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Nutrition-sensitive value-chain development in Ghana: evidence from the field

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ABSTRACT

Increasing the accessibility of nourishing food options is important to tackle micronutrient deficiencies in Ghana. Using a value chain approach that prioritizes nutrition, a Nutrition-Sensitive Value Chain approach, the study aimed to select appropriate value chains based on their economic value, income generation, nutritional significance and potential for high postharvest losses and food waste in Ghana. We employed key informant interviews and commodity scoring methods to select suitable commodity value chains that met all set criteria. Initially, 40 commodities were shortlisted among the five food groups for this study. Subsequently, 27 crops were selected for value chain interventions. Mango, cashew, oil palm, banana/plantain, shea and pineapple were selected as tree crops. Cowpea, groundnut, soybeans and bambara beans were selected as legumes, while maize, rice, sorghum, millet and fonio were selected as cereals. Cabbage, ginger, onion, shallot, eggplant, chilli pepper, okra and tomato were selected in the fruit category. Finally, yam, cassava and sweet potatoes were selected as the roots and tubers. It is recommended that experiments be developed and executed to introduce foods to infants that consist of a balanced mix of locally accessible options. Furthermore, it is important to pursue the creation and promotion of supplements and snack options specifically designed for school children, as well as efforts to implement programs that focus on nutrition and effective communication strategies to encourage behavioral change. Finally, efforts must be directed towards minimizing food waste and improving food safety measures.

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1. Introduction

Overcoming developmental challenges in Ghana cannot be separated from the need to significantly transform the country's food systems. Such a transformation plays a direct role in attaining the Sustainable Development Goals (SDGs), which entails attaining food security and reducing malnutrition (SDG 2), promoting public health (SGD 3) and providing opportunities to reduce poverty (SDG1). Food systems affect both the varieties of foods generated and the methods of transportation from production sources to consumption destinations (HLPE, 2017). On the other hand, access to healthy, safe food and improved livelihoods is not solely dependent on increased agricultural productivity. It requires collective efforts along the food value chain, which are essential to promoting sustainable consumption and production (SDG 12), and emphasizes minimizing food losses along the entire value chain.

In Ghana, agriculture provides employment, food and income for the majority of people, yet the productivity of the sector has generally remained below its potential (Adaku et al., 2023; Agyin-Birikorang et al., 2023). The sector comprises of crops other than cocoa, livestock, fisheries and forestry. Although cocoa, which forms about 10% of agricultural production, plays a key role in the economy, oil palm,

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cashew, rubber and shea, among other tree crops, have also proven to be significant contributors to the economy (Koloma & Some, 2023). Food crops, including rice, maize, groundnuts, soybeans, cassava, yams and plantains, take precedence in agriculture, contributing almost 70% of the total production value (Darfour & Rosentrater, 2016). In recent years, the contribution of the fruit and vegetable subsectors (pineapple, banana, mangoes, pawpaw and oranges) through foreign exchange earnings has been significant (ISSER, 2021). Additionally, the quest for nutritious food has led to an exponential demand for fruits and vegetables in Ghana (Hollinger & Staatz, 2015).

Agriculture also plays a crucial role in enhancing nutrition by designing a food system to guarantee accessibility, affordability and sufficiency of a wide variety of foods that are abundant in nutrients to fulfil the dietary requirements of individuals of all age groups (De la Peña et al., 2018). Changes in agricultural production are essential to improve nutritional outcomes on a large scale. However, the current production structure does not meet the requirements for sufficient micronutrients.

Food availability and affordability are both affected by food production systems (Campi et al., 2021) as well as nutritional quality and variety (HLPE, 2017; Mehraban & Ickowitz, 2021). The loss and contamination of food throughout the supply chain can lead to a decrease in the nutritional value of food. In each phase of the food logistics network, the impact of food safety and losses, as well as waste (FQLW), plays a crucial role in determining dietary quality .

Despite extensive research on these value chains, there is a significant gap in understanding how these chains can be optimized to enhance nutritional outcomes, particularly in West Africa (Allen & De Brauw, 2018). Previous studies have hitherto largely focused on economic viability, leaving a gap in the integration of nutrition-sensitive interventions (Nguyen et al., 2022). Historically, efforts to enhance value chains have mainly focused on elevating the income levels of farmers and other participants in the chain. However, this alone is not sufficient to effectively address malnutrition (Graziose et al., 2018).

The establishment of Nutrition-Sensitive Value Chains (NSVCs) can therefore play a crucial role in guaranteeing that our food systems offer accessibility to a diverse range of nutritious foods essential for sustaining a healthy and balanced diet. NSVCs leverage opportunities to improve nutritional value while boosting both the availability and desire for a wide range of safe and diverse foods and enhancing their nutritional content. Improving dietary quality is the most important contribution of value chains to improving nutrition. Developing value chains for specific commodities can result in increased income for producers, in addition to the potential for improved diets by providing households with the opportunity to buy high-quality food in appreciable quantities. In a standard value chain analysis, smallholder producers choose commodities based on their potential for market success and income generation (De la Peña et al., 2018). However, the current study requires additional selection criteria for the potential of the crop to improve nutrition and high postharvest loss.

This study therefore identified value chains in Ghana whose expansion is most effective at stimulating economic growth, reducing rural poverty, creating job opportunities and ultimately improving nutrition through diet diversification. This study aimed to choose appropriate value chains based on their nutritional benefits and importance, economic value, income generation and potential for high postharvest losses and food waste in Ghana. It identified commodities capable of addressing the nutritional needs of the population while meeting market demand and enabling smallholder farmers to generate income.

