A REVIEW OF THE AGGREGATION MODELS USED IN THE COMMERCIALISATION OF BIOFORTIFIED CROPS PROGRAMME

STRATEGIC INSIGHTS FOR COMMERCIALISATION

GAIN Working Paper n°41

June, 2024

Marcia D de Barcellos(†), Panam Parikh(†), Annette M. Nyangaresi, Bho Mudyahoto, Ishank Gorla, Valerie M. Friesen, Mduduzi N.N. Mbuya, Nathaline O Aparo, Hans De Steur

gain Global Alliance for Improved Nutrition
HarvestPlus Better Crops • Better Nutrition
GHENT UNIVERSITY
NUTRITION FOR IMPACT

ABOUT GAIN

The Global Alliance for Improved Nutrition (GAIN) is a Swiss-based foundation launched at the UN in 2002 to tackle the human suffering caused by malnutrition. Working with governments, businesses and civil society, we aim to transform food systems so that they deliver more nutritious food for all people, especially the most vulnerable.

ABOUT HARVESTPLUS

HarvestPlus is a CGIAR research programme which aims to improve nutrition and public health by developing and promoting biofortified food crops that are enriched with nutrients. Founded in 2003 and hosted by the International Food Policy Research Institute in Washington, DC, HarvestPlus provides global leadership on biofortification evidence, technology, and policy.

ABOUT GHENT UNIVERSITY AND NUTRITION FOR IMPACT

Ghent University (UGent), established in 1817, is an internationally recognised research-intensive university. The Division of Agri-Food Marketing & Chain Management (Department of Agricultural Economics) specialises in socio-economic aspects of agri-food value chain from 'farm to fork'. Nutrition for Impact is a consulting firm specialising in developing strategies, applied research, and literature reviews focussed on food security and agriculture.

Recommended citation

de Barcellos MD[†], Parikh P[†], Nyangaresi AM, Mudyahoto B, Gorla I, Friesen VM, Mduduzi MNN, Aparo NO, De Steur H. A review of the aggregation models for biofortified crops value chains used in the commercialisation of biofortified crops programme: strategic insights for commercialisation. Global Alliance for Improved Nutrition (GAIN), HarvestPlus, Ghent University and Nutrition for Impact. GAIN Working Paper #41. Geneva, Switzerland, 2024. DOI: https://doi.org/10.36072/wp.41

[(†)] These authors contributed equally to the paper.

Acknowledgements

The authors would like to thank Stella Nordhagen for reviewing this paper. The authors would like to acknowledge funding for this work provided by the German Federal Ministry of Economic Cooperation and Development (BMZ) and the Netherlands Ministry of Foreign Affairs for the Commercialisation of Biofortified Crops Programme co-led by GAIN and HarvestPlus.

GAIN WORKING PAPER SERIES

The GAIN Working Paper Series provides informative updates on programme approaches and evaluations, research, and other topics relevant to helping reshape the food system to improve the consumption of nutritious, safe food for all people, especially the most vulnerable.

The Global Alliance for Improved Nutrition
(GAIN)
Rue de Varembé 7
1202 Geneva
Switzerland
T: +41 22 749 18 50
E: info@gainhealth.org

www.gainhealth.org

gain
Global Alliance for Improved Nutrition

SUMMARY

Biofortification (also known as nutrient enrichment) of staple crops, is a cost-effective and sustainable agricultural technology that enhances the quantity, bioavailability and bioaccessibility of micronutrients, with the aim of reducing micronutrient deficiencies. From 2019-2022, GAIN and HarvestPlus coordinated the Commercialisation of Biofortified Crops (CBC) Programme, which sought to scale up the production and consumption of biofortified foods (i.e., wheat, maize, cassava, rice, pearl millet, and beans) through commercial pathways in six countries in Africa and Asia. The programme used a variety of strategic scaling pathways to ensure commercialisation (e.g., increased production and availability of surplus for sale in markets), where aggregation was a key step. The objectives of this paper are to: (1) document the types of aggregation models employed by the CBC programme and their challenges, and (2) make recommendations for improving biofortified crop value chains to better achieve commercialisation. The insights in this paper are based on a desk review of CBC programme documents and semi-structured interviews with programme implementers.

The main aggregation model applied in most of the CBC country-crop combinations was contract farming based on collective sales. Other aggregation models were individual contractual sales and spot market transactions. Thematic challenges identified across these models included supply- and demand-related issues, low consumer awareness, inadequate private-sector engagement, and segregation and traceability issues. We propose actionable recommendations to efficiently commercialise biofortified crop value chains. By applying these principles, biofortification programmes are more likely to reach their goals of improving micronutrient intakes and related health and nutrition outcomes.

KEY MESSAGES

- Aggregation is a critical step to agricultural produce commercialisation; however, there are few clearly defined and characterised aggregation models for commercialising biofortified crops.
- The types of aggregation models employed across six crop value chains in the CBC programme included contract farming, individual contractual sales, and spot market transactions; however, the success of these models was hindered by various challenges.
- Actionable recommendations to improve biofortified crop value chains to better achieve commercialisation include having a pragmatic approach with a business outlook, ensuring the right starting point, better understanding farmers, promoting and mobilising change agents, innovations in route-to-market, investing in farmer engagement, and tailoring to local needs.

BACKGROUND AND OBJECTIVE

Today nearly 828 million people in the world are affected by hunger, and more than a quarter of the total population suffers from 'hidden hunger' or micronutrient malnutrition (1, 2). Recent estimates suggest that over 372 million pre-school-aged children and 1.2 billion women of reproductive age, particularly in South Asia and Sub-Saharan Africa, are deficient in at least one of three key micronutrients (iron, zinc, or vitamin A) (3), affecting their livelihoods, health, wellbeing, cognitive development, and economic capabilities (1, 4).

