



# Putting consumers first in food systems analysis: identifying interventions to improve diets in rural Ghana

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## Abstract

A critical, yet underexplored, dimension of food systems is how consumer food preferences and beliefs interact with the food environment. We present a consumer-centered approach to identifying options for improving diets. The Value Chains for Nutrition (VCN) mixed-methods multi-disciplinary analytical approach was applied in rural Ghana. Data from in-depth consumer interviews, structured vendor interviews, and (secondary) household consumption surveys were analyzed to assess consumer diet patterns, related norms and preferences, and supply and demand characteristics of a set of empirically defined high-potential nutritious foods. Mapping results onto a supply–demand typology, we identify promising interventions to support increased availability, access, and affordability of these foods. Consumption data suggested that diets among Ghanaians were deficient in key micronutrients and calories. Fresh nutritious fruits and vegetables tended to be grown for home consumption rather than sale due to transportation challenges and seasonality of demand, especially near rural markets. Seasonal availability (fruits and vegetables) and affordability (animal foods) severely limited consumption of many nutritious foods. A set of supply, demand, and value chain interventions to enhance availability and affordability of nutritious foods are presented. Critical to success is to consider the set of interventions along each value chain required for impact.

**Keywords** Food systems · Diets · Nutrition · Ghana · Value chains · Food environment · Consumers

## 1 Introduction

Almost 20% of deaths worldwide are attributed to unhealthy diets, according to the Global Burden of Disease study, (GBD 2017 Diet Collaborators, 2019). A food-systems perspective for nutrition is a powerful approach for considering dietary challenges, considering the complexity of factors that determine diets. The food system encompasses all the elements—people, activities, processes, infrastructures, and

institutions—that relate to the many processes and activities in the production, processing, distribution and marketing of food (Global Panel on Agriculture & Food Systems for Nutrition, 2016; HLPE, 2017). Research has explored food systems from various angles, including food access to healthy foods (food desserts), consumer preferences, climate change, and value chains, among others. Most of this work has focused on interactions between farmers, consumers, and businesses (processors and retailers) in the Global North.

Food value chains (FVC) bring together the actors, activities, and relations involved in bringing food to consumers, and thus form a core component food systems (Morgan et al., 2019). While FVC assessments have traditionally been applied to support the participation of small-scale producers and businesses to alleviate poverty, they are also central to determining food availability, affordability, and quality and are increasingly seen as an important mechanism for improving nutrition. However, most studies linking FVCs to nutrition objectives (often referred to as nutrition-sensitive value chains (NSVC)) focus on a single food commodity rather than considering the basket of foods that comprise the diet and might contribute to nutritional improvement and

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the extent to which focus on one food could promote unintended substitutions or displacements (Morgan et al., 2019; Nicholson et al., 2021; Ridoutt et al., 2019). Furthermore, even when nutritious food is available and affordable, the socio-cultural drivers that mediate food choices are critical for promoting diet change and these factors have been largely overlooked in NSVC approaches (Morgan et al., 2019; Nicholson et al., 2021; Ridoutt et al., 2019).

This study applied the value chains for nutrition (VCN) diagnostic framework presented in Gelliet al. (2015) to rural food systems in Ghana. We present an in-depth analysis of the drivers of food choices among rural Ghanaian consumers, including socio-cultural factors, personal preferences and conventions, and characteristics of the food-market environment (such as convenience, availability, and affordability). We demonstrate how this analysis can be used to diagnose the opportunities for and constraints to improving consumption of a set of preferred nutritious foods, and, finally, to lay out a set of high potential food system interventions for improving diets.

### 1.1 Value chains for nutrition (VCN) approach for identifying food systems interventions

The value chains for nutrition (VCN) approach highlights the interplay and interrelatedness of FVCs, consumer characteristics, and the food environment. The food environment mediates the acquisition of food within the broader food system. It refers to the set of structures (physical, social, institutional, etc.) and conditions that determine physical access, affordability, marketing, safety, and quality of food, thus shaping and constraining people's dietary choices (HLPE, 2017). For most rural communities, the food environment consists of the foods they produce or gather, as well as the foods they can purchase from local markets (Downs et al., 2020).