2. Review of interventions in value chains with a nutrition-sensitive approach

The value chain (VC), can be thought of as the entire journey a product or service takes, from its initial idea to various stages of production, all the way to reaching the end consumers, and finally concluding with disposal after use (Kaplinsky et al., 2002). Food value chains involve individuals and stages ranging from producers to consumers. This involves providing inputs, cultivating crops, storing and processing, distributing and transporting, handling retail and labeling, and finally, the satisfying act of consumption. We define NSVC as consisting of all actors participating in the coordinated production and value-addition activities required to make food products and contribute to better food security and nutrition. The NSVC framework is a detective for food systems, delving into their complexities and proposing ways to enhance food security and nutrition. The accelerated health agriculture and nutrition (AHAN) project analysis began by developing the criteria for shortlisting nutrient-rich food value chains that can enhance local nutrition while also having the possibility of

increasing production, demand and income influence pathways for better food systems (AHAN, 2020).

Food security measures, encompassing both food availability and accessibility in developing countries, have improved over the years. The number of undernourished individuals in these countries declined from 900 million in 2000 to 815 million in 2017 (FAO et al., 2017). Even with improvements in ensuring there is enough food, the food systems in developing nations often fall short of providing a diverse range of options. This means that many people in these countries still struggle to maintain a consistently healthy diet (Allen & De Brauw, 2018). Evidence indicates that even among those with means to do so, obtaining a nutritious diet can be challenging within contemporary food distribution systems (Alston et al., 2016). The challenge of securing a nourishing diet is not exclusive to developing nations; it affects people in various parts of the world. Currently, people worldwide are increasingly experiencing issues related to being overweight or obese. In various regions, a mix of malnutrition challenges such as stunting, wasting, micronutrient deficiencies and overweight/obesity coexist. The connection between agriculture, nutrition and health within the framework of SDGs is notably challenging. In simple terms, SDG 2 is about ensuring that everyone has sufficient food, improving nutrition and promoting sustainable farming. Even though places like India are getting richer and producing more food, the problem of high malnutrition rates persists because of the complicated nature of the issue (Maestre et al., 2017). To fulfil SDG 2, the focus must extend beyond merely producing more calories to combat food insecurity. It ought to prioritize providing a variety of foods that promote health, while ensuring affordability and environmental sustainability. Additionally, in lower- and middle-income nations, most food products are obtained through informal markets, constraining the range of measures that can be applied. Nevertheless, focusing solely on farmers and producing for family use has not been effective in improving nutrition. Various assessments of efforts to improve agriculture and its impact on nutrition have yielded unclear or inconclusive results.

Ghana is not exempt from the prevalence of stunting. For instance, 28% of all children under five were stunted in 2008. Stunting, according to the DHS (2008), is a sign of chronic malnutrition, as it shows a long-term failure to consume enough food. Stunting is more common in some regions than in others; Greater Accra has a prevalence of 14%; Northern, 32%; Central, 34% and Eastern, 38%. However, in 2014, DHS data revealed that children in specific areas of the northern region faced a greater risk of stunting. Conversely, some of the lowest prevalence rates were observed in parts of the Greater Accra, followed by the Brong-Ahafo, Ashanti and Eastern regions (Aheto & Dagne, 2021). According to Gyan et al. (2022), the prevalence rate was 10.4% in South Tongu District, Ghana.

The origins of malnutrition are diverse, spanning various sectors, including food and health, and manifest at different levels ranging from individual households and communities to society and the government. The AHAN project, which is supported by a grant from the European Union, used the NSVC strategy to close the nutrition and food security gaps by encouraging the intensification and diversification of the production of certain crops and animals with better market linkages (AHAN, 2020).

de Jager et al. (2023) conducted a study on what would need to be grown in rural households in Northern Ghana to ensure the availability of nutrient-adequate food to satisfy their dietary needs year-round. The results revealed three observations after modeling various scenarios and interventions. First, accounting for seasonality is imperative for nutrition-sensitive farming. Guaranteeing a year-round nutritious diet necessitates the availability of vegetables and fruits throughout the season. Second, although staple crops may not provide all the necessary nutrients, boosting their yields helps reduce farm size. This, in turn, opens up space for growing other vital foods, such as vegetables, which is crucial for a healthy and balanced diet. Third, smallholder farmers struggle to produce sufficient food to meet their needs. They rely on the income generated through farming and other sources, as well as the variety of foods available in markets, to fulfil their nutritional requirements (de Jager et al., 2023).

To address these challenges, agricultural value chains can engage various key players, such as those supplying inputs, traders, processors and consumers, all of whom play crucial roles in ensuring a more nutritious food supply. Unlike other interventions, value chain interventions concentrate primarily on the food marketing pathways and the economic benefits they bring. Several authors have proposed that involvement in value chains could be a key factor in encouraging people to choose and consume foods that are rich in nutrients (Dangour et al., 2012; Hawkes & Ruel, 2012; Gelli et al., 2016). Previous studies have outlined a framework for classifying interventions based on the targeted features of demand and supply has been outlined in past

studies (Gelli et al., 2016). The benefit of engaging in value chain interventions becomes evident when they are carried out in partnership with the private sector, motivating entrepreneurs to continue nurturing and expanding these initiatives because of their promising profitability. However, a change in focus is necessary to ensure that these interventions effectively impact the food systems. When small-scale farmers are involved in value chains related to healthier food choices, they can have intricate effects on households, influencing factors such as income, local environment and what families consume. For instance, in numerous countries, it is essential to boost the cultivation of pulses, fruits and vegetables to ensure that people can obtain the micronutrients necessary for a healthy diet. However, this shift could potentially reduce the production of essential staple grains, such as rice, wheat and maize, resulting in a nuanced impact on nutrition. A drop in overall energy availability could impact struggling families, who heavily depend on staple foods to meet their nutritional requirements (Bouis et al., 2011).

The relationship between agriculture and nutrition has also been examined through observational studies at the farm level. Informed by the agricultural household model, these studies demonstrate that, in the presence of imperfect markets, the traditional separation between production and consumption decisions becomes less distinct. Consequently, farm production output can directly influence consumption patterns and nutritional outcomes. This collection of studies is discussed in the introductory section authored by the editors in a special issue of the *Journal of Development Studies*, focusing on the interconnectedness between agriculture and nutrition (Carletto et al., 2013).