Biofortification is a cost-effective process by which staple crops such as rice, maize, wheat, beans, pearl millet, and cassava (10) are bred to have higher quantities, bioavailability, and/or bioaccessibility of micronutrients, such as iron, zinc, and vitamin A (7-9). Several different varieties of biofortified crops have been developed and adopted worldwide, especially in low- and middle-income countries. However, their reach and coverage beyond farming households is still limited, and traceability of biofortified crops that reach the market remains a challenge.

To this effect, in 2019, HarvestPlus and The Global Alliance for Improved Nutrition (GAIN) launched the Commercialisation of Biofortified Crops (CBC) programme to contribute to addressing the prevalent micronutrient deficiencies in Africa and Asia. The programme was implemented in six countries with a focus on nine country-crop combinations that covered six unique crops, i.e., wheat, maize, cassava, rice, pearl millet, and beans (Figure 1) and aimed to reach at least 190 million consumers with biofortified foods by 2022 through commercial pathways (15). Commercialisation strategies were developed for each of the country-crop combinations at the inception phase of the programme (2019) based on insights from literature reviews and third-party led commercial landscape assessments and were adapted throughout the implementation period (2020-2022) (16, 17). The theory of change proposed to achieve this impact was through (1) increased participation and capacity of value chain actors in the production, processing, and marketing of biofortified seeds, produce, and food products; and (2) ensuring market penetration through integration in the markets. To achieve this, aggregation was seen as a critical process and step.

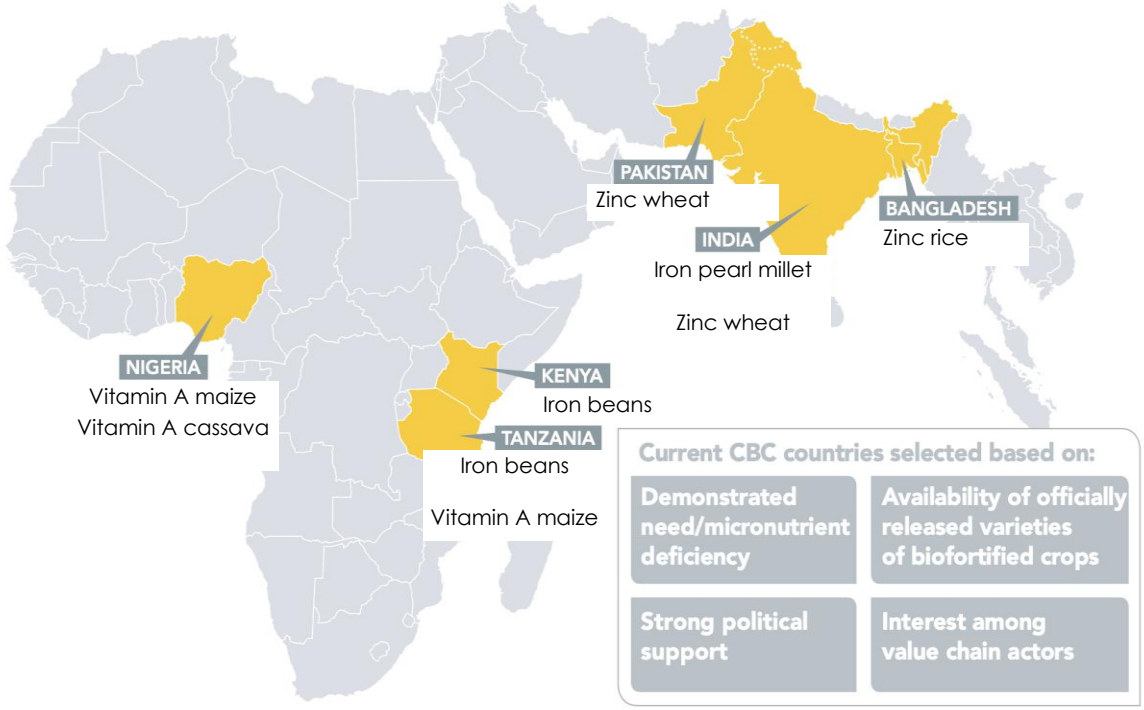

Figure 1. The nine country-crop combinations included in the Commercialisation of Biofortified Crops (CBC) programme. *Source: Adapted from (22)*

'Aggregation' refers here to the process of segregating, collecting, and combining harvested crops or agricultural products from multiple sources, primarily to ensure sufficient or large and marketable volumes for storage, distribution, sale, or processing. It involves working with individual farmers with small quantities of produce (e.g., surplus from their subsistence produce) or formal or informal groups of farmers with relatively large volumes of produce (18). Aggregation aims to streamline the movement of agricultural inputs and produce, improve access to market, and enhance the efficiency of selling agricultural goods, while maintaining product quality (e.g., freshness, colour, taste).

Various aggregation models have been shown to work for different agricultural value chains and different groups. The model of engaging with farmers can vary by crop, country, actors engaged, the kind of produce (e.g., fresh root vs. dry grain), the place at which the produce is aggregated, and the nature of transaction that takes place (18-20). Such variations mean that numerous combinations of aggregation arrangements are possible for each value chain.