The food environment interfaces with a vast set of consumers characteristics to determine food choice (Gissing et al., 2017; Monterrosa et al., 2020; Pitt et al., 2017; Sobal & Bisogni, 2009). The literature suggests that important market environment characteristics have been found to constrain nutritious food consumption, including availability, access (including seasonal shortages and distance or time required to acquire foods), affordability, and diversity of food choices, marketing, and product placement (Downs et al., 2020; Drewnowski et al., 2020; Gissing et al., 2017; Ridoutt et al., 2019). A conceptual framework for food environment research in low- and middle-income countries (LMICs) distinguishes between exogenous dimensions of the food environment (e.g., presence of food and market prices) and the those relative to the individual (e.g., mobility, preferences, and purchasing power) (Turner et al., 2018, 2020).

The latter individual (or personal) characteristics interface with socio-cultural factors to drive food choices and thus are critical to consider when deliberating diet-related policies or interventions (Monterrosa et al., 2020; Morgan et al., 2019; Pitt et al., 2017; Ridoutt et al., 2019). In spite of the documented importance of consumer characteristics-and socio-cultural factors in particular-many authors argue that too few studies give sufficient attention to these issues (Monterrosa et al., 2020; Morgan et al., 2019; Pitt et al., 2017; Ridoutt et al., 2019).

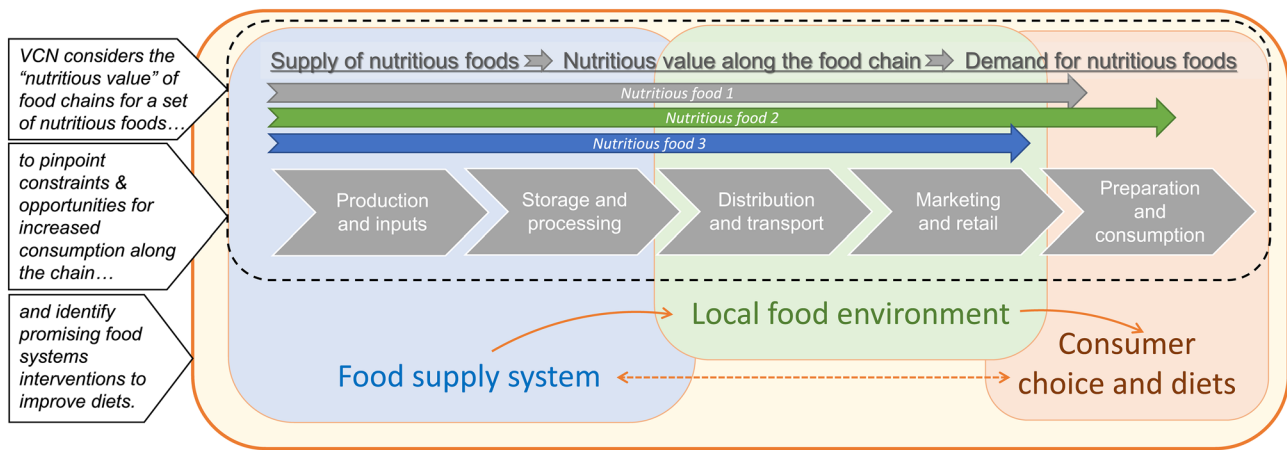
A number of studies use a FVC approach to design or assess nutrition-focused interventions and policies. FVCs are a useful way to conceptualize the series' of activities, embedded within the broader food system, by which food moves through the food system to reach consumers (Morgan et al., 2019; Ridoutt et al., 2019). However, most of these studies consider the value chain of a single product or product family (Morgan et al., 2019; Nicholson et al., 2021). While valuable, this approach can miss out on benefits and complementarities of considering multiple nutritious foods or fail to consider unintended effects of substitution (Morgan et al., 2019).

The VCN analytical approach to identifying food systems interventions to support nutrition was laid out in Gelliet al. (2015) and applied initially in Gelli et al. (2018). The method was designed for analysis of food systems in LMICs, emphasizing both natural and built food environments and tradeoffs and complementarities across FVC. This study builds on Gelli et al. (2018), adapting the method to more strongly center on consumer perceptions and preferences.

The VCN approach adapted for this study is presented in Fig. 1. Areas of inquiry follow the linear steps in a value chain-production through consumption-and can be (imperfectly) mapped to three core components of the food system: the food supply system, the local food environment, and consumer choice and diets (Global Panel on Agriculture & Food Systems for Nutrition, 2016; HLPE, 2017). However, the complexity of the set of options and constraints faced by the study population-rural Ghanaian consumer-producers-highlights the need for a systems perspective that allows for interactions and nonlinearities among value chain actors and activities. Because consumers in this context are also producers and, at times, market vendors, the interconnectedness between food production and consumption decisions is demonstrated by a two-way arrow.