3. Materials and methods

3.1. Commodity scoring and selection process

Given the literature that has been reviewed in the previous section on value chain interventions and how they are useful in improving food and nutrition security, the study employs the nutritive-sensitive value chain methodology to address the questions raised in this article. The nutritive-sensitive value chain measurement uses a scoring and selection process to choose specific food commodities that possess high nutritional value that are needed to address identified dietary gaps, at the same time considering their market demand and profitability to farmers. Both secondary and primary data were used in this study. Secondary data were obtained from literature review, available information sources (Ministry of Food and Agriculture [MoFA], ISSER, GSS), and other research studies. Data was also obtained from development partners in nutrition and agriculture and other relevant institutions. Published articles and reports on nutrition and agriculture will also be consulted. This helped to identify the diet and nutritional gaps and the list of all commodities that can help address these gaps (Table 1). Primary data was collected from farmers, nutrition experts and agricultural policy makers using a structured questionnaire to obtain the information needed to assess each commodity value chain, using these four indicators for selecting commodities based on the nutritive-sensitive commodity selection method. These indicators are: (1) Nutrition-improvement potential: Evaluates how well the product can fulfill the nutritional and dietary needs identified in the target population. This measure consists of three aspects: what people eat, their preferences and the nutritional composition of the food. (2) Market potential: This considers the current and future needs of the market along with opportunities for improvement. It consists of three sub-criteria: market demand, interest from the private sector and the potential for enhancement, considering the agro-ecological conditions and (3) income generation and poverty-reduction potential, which considers how many smallholder farmers can produce and the potential for them and rural communities to earn income. This standard consists of three sub-criteria that assess the involvement of smallholder farmers, profit margins and the creation of job opportunities. (4) Potential for high postharvest losses and food waste: commodities with high potential for postharvest loss and food waste along the commodity value chain. This indicator has three subcriteria: quantity loss (%), economic loss (%) and food safety.

Each of the indicators were scored on a three-point scale: low (3–4), medium (5–7) and high (8–9). The first step involved scoring commodities with

Table 1. The five food groups in Ghana.

No	Food groups	Description/example
1	Tree crops	Coconut, Cocoa, Oil palm, Shea, Orange
2	Legumes	Beans, Groundnut, Cowpea, Soybean, Bambara beans, Peas
3	Cereals/grains	Maize, Sorghum, Millet, Fonio, Rice
4	Vegetables	Tomato, Okra, Chilli pepper, Bell peppers, Eggplant, African cucumber, Ginger, Onion, Shallot, Lettuce, Green beans, Cabbage
4	Fruits	Mango, Guava, Pawpaw, Cashew, Banana/plantain, Pineapple
5	Roots and tubers	Yam, Cassava, Sweet potatoes, Cocoyam (Taro), Potatoes

Source: Bandoh and Kenu (2017).

nutrition-improvement potential. All commodities that scored low were excluded while those that scored medium or high were selected to the next stage of scoring process. The rest of the commodities were scored based on market and income generation potential. Similarly, those that scored low were excluded and commodities rated medium and high were selected for the final stage of scoring. Lastly, the remaining commodities were scored based on potential for high postharvest losses and food waste. Again, commodities that had low scores were excluded while those with medium and high scores were selected for value chain intervention. To support the scoring, objective measures using production levels, energy contributions and GDP contributions, were also used to evaluate the potential of the crops under consideration.

3.2. Informed consent

Informed consent forms were presented and signed by all participants of the study in written form after they were made to fully understand the objectives of the study and that their participation was entirely voluntary. Participants were aware that they were free to skip any question(s) that they did not wish to answer, and that they could choose to withdraw from the study at any time without any consequences. Participants understood that their decision to participate or not will not affect their current or future relationship with any party.

3.3. Data collection

Expert interviews were conducted for relevant stakeholders in nutrition and agriculture sector. Interview guides were developed with a set of questions that focused on exploring how the selected value chains can be used to address the nutritional gaps in Ghana. The participants of the key informants interviews (KIIs) were purposively selected based on their knowledge in agriculture, nutrition and health issues in Ghana.

The participants of KIIs were (1) traders, buyers, lead farmers, and (2) government officials from agriculture departments, extension agents, agronomists and nutritionists. In all, a total of 20 lead farmers, 40 traders and 40 buyers were interviewed between October 2021 and March 2022. In addition, a representative of the Crop Services Division of the MOFA, one agronomist, one nutritionist and ten (10) extension agents were interviewed during the same period.

Ethical approval was obtained from the Ethics Review Committee of the University of Ghana, College of Basic and Applied Sciences, with approval number ECBAS 103/22-23. This study was conducted in adherence to the Declaration of Helsinki.

Table 1 shows the five food groups in Ghana and the foods categorized under them. These foods are the ones frequently cultivated and consumed in Ghana. Initially, 40 crops were shortlisted, based on a review of the commodity list of the five food groups in Ghana (Table 1). Subsequently, 27 crops were selected for value chain interventions.

4. Results and discussions

This section of the article delves into the comprehensive analysis of various value chains to identify their potential in enhancing food and nutrition security in West Africa. The selection process was thorough, incorporating a range of criteria to evaluate each value chain's nutritional, economic and social impact. Commodity scoring results for the value chain analysis are presented in Appendix A1.

4.1. Selection of potential value chains

The potential value chains were assessed based on multiple parameters, including nutritional content, yield potential, market demand, climate resilience and the involvement of smallholder producers. This holistic approach ensures that the selected value chains not only address nutrient gaps but also provide sustainable economic benefits to local communities.