For biofortified crops, aggregation models are critical for linking producers to input and output markets and to the success of commercialisation. There is no 'one size fits all' aggregation model. The feasibility and success of aggregation depend on adapting the model to best fit the unique characteristics of agricultural produce, region of production, characteristics of the producer groups, supply chain structures, market dynamics, and policy environment (18, 19, 21). Despite this importance, a recent scoping review that assessed the available literature on farmer-oriented aggregation systems globally for the six crop value chains included in the CBC programme broadly (including both conventional and biofortified varieties) found a

lack of published literature on aggregation models used in biofortified crop value chains (only two out of the 44 included articles covered biofortified crop varieties) (20).

This working paper aims to (1) document the types of aggregation models that were used to drive commercialisation for each of the six biofortified crops in the CBC programme and their related challenges, and (2) make recommendations for strengthening biofortified crop value chains to better achieve commercialisation. We focused on the farmer aggregation systems used for the nine country-crop combinations in the CBC programme (Figure 1), which are dealt with in the post-harvest node of the value chain (i.e., retail and consumption). Specifically, those used for groups of farmers (not individual farmers) for managing resources, inputs, information, product markets, and transaction costs.

METHODOLOGY

We conducted a desk review of CBC programme documents and undertook semi-structured interviews with key staff who implemented the CBC programme. The multi-step process that was followed is captured in Figure 2.

We reviewed 25 CBC programme documents to better understand the context and details of aggregation within the CBC programme, acknowledging that the programme did not aim to ensure full coverage across all delivery models at all three nodes. The types of documents reviewed are listed in Figure 2. We summarised the key information and identified the relevant themes relevant to the scope of the assessment, in line with those of the scoping review (20).

This document review was further supplemented with six virtual in-depth semi-structured interviews, conducted in February 2023, with the CBC Country Leads and the CBC Global Programme Lead.[1]

[1] All the key informants were from GAIN, as the counterparts for these roles from HarvestPlus had been reassigned to other projects at the end of December 2022 and were unavailable at the time of the interviews.

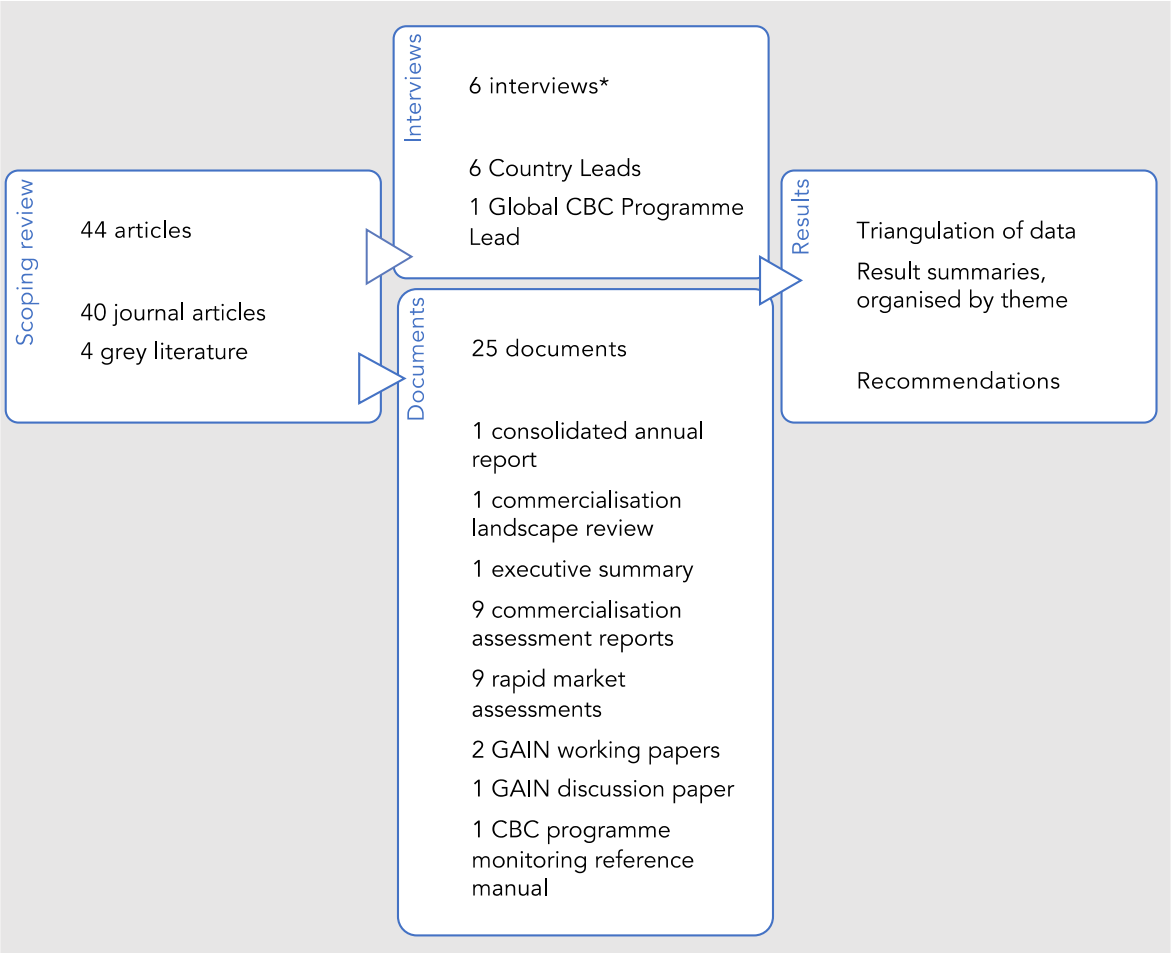

Figure 2. Process flow chart. **One of the Country Leads had a dual role as the Programme Lead.*

Employing responsive interviewing techniques (23), we followed a semi-structured interview guide while also maintaining a degree of flexibility to allow the interviewees to expand on issues most important to them and/or freely transition between the questions. The interviewees were asked to respond to open-ended questions focused on five main topics relevant to aggregation models:

i) farmers' aggregation models in the country;
ii) setting up and implementing the CBC programme in the country;
iii) stakeholders and relationships;
iv) challenges and barriers; and
v) success factors and impacts.