### 1.2 Country context

Over the last decade in Ghana economic growth has coincided with decreased undernutrition and poverty. However, important disparities are evident, between rural and urban



**Fig. 1** Value chains for nutrition (VCN) approach for identifying food systems interventions (Adapted from Gelli et al., 2015; HLPE, 2017; De La Peña et al., 2018)

populations and northern and southern regions, in terms of poverty, food insecurity, and undernutrition. In addition, the emerging problem of health risks associated with rising overweight and obesity are a cause for concern. The prevalence of child stunting in Ghana fell from 28.1 percent in 2008 to 18.8 percent in 2014 (Ghana Statistical Service, Ghana Health Service, and ICF International, 2015). However, stunting declined much more slowly in rural areas (20.3% versus 13.9% in 2014) and is concentrated in the northern regions. Furthermore, The prevalence of overweight among adults was 14.3% nationally and 24.7% among women in 2017 (University of Ghana et al., 2017). While currently concentrated in urban populations (19.8% versus 9% in rural areas), growing incomes, mechanization, and access to processed foods may begin to shift more of the burden to rural populations globally and in Ghana (NCD Risk Factor Collaboration, 2019).

Despite regional diversity in nutrition outcomes, there is evidence that poor consumers throughout Ghana lack access to fresh and diverse of food. Ghana’s rural populations are predominantly engaged in semi-subsistence agriculture on small plots, reliance on seasonally limited own-production to access a diverse basket of foods, especially for remote households (Ecker, 2018; Jayne et al., 2016; Signorelli et al., 2017). Despite a growing urban middle class and associated demands for food products, resource-poor small-holder farmers are not well integrated into growing food markets. Urban diets are increasingly made up of processed and imported food products due to changing food preferences as well as an inability of local producers to meet urban demand (Andam et al., 2018; Ragasa et al., 2019). And for the urban poor, the built environment limits regular access to fresh nutritious foods (Aryeetey et al., 2016).

## 2 Methodology

Food systems are multi-dimensional and complex and their analysis benefits from a multi-disciplinary and mixed methods approaches (Turner et al., 2018). A critical realist research paradigm allows us to integrate data sources and analyses, assess the relationships between factors under analysis, and generate theory-related and context-based explanations of food systems and diets (Modell, 2009; Shannon-Baker, 2016).

We utilize nationally representative secondary data on household food consumption to understand diet patterns and potential gaps in nutritious food consumption. Primary data collected from consumer-producers (48 in-depth interviews) and food and market vendors (109 structured interviews) make up the core of the analysis of the food supply system, the local food environment, and consumer food choice.

### 2.1 Sampling and data

Primary data were collected in eight study sites across four regions. In line with a purposive maximum variation sampling (Marshall, 1996), the study sites represent a diversity of nutrition situations, agro-ecological zones, and major ethnic groups in Ghana. Four target regions were chosen to represent a diversity of agroecological and ethnic affiliations-Ashanti (Semi-deciduous forest; Ashanti people), Central (Coastal savanna; Fanti people), Oti (Semi-deciduous forest/Savanna; Ewe people), and North-East (Guinea savanna; Bimoba and Mamprusi people). A sub-sample of communities was randomly chosen from the respondents of a previously completed survey to support sample variation and

mitigate bias (Gelli et al., 2019). Within each region, two communities were sampled: one remote (defined as distance to market greater than the mean for the region) and one central (distance less than the mean for the region).

Households within the communities were sampled purposively based on a number of factors from the survey data in line with a maximum variation sampling approach. The factors considered include: household expenditures; size of land holdings; ages of heads of household; structure of household to include single-adult headed, dual-adult headed, and polygynous households.

48 IDIs were completed, with 28 women and 20 men. The interview instrument included detailed modules with open-ended questions on: preferred foods and eating patterns across seasons; perceptions of nutritious foods; food sharing and allocation; constraints to eating preferred foods; purchase of preferred foods; foods produced and either consumed or sold; household decision-making related to food production; and women's role in marketing of food crops.

Food sellers sampling was based on IDI responses on commonly patronized food outlets/sellers. They included community kiosks and food sellers and a key traditional market for each community. Structured food seller interviews asked a mix of open and closed questions about changes in prices and sales of PNFs throughout the year, value addition activities, main buyers, main sources of produce, and business challenges/expenses. When possible, at least two vendors within each food category (fruits, vegetables, legumes, meat/fish, and packaged foods) were interviewed. In total, 17 local food sellers and 92 market vendors were interviewed. Sample characteristics are presented in Table 1.