4.1.1. Tree crop value chains

Cashew, oil palm and shea demonstrated significant potential for enhancing nutrition, whereas guava exhibited moderate potential for nutritional improvement. Despite favorable scores in various criteria, these commodities had lower ratings in terms of smallholder producer involvement. Although guava has high nutritional and income generation potential, it was rated low for market potential mainly due to low demand and profit margins. Coconut was not selected across criteria because of its very low postharvest loss; however, it has high nutritional, market, and income generational potential. The marketing of processed bananas and plantains is mainly performed by women. Farmers sell bananas and plantains to traders who distribute them in the market or to other small-scale traders. Although oranges and pawpaws had high nutrition improvement potential,

Table 2. Production, energy and GDP contribution of some crops in Ghana.

		Years			
		2010–2020		2020–2021	
SN	Commodity	Average production (tons)	Average energy (million kcal/year)	Contribution to GDP (USD) at exchange rate of 5.8 ghc to 1USD	Contribution to GDP (GHC)
Tree crops					
1	Coconut	407,085.70	195,459.18	4,945,697	28,234,266
2	Mango	95482.23	36,416.27	20,545,410	119,191,024
3	Pawpaw	5,364.48	674.67	723,864	4,247,440
4	Cashew	63,343.99	–	251,377,478	1,475,585,796
5	Banana/plantain	90,233.77	14,942.80	156,691	888,532
6	Cocoa	828,066.50	584.30	495,888,783	2,880,339,647
7	Oil palm	2,364,469.94		127,124,318	746,219,747
8	Shea	23,812.49	146,717.55	92,255,770	541,541,370
9	Rubber	199,128.15		73,599,142	432,026,964
10	Orange	459,973.83	206,115.17	510,209	2,887,196
11	Guava	89,859.36	36,416.81	328	1,860
12	Pineapple	495,972.18	138,713.38	8,785,492	51,046,566
Legumes					
1	Cowpea	198,582.11	2,296.52	32,800	192,536
2	Groundnut	469,375.89	613,868.20	20,742	118,499
3	Soybean	136,241.84	216.69	43	246
4	Bambara beans	205,811.29	–	39,908	229,764
5	Peas	0.18	26.62	2	12
Fruit crops					
1	Mango	95,482.23	36,416.27	20,545,410	119,191,024
2	Pawpaw	5,364.48	674.67	723,864	4,247,440
3	Banana/plantain	90,233.77	14,942.80	156,691	888,532
4	Orange	459,973.83	206115.17	510,209	2,887,196
5	Pineapple	495,972.18	138,713.38	8,785,492	51,046,566

they were found to have a low-income generation potential due to low profit margins. Oil palm and cashew were found to have high postharvest losses, whereas coconuts, cocoa and shea were rated low.

In summary, three commodities (cashews, oil palms and shea) demonstrated promising potential when assessed across all criteria.

Table 2 presents the production, energy and GDP contribution of some crops in Ghana for the years 2010–2020 and 2020–2021. Year by year data on the production, energy and GDP contribution of some crops in Ghana from 2010 to 2020 are presented in Appendix A2.

From the secondary data gathered (Table 2), it is seen that with a production level of 63,343.99 tons and a significant GDP contribution of $251,377,478 (GH₵1,475,585,796), cashew was identified as a high-potential value chain (MoFA, 2023). Although it had zero energy contribution in the data, its economic impact justifies its inclusion. Oil palm demonstrated the highest production at 2,364,469.94 tons and a GDP contribution of $127,124,318 (GH₵746, 219,747), highlighting its significant role in both nutrition and economy (MoFA, 2023). In the case of Shea, production levels stood at 23,812.49 tons and an energy contribution of 146,717.55 million kcal/year, according to MoFA (2023), and also had a notable GDP contribution of $92,255,770 (GH₵541,541,370), reinforcing its importance.

4.1.2. Legumes value chains

Cowpeas, ground nuts, soybeans and bambara beans were identified to be able to address key nutrient gaps. Although cowpeas and groundnuts are frequently consumed by households, soybeans and bambara are not frequently consumed. The demand for soybeans is mainly for industrial purposes, such as livestock feed and soybean oil. Soybeans are not commonly consumed directly because of their extended cooking time and distinct aroma. Nevertheless, soy cheese is enjoyed as a snack and soy milk is provided to children. Households have numerous traditional recipes that incorporate cowpeas, resulting in significant local demand. Furthermore, institutional buyers such as schools and prisons are present; however, smallholders are likely to rely on market intermediaries to access these markets. Storing commodities in these categories for extended periods can serve as lucrative income sources for farmers. Given the substantial involvement of women in production and processing, there is potential for enhancing nutrition and empowering women by granting them greater control over financial resources. However, considering that these commodities are viewed as profitable cash crops with significant local, national, and international demands, there is a potential concern that increased promotion could prompt households to prioritize selling them rather than fulfilling their own consumption requirements. Although the crop has high nutritional,

market and income generational potential, it also has high postharvest losses. Production involves fewer chemicals, thereby limiting potential food safety hazards. To promote these value chains, efforts must be made to reduce the quantity and economic loss through high postharvest losses. From Table 2, the legumes value chains were also evaluated using production levels, energy contributions and GDP contributions to determine their potential for addressing nutrient gaps. Cowpeas had a production level of 198,582.11 tons and an energy contribution of 2296.52 million kcal/year, with a GDP contribution of $32,800 (GH₵192,536) (MoFA, 2023). This highlights its local demand and nutritional value. Groundnuts showed the highest energy contribution among legumes at 613,868.20 million kcal/year from a production level of 469,375.89 tons (MoFA, 2023). Its GDP contribution was $20,742 (GH₵118,499) (MoFA, 2023).