We conducted the interviews via the Microsoft Teams virtual platform, with a duration of approximately 60 minutes each. Interviews were digitally recorded and transcribed to reflect the format of the question guide. Key findings from each question were then included in a findings-conclusion-recommendations matrix, allowing us to analyse the primary data and triangulate it with the findings of document review and the scoping review.

METHODOLOGICAL LIMITATIONS

The principal limitation to this review was that the sampling frame for the interviewees was limited to market node implementers and was missing respondents from other nodes of the biofortified crop value chains (specifically supply side implementors, farmers, aggregators, and off-takers). Another limitation was that the available CBC programme documents did not have sufficient detail on the factors that drove the choice of aggregation models for the six country-crop combinations. As a result, we relied on the qualitative data from interviews to gather these insights and arrive at recommendations to optimise the marketing and commercialisation of biofortified crops. However, some details and/or specific issues across the overall CBC programme-related activities may be missing and/or underreported, which may limit the relevance of the conclusions and recommendations.

RESULTS

AGGREGATION MODELS FOR COMMERCIALISATION OF BIOFORTIFIED CROPS

In 2020-2021, within the CBC programme, an estimated 8.3 million total farming households produced nearly 22.3 million MT of biofortified crops. The CBC programme reported working with 331 aggregators/middlemen/off-takers for three crops (vitamin A maize and cassava in Nigeria, zinc rice in Bangladesh)[2] and 184 processors for five crops (vitamin A maize and cassava in Nigeria, high-iron beans in Kenya, zinc rice in Bangladesh, zinc wheat in Pakistan)[2] to distribute and market the biofortified foods. In the CBC programme, the most common aggregation arrangements seen were either collective or individual sales through forms of contracting or farmers' groups and associations or a combination of the two. Spot market deals with farmers selling their produce at farm-gate or in local markets (often a means of handling surplus or as side-selling) and spot market deals on market days (either individually or collectively) were also reported. As farmers' linkages to the market within the CBC programme ranged from the basic traditional approach of *ad-hoc* selling to contract selling arrangements, we have captured all transactional arrangements in our evaluation. (25).

Table 1 presents an overview of the arrangements reported, by country.

The selection of the aggregation arrangements was based on third-party led commercial landscape assessments as well as on-the-ground experiences of implementation agencies and leveraged existing local structures or systems. While interviewees saw farmers' groups and cooperatives as the most suitable for achieving economies of scale, they also acknowledged that local societal structures did not always facilitate this approach. For example, in *India*, the 'agri-entrepreneur[3]' model was implemented for clusters of farmers across all states and adapted based on the presence and reach of farmer-producer organisations. In states such as Karnataka and Maharashtra, where farmer-producer organisations were well organised and

[2] No data were available for the other value chains at the time of this review.
[3] The 'Agri-Entrepreneur' Model follows a decentralised approach whereby it empowers rural youth and incentivises them to act as business correspondents to facilitate agri-credits and market linkages for clusters of small and marginalised farmers (24).

established, these were leveraged for the contract arrangements for biofortified crops. In contrast, in states lacking established farmer groups, such as Uttar Pradesh and Bihar, individual 'agri-entrepreneurs' were identified and trained to support clusters of farmers. In *Kenya*, aggregators were seen as critical partners for farmers' profitability when entering into arrangements with farmer groups (as they have collective bargaining power), in contrast to the common belief that short value chains are more advantageous (25).

Table 1. Forms of aggregation in the CBC programme

	Collective sales	**Individual sales**
Contract[4]	Groups of farmers (e.g., farmers' associations and cooperatives): - directly to processors and companies (*Nigeria, Tanzania, India*) - to processors and companies, with government as an intermediary (*Tanzania*) - to processors and companies, with aggregator as an intermediary (*Kenya*) - to processors and millers, with private sector aggregators as intermediaries (*Pakistan*) 'Agri-entrepreneur' model[3] (*India*) Groups of farmers to processors and companies, with farmer producer organisations as an intermediary (*India*) Groups of farmers or traders directly to government (and affiliated agencies) through public procurement (*Pakistan*)	Independent farmers directly to processors (*Tanzania, Kenya*) 'Lead farmer' approach[5] (*Kenya*) Independent farmers to processors and/or millers, with aggregators or Paikars/Farias as intermediaries (*Bangladesh*)
Spot marketing (i.e., non-contracted)	Aggregators directly to retailers and consumers at market days (*Nigeria*) Processors directly to market (*Tanzania*)	Farmers directly to aggregators, retailers, and consumers at market days (*Nigeria*) Farmers directly to consumers at farm-gate (*Pakistan*)

[4] Includes formal and informal arrangements.
[5] Other names are 'farmer-to-farmer' or 'contact farmer' approach. A Lead Farmer is defined as an individual farmer who has been elected by the community to play a role (voluntarily) as network 'injection point' or optimal entry point for maximising and speeding up information and technology diffusion (26).