Data were collected from July–September 2018. Except the principal investigator, the research team was Ghanaian and trained in qualitative data collection approaches. Interviews were facilitated in the language most comfortable for the respondent. Interviews led by the principal investigator made use of translators.

## 2.2 Analysis

Data from IDIs were translated, transcribed, and thematically coded using NVivo 12. After an initial coding pass, a set of predetermined codes were applied to the data. Next, codes were organized according to common emergent themes within and across communities. Framework matrices were used for thematic and explanatory analysis. When necessary, data were recoded as the analytical framework evolved. Structured market interview responses were captured in notes templates and subsequently typed in MS Excel. These responses were collated, and patterns of responses were summarized by market and by food type.

To select a basket of foods with high potential to improve diets, we triangulated analyses on food preferences and availability in local food environments for foods rich in missing nutrients, yielding a list of commonly preferred nutritious foods (PNFs). These foods are presented with their key nutrients in Annex 1, Table 2 and used to determine which foods to prioritize in the analysis.

The secondary data analysis draws from a survey of 2,166 households across all regions of Ghana conducted in March 2016 as part of an impact evaluation of the national school feeding program (Gelli et al., 2019). The survey included a module on a seven-day recall of household consumption and expenditures that was used to provide a breakdown of food and nutrient consumption shares. The nutritional content of individual foods was estimated by using the West African Food Composition Table (FCT) (Stadlmayr et al., 2012). Food quantities consumed were multiplied by conversion factors from the FCT to allow the estimation of nutrient availability by adult equivalent, a proxy indicator for nutrient intake (Fiedler et al., 2012). We employed the recommended daily nutrient requirements for both macro- and micronutrients as published in WHO/FAO guidelines (FAO, 2004; WHO & FAO, 2004, 340–342). We first estimated household requirements by nutrient, using household

**Table 1** Respondent characteristics

	In-depth interviews			Market interviews		
	N	Age (mean)	Female (share)	N	Female (share)	
	48	47.4	0.58	Market vendors	92	0.95
				Local food sellers	17	0.77
<b>Household structure (share)</b>						
<i>Female headed</i>		0.10				
<i>Dual headed</i>		0.69				
<i>Polygynous</i>		0.19				
<i>Sole male head</i>		0.02				

demographics and nutrient requirements by age and gender, adjusting for low to moderate bioavailability for iron and zinc. We then estimated the mean adequacy ratio (MAR), or in this case the nutrient availability adequacy of household food consumption, by dividing the household level nutrient availability from food consumed, by the household level requirements (Fiedler et al., 2012). This analysis also allowed for the identification of the contributions to nutrient intake from the different foods. The analysis of food consumption and nutrient availability/access patterns at household level can also provide some insights on the potential nutrient gaps in dietary intake. For this purpose we employed the recommended daily nutrient requirements for both macro- and micronutrients as published in WHO guidelines. We first estimated household requirements by nutrient, using household demographics and nutrient requirements by age and gender. We then estimated the nutrient availability adequacy of household food consumption by dividing the household level nutrient availability from food consumed, by the household level requirements.

### 2.3 Limitations

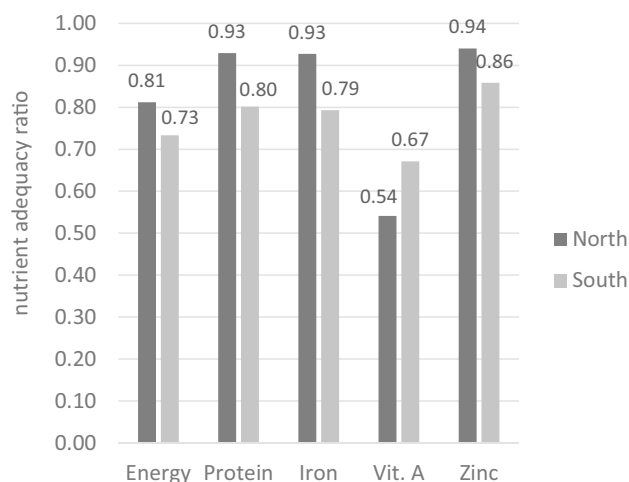
Using household food consumption data to characterize diets severely limits the validity of findings for several important reasons. Primarily, as consumption is aggregated at household level, the intra-household allocation of food is not examined explicitly. In order to gauge nutrient adequacy, a major assumption is made on the distribution of food within households based on individual nutrient requirements by age and gender. Evidence on this assumption of equitable distribution within households is scarce. A review of 28 studies across 14 countries found that for energy intake, individual intake fell within  $\pm 20\%$  of estimates from the equitable distribution rule (Berti, 2012). There is evidence also that adult male equivalent estimates are particularly inaccurate for children under 5 (Coates et al., 2017). Furthermore, as food availability is seasonal, a single panel of food consumption data may miss important seasonal patterns.