4.1.3. Cereals and grains value chains

The results also revealed that maize, sorghum, millet, fonio and rice are consumed in adequate proportions; however, maize and rice are consumed in relatively large quantities compared to other cereals. Rice, maize, sorghum and millet are primarily produced for domestic consumption at the household level. Enhancing nutrition can result from direct consumption and empowerment of women, given their pivotal role in processing these commodities. Current traditional recipes can be promoted to increase local demand for crops. High industrial interest and upgrading of sorghum as a product is processed into malt. These commodities experience substantial demand at the local, national and international levels, indicating considerable potential for income generation. Additionally, farmers can readily store these commodities for extended periods, allowing them to capitalize on seasonal price increases. These crops are rated high for postharvest losses. Both quantity and economic losses are high; therefore, efforts must be made to address these losses. Although maize and rice are cultivated in all ecological zones, sorghum and millet are grown mainly in northern Ghana. Private sector interest is very high in maize, mainly for processing corn flour and poultry feed. In summary, all crops in this category were selected across the criteria as having great potential to be evaluated. Maize, a staple in many diets, had substantial production levels and energy contributions, making it essential for both direct consumption and economic impact (Ntiamoah et al., 2022). Rice showed high production and consumption rates, indicating its crucial role in household nutrition and market demand. Sorghum and Millet had significant production levels and were important for both local consumption and industrial processing into products like malt.

4.1.4 Vegetables value chains

Tomato, okra, chilli pepper, eggplant, ginger, lettuce, green beans and cabbage are highly consumed and have medium nutritional improvement potential. They are rich sources of vitamins and minerals such as vitamin A (vision/cell health), vitamin C (cellular health/iron absorption), folate, vitamin K, vitamin E and iron as well as other micronutrients that are essential for a healthy life. These vegetables are widely consumed and are commonly found in many local dishes. Lettuce and green beans were eliminated because of their low consumption, and households consumed them infrequently. Pepper and tomatoes were found to have nutritional and income generation potential, mainly due to high household consumption and engagement by smallholder farmers. The production and processing of these crops are mainly performed by women. With regard to private sector interest and upgrading, tomatoes, okra, chilli peppers, ginger, onions and shallots are rated high. Tomatoes, chilli peppers and onions were noted to have high market potential. There is high local demand and international markets for crops. These vegetables, especially tomatoes, have been found to have high postharvest loss. The primary contributors to these substantial postharvest losses include (1) inappropriate harvest timing, (2) unanticipated harsh climatic conditions and environmental factors, (3) insect and pest infestations, (4) suboptimal harvest and handling practices, (5) challenges related to infrastructure and marketing and (6) a deficiency in storage facilities. In total, eight commodities (tomato, chilli pepper, cabbage, ginger, onion, shallots, egg plants and okra) were selected out of the initial 12 crops. Interventions in these value chains must focus on increasing production, adding value and reducing postharvest losses.

4.1.5. Fruits value chain

Orange and pineapple demonstrated a high potential for nutritional enhancement, while mango and banana/plantain had medium nutritional improvement potential. In addition, mangoes were found to have high private sector interest, while other crops in this category, with the exception of shea, were rated as medium. Modern fruit processing companies

buy mangoes and process them into juice, cut and dried fruits for local markets and exports. However, pineapple, orange, banana/plantain and mango were found to have high postharvest losses. All crops (mango, pineapple, orange and banana/plantain) in this category were selected. However, intervention in these value chains must aim to reduce the postharvest loss of these commodities. According to MoFA (2023), production of banana/plantain, mango, orange and pineapple stood at 110,233.77, 101,573.24, 698,216.75 and 679,191 tons, respectively in 2022. They contributed significantly to GDP as well as energy in million kcal/year. These numbers, according to MoFA (2023), were 844.87, 39416.23, 213,115.87 and 157,713.78 million kcal/year, respectively for these crops.

4.1.6. Roots and tubers value chains

Yam, cassava, sweet potato, cocoyam and potatoes have medium nutritional improvement potential. The low involvement of smallholder producers and limited employment generation potential led to the exclusion of cocoyams and potatoes. Cassava and yams are frequently consumed by households in Ghana. Cassava flour and dough derived from processed products are marketed in local and district markets. Small-scale processing is performed for both personal and commercial sales. Private sector engagement is also high in processing cassava into cassava flour and starch for industrial purposes. Cassava is processed into fufu, banku and kokonte for local consumption. The local demand for yams and cassava is very high. However, yam and cassava were found to have high postharvest losses. Interventions in these value chains must aim to increase production at the farm level and encourage the private sector to add cassava to its industrial products. For nutritional value, intervention should be advocated for the cultivation of biofortified cassava varieties with yellow flesh, as they contain high levels of beta-carotene, which is essential for vitamin A production.

4.2. Suggestions for potential interventions for specific value chains

The following outlines the suggested interventions aimed at cultivating more NSVCs derived from the analysis of the value chain. These interventions focused on potential innovations in supply and demand to ensure a ready market for nutritionally enhanced food products in Ghana.

(1) Devise and execute trials for complementary infant food formulations, utilizing a nutritionally balanced blend of locally accessible foods. The examined commodities encompass the essential nutrients needed to create a well-balanced food suitable for infants aged 6 months and older. Legumes such as soybeans, fruits and vegetables contain a wide variety of nutrients, such as proteins, that can be used to formulate children's food. In addition, roots and tubers, such as cassava and potato leaves, contain minerals and vitamins. Testing of potential formulations will be conducted to assess their nutritional adequacy and acceptability among infants and mothers.

(2) Develop and promote nutritional supplementary and snack foods for school children. The intervention seeks to provide healthy alternatives to the currently consumed commercially manufactured snacks. These alternative food products will be tested for both nutritional content and consumer acceptability. These could include expansion and production and processing of certain commodities, as identified as having potential for nutritional improvement. This could have a significant impact on the empowerment of local women.

