agriculture. London: Agriculture for Impact.

Table 2: Key actors and institutions in the promotion

| Key actors and institutions | Strengths | Role |
|---|---|---|
| **Ministry of Health National Nutrition Department, Hospital Food Services** | National coverage down to village level | To catalyse awareness-raising, information dissemination and the monitoring and evaluation of nutrition aspects. Protection of the rights and interests of consumers through policy on biofortification and GE. |
| **Ministry of Agriculture and AGRITEX** | National coverage to ward level | To protect the rights and interests of farmers through policy on biofortification and GE. |
| **FNC** | National coverage. Capacity through Healthy Harvest programme | To catalyse information dissemination through the Healthy Harvest programme building on work already started. Support on monitoring and evaluation through national nutrition surveillance. |
| **National University for Science and Technology and Zvitambo** | Track record in high-quality research | To collect, analyse and disseminate data on nutrition impact and help monitor the programme. |
| **UNICEF** | Strong global institutional capacity and experience in nutrition interventions | To help in developing M and E framework. |
| **CBI/CIMMYT** | Strong institutional capacity | To import germplasm, developing adapted lines, developing certified breeder seed, |
| **Seed houses** | Expertise in seed production, bulking and sales. Access to the market | To make adequate seed of biofortified varieties available to farmers. Creating a market for seed. Giving technical support to farmers on seed production. |
| **SAMP** | Successful track record on community-based seed production systems. Already working with farmers and seed companies | To provide, as potential implementing partners, a link between farmers and seed companies. To make adequate seed available to farmers at fair prices. To create a market for seed. To give technical support to farmers on seed production. |
| **National food processors** | National coverage. Knowledge of the market | To develop and distribute marketable products. |
| **Mass media organizations (radio, newspapers)** | National coverage. Institutional expertise | To raise awareness of the benefits of biofortification. To facilitate the promotion of products and consumption of foods. |
| **Technoserve** | Institutional technical expertise on pro-poor market solutions | To help to develop community-based food processing and storage enterprises for biofortified crops including composite flours. To help these enterprises access finance. |
| **CADS** | Expertise in developing composite blends and promoting community-based processing and value-addition enterprises | As potential implementing partners to support consumption promotion and product development for marketing. To give support on food processing. |
| **HarvestPlus** | Global expertise in biofortification. Capacity to monitor nutrition outcomes | To provide information and advice. |
| **World Food Programme** | Experience in institutional feeding programmes | To provide information and advice. Potential implementing partners through feeding programmes. |

## 11. Conclusion

Based on this research conducted in early 2104, it is clear that there is significant interest and potential for biofortified crops in Zimbabwe. A wide range of institutions including government, development sector (including UN, NGOs and international consortia), have already initiated efforts to expand production of biofortified crops in the country. However, additional efforts are required to develop markets and consumer demand for biofortified crops, especially given that cultural preferences for white maize and low status afforded to beans may act as limiting factors. Nevertheless, if markets can be identified, the promotion of biofortification does appear to hold important potential for improving smallholder-led production of nutritionally appropriate food.

The recommendations below suggest a potential way forward for the promotion of biofortification within the APN, but do not represent an unequivocal endorsement. Given the extensive number of actors and interests in the sector, as well as the strong opinions and concerns articulated in the course of this research, it is strongly recommended that FAO Zimbabwe devote additional efforts and resources to better defining its role in biofortification, and how this role would support the objectives of the APN and the organization's global mandate. It is understood that this process is underway at the organization's headquarters, as FAO is in the process of developing its position on this issue at a global level. This paper therefore is proposed simply as a first step in a necessarily longer and broader process, and should be understood as such.