Based on the interviews, contracts were noted to be either written agreements or trust-based informal arrangements, with the latter being more the norm in the studied countries. All arrangements – contracts and spot marketing – involved linked support and/or provision of services across the value chain. These included some or all the below components:

- provision of biofortified seeds or stems to the farmers;
- guaranteed markets;
- capacity building (e.g., training on good agronomy practices, post-harvest handling, aflatoxin mitigation in the vitamin A maize value chain, or business development skills; sensitisation and awareness campaigns; network engagement), often in collaboration with other organisations such as the International Institute of Tropical Agriculture (IITA; Nigeria) or Clinton Foundation (Tanzania);
- output marketing support (e.g., linking farmers to aggregators/processors/ companies, in-store branding programmes);
- resources and logistic support (e.g., supplemental irrigation to cassava seed entrepreneurs, packaging, and transport of outputs); and
- policy development and advocacy with local authorities.

The support and services included in the CBC programme, while aligned with those found in the scoping review, were limited and did not address many of the commonly cited requirements (20). Support or collaborations for access to credit, inputs (e.g., fertilisers in addition to seeds), market information, and resources (e.g., labour, infrastructure) were some commonly cited components of service packages and/or requirements, which did not appear to be a part of the CBC programme.

PROGRAMMATIC CHALLENGES TO COMMERCIALISING BIOFORTIFIED CROPS

Development of sustainable agri-food value chains and markets for biofortified crops was critical for the CBC programme and other biofortified crops programmes to achieve scale (15). Understanding the needs and challenges faced by programmes supporting the scaling of biofortified crops can help identify interventions that increase the likelihood of programme success. Nearly all interviewees echoed many of the same challenges as those reported in the third-party led commercial landscape assessments at inception (in 2019) and during rapid market assessments (in 2022). For illustration, the analysis of common themes for challenges under the CBC programme is presented below.

High demand, low supply

Demand creation activities outperformed availability of biofortified seeds and stems, negatively impacting production and overall supply of the biofortified crops. This was a common constraint highlighted in all interviews. Limited availability of segregated

seed and suboptimal yields due to quality and/or underdeveloped market systems also affected the supply of biofortified crops. For, example in Tanzania, high-iron bean seed was not available in the first and second years of the programme, which delayed availability and access for farmers who were ready to adopt and, as a result, delayed availability in commercial markets. In Kenya, despite intensified demand generation efforts for the high-iron beans, prospective farmers struggled with seed availability and accessibility during planting season. This resulted in reduced adoption, and high dis-adoption rates were observed in some regions.

Lack of segregation and traceability

The practice of intercropping and selling or distributing both biofortified and non-biofortified varieties of crops using the same aggregator and/or market channel without any visible or identifiable distinguishing feature is a major bottleneck for traceability. Without the ability to segregate the biofortified varieties from conventional varieties, neither farmers nor biofortification programmes can confidently assess the profitability and impact of the biofortified crops. Having a database (electronic or paper) of farmers involved in cultivating biofortified crops coupled with other strategies such as branding could help address this challenge. Increasing awareness on the nutritional benefits as well as the additional benefits such as aroma, taste, faster cooking time, could also help generate demand for segregated biofortified crops.

Quality

Issues of quality in the vitamin A cassava (Nigeria) and iron pearl millet (India) value chains impacted crop performance (yield) and farmers' willingness to adopt the biofortified varieties. The issues in the case of vitamin A cassava can be attributed to the lower dry-matter content of the earlier varieties of biofortified stems. This resulted in conventional varieties outperforming the biofortified varieties, making it unviable for farmers to continue growing vitamin A cassava. While a newer, improved variety of the biofortified cassava stem was subsequently released, its similarity in appearance to the underperforming variety negatively affected its adoption by farmers in Nigeria. In India, poor germination, due to non-compatibility with the soil, impacted the performance of biofortified iron pearl millet.

Inefficient inter-cropping

In some cases, biofortified and conventional variety cultivation were combined on the same farm in all the CBC countries. Farmers intercropped these food crops, either at the same time or based on seasonality, for subsistence, profitability, or to meet market requirements (e.g., for animal feed). Whilst not measured in the CBC programme, this likely reduced the marketable yields of the biofortified crops.

Largely unorganised and dispersed production

Large but sporadic production volumes coupled with limited presence of farmer groups and a lack of farmer databases were crucial barriers to achieving economies of scale in India. Whilst not reported by stakeholders for other countries, a similar

bottleneck may exist in their country-crop value chains: only 14% of Asian farmers and 7% of African farmers are members of farmer groups or cooperatives (21).

Outdated sectoral data

Nearly all interviewees noted reliance on old (i.e., pre-COVID-19 pandemic) data for understanding the value chain and especially, farmers' needs and/or resource requirements as a constraint, given the programme was implemented from 2019-2022. They highlighted the need for current analyses, keeping in mind the potentially significant impacts of COVID-19.

Consumer awareness

There was a mismatch between the perspectives gained from CBC programme implementers and the insights uncovered in the third-party led rapid market assessments. Whilst the CBC interviews suggested high awareness and interest from consumers, processors, and farmers, the rapid market assessments indicated a mixed awareness. This was noted for vitamin A cassava, vitamin A maize, high-iron beans, and iron pearl millet. While the mismatch could be attributed to the methods and language, implementer bias, or a lack of a representative sample of respondents during the market assessments, it highlights the potential need for more awareness raising.

Inadequate private-sector engagement

There was a perceived misalignment between private-sector requirements and CBC programme planning on two levels: (a) current production of biofortified crops is not sufficient to meet the volumes of large-scale millers and processors, such as General Mills, and (b) little to no interest from large seed companies in biofortification, as it is not seen as a viable business opportunity. Strategies aimed at increasing private-sector involvement must have clear objectives and must take into consideration the sector culture, mode of operation, and issues related to profitability and long-term sustainability.