(3) Create and advocate for nutritional supplementary and snack foods designed for school children. This initiative aims to offer wholesome alternatives to the commercially available and widely consumed snacks currently in the market. However, this intervention focuses mainly on local markets. There will be a focus on promoting food preparation methods that preserve the nutritional value and enhance food safety. Pregnant and lactating mothers were targeted for this intervention. Provision of nutritional information for various food products will be displaced to encourage consumers to increase demand for such products.

(4) Mitigate food loss and enhance safety by implementing upgraded storage facilities and practices. Implementing economical storage solutions could benefit small-scale producers and processors by allowing them to preserve harvested raw produce until market prices are favorable. This is particularly crucial in the face of climate change, which introduces greater variability in weather conditions, rendering traditional storage methods less effective. Technological advancements should also address the management of food safety and the preservation of nutritional value. This intervention targets fruits and vegetables, roots and tubers to reduce postharvest loss.

5. Conclusions and recommendations

The findings of this research offer insights and suggestions to the government, producers, businesses and NGOs regarding methods to enhance nutrition in Ghana by fostering the development of nutrition-sensitive value chains. Approximately 40 different food crops, categorized into five food groups: tree crops, legumes, cereals/grains, fruits and vegetables, roots and tubers, were initially selected for the study. Situation analysis was conducted for all crops to gain information on the current production, supply, demand, nutritional gaps, income generation and market potential of these value chains. The postharvest and food loss levels of these crops were also analyzed.

A NSVC approach was employed in this study. This approach creates possibilities to improve the nutritional content, boost the availability and demand for safe and varied foods, and contribute to nutritional enhancement. To address prevailing challenges in nutrition and food security, it is necessary to enhance the entire process of food production, processing, distribution, marketing and delivery to consumers. These collective activities constitute the value chain. Examining each stage in the value chain for a particular commodity allows the implementation of interventions to tackle challenges and enhance the responsiveness of the value chain to nutritional issues. This is especially true for optimizing diet.

The methodology employed in this study consists of four consecutive steps: strategically crafted to guarantee that selected commodities and proposed interventions for value chain development accurately address nutrition issues associated with diet. These steps were as follows: Recognize the Nutrition Issue: Identify deficiencies in nutrient intake linked to dietary patterns. Opt for Commodities: Select items that not only address the nutritional gaps but also demonstrate economic viability, indicating a promising potential for the development of an (NSVC). Analyze the Value Chain with a Nutrition Lens: Analyze the nutritional aspects of the chosen commodities within the value chain, pinpoint limitations and opportunities, and evaluate investment potential. Identification of possible interventional strategies. Identify options for interventions that can effectively address the identified constraints and capitalize on opportunities within the value chain. Value chains in Ghana were chosen considering their economic value, capacity for income generation, nutritional importance and the likelihood of experiencing significant postharvest losses and food waste.

In all, 27 crops were selected for value chain interventions. Mango, cashew, oil palm, banana/plantain, shea and pineapple were selected as tree crops. Cowpea, groundnut, soybeans and Bambara beans were selected as legumes, whereas maize, rice, sorghum, millet and fonio were selected as cereals. Cabbage, ginger, onion, shallot, eggplant, chilli pepper, okra and tomato were also selected for the vegetable and fruit categories. Finally, yam, cassava and sweet potatoes were selected as the root and tuber crops. The selection of these commodities from their food groups are consistent with previous studies that sought to select commodities using the nutritive-sensitive value chain approach. These studies include de Jager et al. (2023); FAO (2022); Nguyen et al. (2022) and De la Peña et al. (2018).

These selected commodities have high nutritional and economic values and therefore the potential of addressing identified dietary gaps and improving the income and livelihoods of farmers. Strengthening the value chains of these selected commodities will result in food and nutrition security. This selection gives a scientific basis for research that is need-based and impact-driven. It also ensures that the acceptability of beneficiaries (farmers in particular) is guaranteed because of the inclusive approach used.

Based on the findings of this study, the following interventions are recommended: First, we recommend formulating and implementing trials for complementary infant food utilizing a nutritionally balanced blend of locally available ingredients. Additionally, we suggest creating and promoting nutritional supplements and snack foods for school children. Furthermore, it is advisable to implement nutritional education and behavior-change communication campaigns to support this initiative. Finally, we suggest directing efforts towards minimizing food loss and enhancing food safety through the utilization of improved storage facilities and practices.

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Authors' contribution

All coauthors of this article reviewed the final version and approved the manuscript for submission. The detailed contributions of all authors of this manuscript are listed below:

Contribution of authors		
No	Name of author	Role
1.	Freda Elikplim Asem	• Conceptualization and design • Methodology • Data collection/investigation • Formal analysis and interpretation • Original draft preparation • Review and editing • Final approval of the version to be published
2.	Selorm Ayeduvor	• Methodology • Data collection/investigation • Formal analysis and interpretation • Original draft preparation
3.	Firibu K. Saalia	• Funding acquisition • Original draft preparation • Review and editing
4.	Matilda Steiner-Asiedu	• Conceptualization and design • Original draft preparation • Review and editing
5.	Nicole Sharon Affrifah	• Conceptualization and design • Methodology • Original draft preparation • Review and editing
6.	Angela Parry-Hanson Kunadu	• Conceptualization and design • Original draft preparation
7.	Emmanuel Essien	• Original draft preparation

Disclosure statement

The authors declare no conflicts of interest.

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Data availability statement

The data that support the findings of this study are available from the corresponding author, FEA, upon reasonable request.