### 2.4 Ethical review

Approval for this study was received by the Ethical Review Board of the International Food Policy Research Institute.

## 3 Household food consumption patterns and nutrient gaps

Household food consumption data from across Ghana provides critical insights into the existing diets patterns and nutrient gaps. Household consumption data collected from a nationally representative sample of rural households provides an estimate of daily per capita consumption amounts, as well as the corresponding nutrient amounts. Nutrient availability depends on both the intrinsic nutritional content and the amount consumed of a specific food. The analysis presented here focusses on two macronutrients (energy and protein) and three micronutrients (iron, vitamin A, and zinc). Figures are for the poorest income quintile and divided into those residing in the *northern regions (savanna zone) and the southern regions (forest and coastal zones)*. Figure 2 estimates the per capita adequacy of nutrient availability in relation to average requirements, showing that sampled households face important deficits in nutrient access that differ by north and south. Estimated calorie consumption is lower in the south than the north. Protein, zinc, and iron consumption are close to adequate in the north, while vitamin A consumption is about half of requirements. In the south, protein, iron, and zinc consumption are lower while vitamin A consumption is inadequate but higher than in the north.



**Fig. 2** Estimated mean adequacy ratio of nutrient availability by adult equivalent based on household consumption over a 7 day period, by north and south. Source: Author’s calculations of household survey data (Gelli et al., 2019) based on nutrient values in the West African FCT (Stadlmayr et al., 2012)



These consumption deficiencies can be better understood by looking at the patterns of the specific foods consumed and their nutrient contributions. Figure 3 suggests that diets include a wide range of staples including maize, cassava, rice and yam, accounting on average for 73% of food and 77% of calories in the north. In contrast, in the south, these foods account for 53% of food and 64% of calories. A wide range of higher-nutrient foods including leafy greens (e.g. kontomire and cassava leaves), fruits (bananas and plantain-which is consumed as a staple food-mango, guava and papaya), beans and peas (e.g. cowpea and bambara bean), and groundnuts are consumed in smaller amounts. Animal sourced foods, including fish, eggs, dairy and meats, are consumed in very small amounts. While overall amounts consumed are low for the whole sample, legumes account for a much higher proportion of calories in the north than in the south. Whereas, in the south, the proportion of calories derived from vegetables and from animal source foods are double that of the north. Oil makes up 6% of calories in the south compared to 3% in the north.

In the north, maize alone contributes between a third and a quarter of all the five macro and micronutrients considered. However, the bioavailable supply of nutrients is likely much lower than suggested in Fig. 3. While maize makes

up 20% of calories in the south, cassava-a food for which the micronutrient content is extremely low-is consumed in higher amounts.

Fish is an important source of high-quality protein and iron in highly a bioavailable form throughout the sample, although consumed in small amounts. Chili pepper provides a significant proportion of both iron and vitamin A (8% and 47% on the north and 17% and 44% in the south). In the south, banana and plantain are also an important source of iron and vitamin A. Egg consumption, though low, is another important source of protein and micronutrients in the diet in the south.

Figure 3 also provides information about the market orientation of the north versus the south. While markets and own production are both important across the whole sample, a greater proportion of foods are mostly sourced from markets in the south: 20 of 29 foods are mostly purchased from markets in the south while 17 of 29 foods are mostly purchased in the north. Overall, staples are mostly consumed from own production, except for rice. In the south, all legumes and seeds are mostly purchased, while in the north it varies by type of legume/seed. Chili pepper and tomato are mostly purchased throughout the country.