DISCUSSION

Based on the results above, we propose seven actionable recommendations to efficiently expand the reach of biofortified crops and achieve the intended nutritional impacts through commercialisation (Figure 3). Agricultural value chains, particularly for value-added biofortified crops, have many interrelated and multi-dimensional elements akin to any complex economic system. These recommendations, therefore, span beyond aggregation systems at the post-farm node to include all three nodes in the CBC commercialisation framework: pre-farm, on-farm, and post-farm. Whilst the recommendations were designed for the CBC programme, they can also serve as a roadmap of action areas to steer other programmes focused on related agricultural value chains.

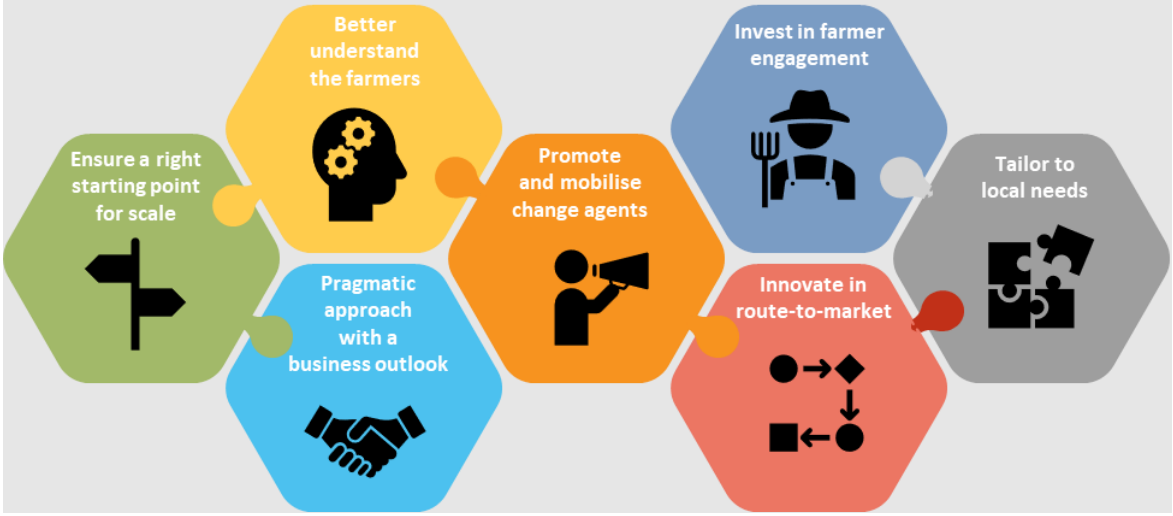

Figure 3. Seven actionable recommendations to scale up the commercialisation of biofortified crops

Pragmatic approach with a business outlook

Approaching commercialisation with a business mind-set is critical to success of biofortified crops programmes. While coordination with the public sector is essential, it is equally important to have a viable private-sector engagement strategy early in the process. This can help in early identification of key players (e.g., large seed companies, millers) and their requirements, which is needed to support the development of a robust, commercially viable business plan that can attract their interest. Without this, commercialisation may proceed but lack momentum and/or not reach scale.

Ensure the right starting point for scale

Implementing a programme such as CBC requires multiple parallel advancements. For example, improvements in the crop variety might enable farmers to adopt more productive, nutritious crops, but a shortage in supply of inputs or underperforming seeds is likely to make the farmer hesitant to use the variety, with high possibility of dis-adoption. Integrating seed supply in business planning and ensuring alignment between seed production and demand creation activities can help in retaining farmers, ensuring supply for processors/millers, and supporting private-sector engagement.

Better understand farmers

Segmentation is not a new concept – companies use this to better understand their target customers and tailor products and/or advertising to them. An improved understanding of farmers can help to design more effective plans around distribution and procurement that would help both the CBC programme partners and farmers. This can be reinforced through leveraging digital technology and other relatively simple methods, such as SMS-based surveys and field visits to gather practical information on farmers. For example, such tools can be used to identify whether the

farmer is a mono-cropper or an inter-cropper or whether he/she cultivates biofortified or conventional varieties, or both. Whilst simple information, this can allow for better targeting of demand creation efforts and facilitate segregation and traceability based on cropping practices.

Invest in farmer engagement

There is a benefit in tailoring bundled services to farmers' unique needs based on 'on-the-ground' understanding of farmers' demands. Capacity building, technical assistance, market information services, quality inputs, and access to credit are key for long-term implementation of biofortification programmes and, potentially, engaging the private sector. Working with local governments can help to establish targeted incentive mechanisms for long-term delivery of these services and strengthen performance.

Promote and mobilise change agents or influencers

A valuable avenue to support behaviour change among farmers is to leverage and scale-up the 'change agents model'. These change agents can be agri-entrepreneurs, lead farmers or cooperatives, or women who have historically played a critical role in providing extension services to farmers (Box 1). By enabling smaller, on-farm changes that can be sustained, these agents can support the achievement of the high-level objectives of biofortified crops commercialisation and other market facilitation-based programmes.

BOX 1. AGRI-ENTREPRENEURS POWER THE INDIAN FARMERS

The agri-entrepreneur model is a flagship initiative of Syngenta Foundation. This initiative takes a decentralised market development approach by training local youth to become 'one-stop resource providers' for the agricultural needs of small and marginal farmers in their region. An agri-entrepreneur has four critical functions: providing better-quality inputs, knowledge and crop advice, market linkages, and credit facilitation, with the end objective of increasing farmer incomes. Given that farmer communities are often remotely distributed, disconnected from one another and from larger markets, these agri-entrepreneurs serve as a bridge, facilitating access for producers. As of 2020, around 2,666 agri-entrepreneurs across nine states in India serve approximately 220,000 farmers (23).