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Appendix A1: Commodity scoring for value chain analysis

A1.1. Tree crops

Scoring on nutrition improvement potential

S.No.	Commodity	Food consumption (1–3)	Food preference (1–3)	Food composition (1–3)	Total score (3–9)	Justification/ comments
1	Coconut	2	2	1	5	
2	Mango	2	2	2	6	
3	Pawpaw	3	2	1	6	
4	Cashew	3	2	2	7	
5	Banana/plantain	1	3	2	6	
6	Cocoa	1	2	2	5	
7	Oil palm	2	3	2	7	
8	Shea	3	2	3	8	
9	Rubber	2	1	1	4	
10	Orange	1	3	3	7	
11	Guava	3	1	2	6	
12	Pineapple	1	3	3	7	

Scoring on income-generation potential

S.No.	Commodity	Level of engagement of smallholder producers (1–3)	Margins (1–3)	Employment generation (1–3)	Total score (3–9)	Justification/ comments
1	Coconut	1	3	2	6	
2	Mango	1	2	3	6	
3	Pawpaw	1	1	2	4	
4	Cashew	2	2	2	6	
5	Banana/plantain	3	2	2	7	
6	Cocoa	3	3	2	8	
7	Oil palm	2	2	3	7	
8	Shea	2	2	3	7	
9	Rubber					
10	Orange	3	1	2	6	
11	Guava	1	1	3	5	
12	Pineapple	3	2	3	8	

Scoring on market potential

S.No.	Commodity	Market demand (1–3)	Private-sector interest and upgrading (1–3)	Agroecological zones	Total score (3–9)	Justification/ comments
1	Coconut	3	3	2	8	
2	Mango	3	3	3	9	
3	Pawpaw					
4	Cashew	3	2	2	7	
5	Banana/plantain	3	3	2	8	
6	Cocoa	3	2	1	6	
7	Oil palm	3	2	2	7	
8	Shea	3	2	1	6	
9	Rubber					
10	Orange	2	2	2	6	
11	Guava	1	1	2	4	
12	Pineapple	3	3	2	8	

Scoring on Postharvest Loss

S.No.	Commodity	Quantity loss (%) (1–3)	Economic loss (%) (1–3)	Food safety (1–3)	Total score (3–9)	Justification/ comments
1	Coconut	1	1	2	4	
2	Mango	3	3	3	9	
3	Pawpaw					
4	Cashew	2	2	3	7	
5	Banana/plantain	3	3	3	9	
6	Cocoa	1	1	2	4	
7	Oil palm	2	2	3	7	
8	Shea	1	1	3	5	
9	Rubber					
10	Orange	3	3	3	9	
11	Guava					
12	Pineapple	3	3	2	8	

A1.2. Legumes

Scoring on nutrition improvement potential

S.No.	Commodity	Food consumption (1–3)	Food preference (1–3)	Food composition (1–3)	Total score (3–9)	Justification/ comments
1	Cowpea	1	3	3	7	
2	Groundnut	1	3	2	6	
3	Soybean	3	1	3	7	
5	Bambara beans	2	2	3	7	
6	Peas	2	2	2	6	

Scoring on income-generation potential

S.No.	Commodity	Level of engagement of smallholder producers (1–3)	Margins (1–3)	Employment generation (1–3)	Total score (3–9)	Justification/ comments
1	Cowpea	3	2	2	7	
2	Groundnut	2	2	2	6	
3	Soybean	1	3	2	6	
4	Bambara beans	1	2	2	5	
5	Peas	1	1	2	4	

Scoring on market potential

S.No.	Commodity	Market demand (1–3)	Private-sector interest and upgrading (1–3)	Agroecological zones (1–3)	Total score (3–9)	Justification/ comments
1	Cowpea	3	2	3	8	
2	Groundnut	2	2	3	7	
3	Soybean	3	3	1	7	
4	Bambara beans	2	1	2	5	
5	Peas					

Scoring on postharvest Loss

S.No.	Commodity	Quantity loss (%) (1–3)	Economic loss (%) (1–3)	Food safety (1–3)	Total score (3–9)	Justification/ comments
1	Cowpea	2	2	2	6	
2	Groundnut	2	2	2	6	
3	Soybean	3	2	2	7	
4	Bambara beans	2	2	2	6	
5	Peas					

A1.3. Fruit crops

Scoring on nutrition improvement potential

S.No.	Commodity	Food consumption (1–3)	Food Preference (1–3)	Food composition (1–3)	Total score (3–9)	Justification/ comments
1	Mango	2	2	1	5	
2	Pawpaw	2	2	2	6	
3	Banana/plantain	3	2	1	6	
4	Orange	3	2	2	7	
5	Pineapple	1	3	2	6	

Scoring on income-generation potential

S.No.	Commodity	Level of engagement of smallholder producers (1–3)	Margins (1–3)	Employment generation (1–3)	Total score (3–9)	Justification/ comments
1	Mango	1	3	2	6	
2	Pawpaw	1	2	3	6	
3	Banana/plantain	1	1	2	4	
4	Orange	2	2	2	6	
5	Pineapple	3	2	2	7	

Scoring on market potential

S.No.	Commodity	Market demand (1–3)	Private-sector interest and upgrading (1–3)	Agroecological zones	Total score (3–9)	Justification/ comments
1	Mango	3	3	3	9	
2	Pawpaw					
3	Banana/plantain	3	3	2	8	
4	Orange	2	2	2	6	
5	Pineapple	3	3	2	8	

Scoring on Postharvest Loss

S.No.	Commodity	Quantity loss (%) (1–3)	Economic loss (%) (1–3)	Food safety (1–3)	Total score (3–9)	Justification/ comments
1	Mango	1	1	2	4	
2	Pawpaw	3	3	3	9	
3	Banana/plantain					
4	Orange	2	2	3	7	
5	Pineapple	3	3	3	9	