## 12. Key recommendations

The promotion of biofortification is feasible through the APN per the opportunity analysis and entry points presented in section 2. However, interventions must be developed with caution, using a systems approach that takes into account the complex, multifaceted nature of the problem and the risks of promoting biofortification outlined in this report. Because of the difficulty of measuring nutrition outcomes attributable to biofortified foods (as in the case of HarvestPlus Zambia discussed above), it is recommended that the role of biofortification in the APN be further evaluated on the basis of its commercial potential, that is, as a mode of generating income for smallholders, rather than just as a nutritional input. Planning and programming for biofortification should be premised on this approach.

### 12.1 Coordination and Collaboration:

It is recognized that global debates on biofortification are at a highly advanced stage, and the timing of this research is therefore fortuitous. At the end of March 2014, a global conference on biofortification will be held in Kigali, Rwanda, and key technical staff from FAO Zimbabwe and RAF will attend. This represents an ideal opportunity to further expand FAO Zimbabwe's knowledge base, and to network with key stakeholders in the sector. Additional meetings are scheduled to take place in April-May with HarvestPlus in Zimbabwe.

These efforts are to be welcomed, and the APN should continue to be sued as a platform for FAO engagement on biofortification. Given its mandate and scope, FAO has an important role to play in at both global and national level on biofortification, and this opportunity should be taken up.

In Zimbabwe itself, this study has shown that multiple organizations in many spheres of interest are already involved with biofortification in Zimbabwe and it is important that FAO and the APN should play a complementary role rather than duplicating what is already underway. Biofortification interventions through the LFSP must be guided by and complement pre-existing holistic nutrition initiatives already being promoted by the Ministry of Health, UNICEF and NGOs.

### 12.2 Potential crops to be considered:

Given the analysis summarized in this paper, it appears that the crops with the most potential to obtain secure markets are NUA45 beans and Provitamin A maize.
NUA 45 has the advantage of containing protein as well as two micronutrients. In addition, the soil improvement abilities of legumes can be included as an advantage. Furthermore, beans are traditionally considered women's crops and thus more likely to appeal to women farmers.
Provitamin A maize has a long track record of promotion that can be built upon and the advantages of the orange colour possibly conferring a marketing advantage on the crop.
Other crops discussed here, including QPM maize and OFSP are not recommended for the APN at this point. OFSP has potential and should not be discounted but its overall contribution to nutrition would be limited, given the frequency with which it is consumed. QPM would be viable if isolated production and market chains were guaranteed.

### 12.3 APN Programming:

The APN should thus consider the following components linked to the activities described under output 4 detailed in the APN project document:

- Supporting the development of biofortified seed production in partnership with CBI, private sector seed houses and SAMP which would enable farmers themselves to develop seed production enterprises supplying seed companies. Microfinance institutions would be approached to support these enterprises to ensure sustainability. (Activity 4.1 and 4.4)
- Promoting the production of biofortified crops in target communities in partnership with CBI, AGRITEX and seed companies. This would entail extension support in sustainable intensification methods reducing unfavourable environmental impacts. (Activity 4.2)
- Creating mainstream markets for biofortified foods through community based milling schemes developed through access to rural microfinance and national scale food producers, supported by a nation-wide advocacy campaign. (Activity 4.2 and 4.4).

- Institutional market linkages would be facilitated involving contracts with farmers. (Activity 4.4)
- Promoting consumption of biofortified foods through community based nutrition interventions supported by the Ministry of Health, FNC, UNICEF and NGO implementing partners such as CADS involving training and Behaviour Change and Communication tools. This builds on the Healthy Harvest approach.
- Post-harvest and food preservation issues would be addressed during production extension, and through Healthy Harvest training drawing on the expertise of CADS. Community-based milling enterprises would receive technical support in this regard (Activity 4.3)
- Currently FAO Zimbabwe does not have a staff member who could oversee the different aspects of a biofortification intervention (including crop breeding, production, and promotion of consumption). A full time biofortification specialist would need to be engaged to take on this role.
- FAO to facilitate stakeholder co-ordination and alert stakeholders to the risks involved in with biofortification. In particular to ensure that the interests of smallholder farmers are represented in the national agenda to promote biofortification.

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