Innovate in route-to-market

Unlocking the potential of biofortification or agricultural value chain programmes requires practical, on-the-ground effort and innovation. Leveraging institutional channels such as home-grown school feeding programmes and/or investing in school farms, as was piloted in the Tanzania CBC programme (Box 2), may offer a sustainable route to improve accessibility of biofortified foods for population subgroups that may particularly be vulnerable to malnutrition. Another approach could be to use digital

solutions to provide reliable distribution for inputs and produce, while improving traceability.

BOX 2. SCHOOL MEAL PROGRAMME ACCELERATES CONSUMPTION OF BIOFORTIFIED CROPS IN TANZANIA

The CBC program leveraged institutional channels and partner alliances for commercialising vitamin A maize and high-iron beans in Tanzania. In 2021, the programme trained heads of schools, food suppliers to schools, education officials, and nutrition officers from nine project regions on biofortification and strengthening the supply chain for school meal programmes. Regional Multisectoral Nutrition Committees were engaged to raise awareness of nutrient-enriched crops, and on-ground participatory techniques such as cooking demonstrations were used to reinforce the importance of biofortified crops. Strong support demonstrated by the government was key in driving these efforts in the country.

As of 2022, nearly 71 schools were procuring biofortified maize and beans for school meals and six schools had started planting biofortified seeds in their own farms.

Tailor to local needs

Branding may be beneficial in creating recognition and awareness of biofortified crops and food products. Thus, biofortified crop commercialisation could benefit from branding for the value-added crops that is differentiated, clearly visible, and resonates with the target audience. This could be achieved through campaign activations to create awareness of the branding while highlighting the relevance of biofortified crops. Key branding messages on biofortified crops and foods could be framed around their agronomic, environmental, and nutritional benefits.

Box 3 provides an example of how the adoption of the seven recommendations facilitated the transformation of a highly disaggregated sector into a successful programme with global reach in Brazil.[6] Although meat production has its own challenges, specificities, and differences from staple crops, some insights can still be drawn from the example.

[6] The case is based on the experience of one of the authors (MD Barcellos) as Director (2003-2007) and Board Member of the Brazilian Angus Beef Program (2007-current), personal communication with the current Manager, and on information available on the website https://angus.org.br/o-que-e-o-programa-carne-angus-certificada/

BOX 3. AGGREGATION AS A SUCCESS FACTOR FOR TRANSFORMING THE LIVESTOCK VALUE CHAIN

Launched in 2003, the Brazilian Angus Beef Program is led by the Brazilian Angus Association with the aim of promoting the quality of Angus beef produced in the country and boosting ranchers' incomes. The programme is a voluntary marketing effort held together by each participant's desire to receive above-average prices. Participation of nearly 24,800 producers and 22 beef processors in 42 plants across 11 states of Brazil[6], exporting high-quality beef to over 100 countries, is a testament to the success of the programme.

Yet, the beginning of the programme was not without its challenges: disaggregated producers, multiple value-chain actors with strong interdependencies, distrust in the industry, varied beef quality, no rewards for high quality, and low consumer awareness about the quality and eating experience related to Angus. Designing and implementing a coordinated effort across the value chain, with strong multi-sectorial engagement, helped turn around this programme. Some key aspects include:

- Angus Association led the programme and developed strategies to address the challenges of the value chain.
- The programme adopted a vertical coordination model, driven by a pull-through-demand strategy and requiring no upfront investment from any value chain participants.
- A robust business plan, based on on-ground learnings of two years, formed the basis for determining the market size and defining sales for launch.
- Formal engagements with the government, retail for brand development, and official certification to provide assurance that traceability was created.
- Capacity building, sensitisation activities, and awareness campaigns to engage seedstock sector and beef producers.
- Single-partner pilot launch in 2003, learnings from which fuelled the subsequent scale-up.
- The programme is not responsible for trading operations but follows quality, volumes, and prices to ensure legitimacy. Beef processors pay a levy per certified animal, which is used to cover the cost to the Angus Association for developing requirements and standards and supporting the marketing activities of the programme.

CONCLUSION

Programmes that aim to commercialise and scale up the production and consumption of nutritious foods, such as the CBC programme and related initiatives for other agricultural value chains, aim to contribute to improving micronutrient intakes and related health and nutrition outcomes. The findings from this review of aggregation models used in the CBC programme for commercialising biofortified crops demonstrate the importance of understanding and supporting different farmer aggregation systems to develop value chains for biofortified crops. Collective, coordinated, and synergetic action between different stakeholders is essential to ensure seed supply meets product demand, and that markets are facilitated to offtake the produce. Additionally, sustainable and long-term results often require a business strategy that considers both local and global aspects, public-private partnerships, investment in inputs and change agents, and innovative approaches to unleash their full potential. By applying these principles to biofortified crop value chains, biofortification programmes are more likely to reach their goals and improve the health and nutrition of populations.

REFERENCES

1. FAO, IFAD, UNICEF, WFP, WHO. The State of Food Security and Nutrition in the World: Repurposing food and agricultural policies to make healthy diets more affordable. Rome, Italy: Food and Agriculture Organization; 2022.

2. FAO, The State of Food and Agriculture: Food Systems for Better Nutrition. Rome, Italy: Food and Agriculture Organisation; 2013.

3. Stevens GA, Beal T, Mbuya MNN, Luo H, Neufeld LM. Micronutrient deficiencies among preschool-aged children and women of reproductive age worldwide: a pooled analysis of individual-level data from population-representative surveys. The Lancet Global Health. 2022;10(11): e1590-e1599.