Appendix A2: Production, energy and GDP contribution of some crops in Ghana

		Production (tons)										
		Year										
S.No.	Commodity	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Tree crops												
1	Coconut	292,000	344,000	345,000	366,183	380,380	380,380	456,000	460,800	474,000	484,800	494400
2	Mango	80,000	85,000	90,000	95,460	99,358	99,358	99,358	99,344.3	99,040.83	101,812.07	101573.28
3	Pawpaw	4500	4800	5000	5348	5561	5561	5561	5744.21	5622.07	5642.43	5669.57
4	Cashew	32,638.02	36,000	40,000	42,000	50,000	50,000	78,268	90,000	102,531	85,962	89384.9
5	Banana/ plantain	70,000	75,000	80,000	84,240	87,505	87,505	87,505	93,181.83	99,082.57	106,000	110233.8
6	Cocoa	63,2037.4	700,020	879,348	835,466	858,720	858,720	858,720	969,300	904,700	811,700	800000
7	Oil palm	2,004,300	2,125,600	2,196,100	2,326,920	2,443,270	2,443,000	2,443,000	2,485,557	2,543,860	2,490,806	2506741
8	Shea	36,686.71	32,655	33,310	33,630	34,300	34,300	34,300	33,782.67	33,442.38	33,865.72	33794.53
9	Rubber	20,150	20,185	20,200	21,440	22,427	22,427	22,427	37,000	41,300	42,200	69000
10	Orange	580,000	600,000	625,000	663,170	690,130	690,130	690,130	703,776.4	694,678.8	696,195.1	698216.8
11	Guava	80,000	85,000	90,000	95,460	99,358	99,358	99,358	99,344.3	99,040.83	101,812.07	101573.28
12	Pineapple	500,000	550,000	600,000	636,540	661,500	661,500	661,500	675,933.8	686,872	674,768.6	679191.5
Legumes												
1	Cowpea		236,679	223,253	200,400	201,260	203,320	206,380	211,470	237,000	254,000	257000
2	Groundnut	530,887	465,103	475,056	408,814	426,280	417,198.5	425,824.8	433,771.9	521,032.1	563,000	565000
3	Soybean	530,887	465,103	475,056	408,814	426,280	417,198.5	425,824.8	433,771.9	521,032.1	563,000	565000
4	Bambara beans	188,082.2	191,977.9	223,200	200,400	201,150	201,150	143,216.1	170,490.3	176,671.8	190,580.7	195328.6
5	Peas	0.73	0	0	0	0	0	0.13	1	0.1	0	0.066
Fruit crops												
1	Mango	80,000	85,000	90,000	95,460	99,358	99,358	99,358	99,344.3	99,040.83	101,812.07	101573.28
2	Pawpaw	4500	4800	5000	5348	5561	5561	5561	5,744.21	5622.07	5642.43	5669.57
3	Banana/ plantain	70,000	75,000	80,000	84,240	87,505	87,505	87,505	93,181.83	99,082.57	106,000	110233.8
4	Orange	580,000	600,000	625,000	663,170	690,130	690,130	690,130	703,776.4	694,678.8	696,195.1	698216.8
5	Pineapple	500,000	550,000	600,000	636,540	661500	661,500	661,500	675,933.8	686,872	674,768.6	679191.5
		Energy contribution (million kcal/year)										
		Year										
S.No.	Commodity	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Tree crops												
1	Coconut	117,795.6	146,536	143,612.8	158,863.4	179,453.3	165,138.9	158,118.6	159,447.4	151,332.3	154,929.2	205459.1
2	Mango	31,897.28	33,798.34	35,520.62	37,615.89	39,469.79	39,358.27	39,406.23	35,641.49	40,242.41	355,33.56	39416.23
3	Pawpaw	1109.53	1183.5	1129.21	1068.09	867.91	1020.44	1243.39	1062.29	1,181.35	998.64	844.87
4	Cashew											
5	Banana/ plantain	35,008.51	30,830.01	44,552.74	48,112.36	20,912.66	19,150.14	14,191.58	0	0	0	14342.8
6	Cocoa	690.5	821.76	482.6	592.8	553.49	0	487.11	497.84	765.82	992.44	548.42

		Energy contribution (million kcal/year)										
		Year										
S.No.	Commodity	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
7	Oil palm											
8	Shea	36,686.71	32,655	33,310	33,630	34,300	34,300	34,300	33,782.67	33,442.38	33,865.72	33794.53
9	Rubber											
10	Orange	177,476.5	184,145.3	191,529.6	203,128	211,207.5	212,370.1	211,940	215,328.1	231,169.7	212,356.8	213115.9
11	Guava	31,897.28	33,798.34	35,520.62	37,615.89	39,469.79	39,358.27	39,406.23	35,641.49	40,242.41	35,533.56	39416.23
12	Pineapple	118,426.5	120,904	143,190	151,882.5	157,623.2	152,822.8	159,667.7	154,504.9	167,593.5	156,511.8	157713.8
Legumes												
1	Cowpea		6297.6	5940.36	4870.59	2521.04	2578.89	2637.48	3623.78	2756.49	2829.42	2880.29
2	Groundnut	875363.7	799,146	854,800	705,568.4	801,102.3	728,422.9	743,424.5	754,556.9	90,9735.9	807,207.6	605558.8
3	Soybean	466.41	525.24	483.22	441.45	225.33	230.84	236.36	242.99	241.68	257.24	276.74
4	Bambara beans											
5	Peas	19.82	78.69	0	9.51	13.82	7.16	22.91	69.51	27.35	9.6	33.89
Fruit crops												
1	Mango	31,897.28	33,798.34	35,520.62	37,615.89	39,469.79	39,358.27	39,406.23	35,641.49	40,242.41	35,533.56	39416.23
2	Pawpaw	1109.53	1183.5	1129.21	1068.09	867.91	1020.44	1243.39	1062.29	1181.35	998.64	844.87
3	Banana/ plantain	35,008.51	30,830.01	44,552.74	48,112.36	20,912.66	19,150.14	14,191.58	0	0	0	14342.8
4	Orange	177,476.5	184,145.3	191,529.6	203,128	21,1207.5	212,370.1	21,1940	215,328.1	231,169.7	212,356.8	213115.9
5	Pineapple	118,426.5	120,904	143,190	151,882.5	157,623.2	152,822.8	159,667.7	154,504.9	167,593.5	156,511.8	157713.8