4. Bacon CM, Sundstrom WA, Flores Gómez ME, Méndez VE, Santos R, Goldoftas B, Dougherty I. Explaining the 'hungry farmer paradox': Smallholders and fair trade cooperatives navigate seasonality and change in Nicaragua's corn and coffee markets. Global Environmental Change. 2014;25:133-149.

5. FAO. Tracking Progress on Food and Agriculture-Related SDGs Indicators 2021. A report on the indicators under FAO custodianship. Rome: Food and Agriculture Organization; 2021.

6. Lowder SK, Sánchez MV, Bertini R. Which farms feed the world and has farmland become more concentrated? World Development. 2021;142:105455.

7. CAST. Food biofortification: Reaping the benefits of science to overcome hidden hunger. Iowa, USA: Council for Agricultural Science and Technology; 2020.

8. De Steur H, Wesana J, Blancquaert D, Van Der Straeten D, Gellynck X. The socioeconomics of genetically modified biofortified crops: a systematic review and meta-analysis. Ann N Y Acad Sci. 2017; 1390(1):14-33. doi: 10.1111/nyas.13199.

9. Saltzman A, Birol E, Oparinde A, Andersson MS, Asare-Marfo D, Diressie MT, Gonzalez C, Lividini K, Moursi M, Zeller M. Availability, production, and consumption of crops biofortified by plant breeding: current evidence and future potential. Ann N Y Acad Sci. 2017; 1390(1):104-114. doi: 10.1111/nyas.13314.

10. Bouis HE, Hotz C, McClafferty B, Meenakshi JV, Pfeiffer WH. Biofortification: a new tool to reduce micronutrient malnutrition. Food Nutr Bull. 2011; 32 (Suppl):S31-40. doi: 10.1177/15648265110321S105.

11. Talsma EF, Melse-Boonstra A, Brouwer ID. Acceptance and adoption of biofortified crops in low- and middle-income countries: a systematic review. Nutrition Reviews. 2017;75:798-829.

12. De Steur H, Wesana J, Blancquaert D, Van Der Straeten D, Gellynck X. Methods matter: a meta-regression on the determinants of willingness-to-pay studies on biofortified foods. Ann N Y Acad Sci. 2017; 1390(1):34-46. doi: 10.1111/nyas.13277.

13. Ruel MT, Alderman H; Maternal and Child Nutrition Study Group. Nutrition-sensitive interventions and programmes: how can they help to accelerate progress in improving maternal and child nutrition? Lancet. 2013; 382 (9891):536-551. doi: 10.1016/S0140-6736(13)60843-0).

14. Vaiknoras K, Larochelle C, Birol E, Asare-Marfo D, Herrington C. Promoting rapid and sustained adoption of biofortified crops: What we learned from iron-biofortified bean delivery approaches in Rwanda. Food Policy. 2019;83:271-284. doi: 10.1016/j.foodpol.2018.11.003.

15. GAIN , HarvestPlus. The Commercialisation of Biofortified Crops: Expanding the reach of nutrient-enriched staples. 2020.

16. Nyangaresi AM, Friesen VM, McClafferty B, van der Merwe C, Haswell D, Reyes B, Mudyahoto B, Mbuya MNN. Developing strategies to commercialise biofortified crops and foods: Identifying opportunities and barriers to inform country-level interventions. Global Alliance for Improved Nutrition (GAIN) and HarvestPlus. Working Paper #28. Geneva, Switzerland, 2022. DOI: https://doi.org/10.36072/wp.28.

17. NyangaresiAM, Granger K, Friesen VM, McClafferty B, Haswell D, Mudyahoto B, Reyes B, Mbuya MNN, Greenberg A. Commercialising Public Agricultural Technologies and Goods: A framework to identify opportunities for interventions. Global Alliance for Improved Nutrition (GAIN), HarvestPlus, and The Development Practice. GAIN.

18. Abraham M, Verteramo Chiu L, Joshi E, Ilahi MA, Pingali P. Aggregation models and small farm commercialization – A scoping review of the global literature. Food Policy. 2022;110:102299. doi: 10.1016/j.foodpol.2022.102299.

19. Wiggins S, Compton J. Factors Leading to Agricultural Production Aggregation and Facilitation of the Linkage of Farmers to Remunerative Markets. London: Evidence on Demand; 2016.

20. Parikh P, Aparo NO, de Barcellos MD, Nyangaresi AM, Gorla IM, Mudyahoto B, Friesen VM, De Steur H. Farmers' aggregation models as pathways for the development and scaling up of staple crop value chains: A scoping review. J Dev Econ. 2023. (*under review*)

21. IFC. Working with Smallholders: A Handbook for Firms Building Sustainable Supply Chains. Washington DC, USA: The World Bank; 2018.

22. GAIN. Commercialisation of Biofortified Crops 2023; Available from: https://www.gainhealth.org/sites/default/files/publications/documents/commercialisation-of-biofortified-crops--flyer.pdf.

23. Lune H, Berg BL. Qualitative Research Methods for the Social Sciences. London: Pearson; 2021.

24. Syngenta Foundation. Agri-Entrepreneur Model. 2023. Available from https://www.syngentafoundation.org/agriservices/whatwedo/ae/agri-entrepreneurmodel.

25. Jarzębowski S, Bourlakis M, Bezat-Jarzębowska A. Short Food Supply Chains (SFSC) as Local and Sustainable Systems. Sustainability. 2020;12(11):4715.

26. Anderson R. The Impact of the Lead Farmer Extension Approach Implemented by the Development Fund of Norway in Malawi; FNI Report 5/2019. Lysaker, Norway: Fridtjof Nansen Institute; 2019.