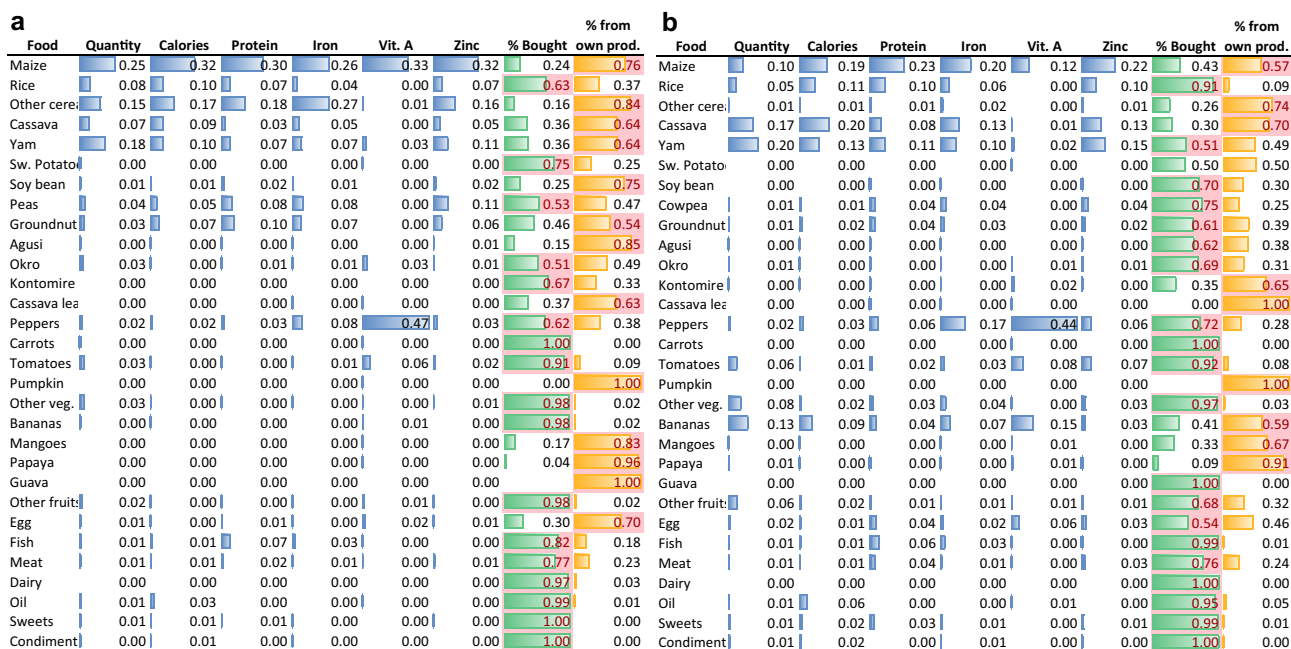


Fig. 3 Share of total nutrients (calories, protein, iron, vitamin A, and zinc) contributed by individual foods, and percentage of foods sourced from own production, for lowest quintile, by north and south. Source: Author’s calculations of 7-day household consumption data

(Gelli et al., 2019) based on nutrient values in the West African FCT (Stadlmayr et al., 2012). Note: Figures are not adjusted by bioavailability so are likely to be overestimates

### 3.1 Consumer preferences and diet choices

Based on in-depth interviews (N=48) with farm households, diet patterns and preferences were broadly similar across field sites, although specific preferred foods varied between north and south and by region. Ghanaians noted enjoying variety, consuming various starchy staples and different accompanying soups and stews. Staple foods mentioned include maize, plantain, cassava, yam, cocoyam, and rice. In the north, millet and sorghum are also common. Soups and stews typically start with a base of dried fish, onion, chili pepper, and tomato, and include small amounts of ground groundnuts or seeds, vegetables, and-when possible-poultry or meat. In addition to onion, chili pepper, and tomato, commonly preferred vegetables include okra, garden egg (a variety of eggplant), abedru (turkey berry), and different leafy greens (most commonly *kontomire* in the south and *guant* in the north). Households throughout Ghana enjoyed many different types of fruits when they are in season.

“Food” was equated with starchy staples: when describing the foods they like, people started by naming the staple preparation. When prompted, they would also specify which type of soup or stew they like to eat with it. There were some typical combinations-for instance, one eats light soup with fufu (dumpling made from cassava and yam or plantain), okra soup with banku (fermented then steamed maize dough), and stew with rice-and common formulations of the recipes, but there were many different variations.

*Female Respondent, Central (south): “We don’t eat a single food for a long time to avoid losing appetite for it; there are times I prepare banku and other times I pound fufu and other times I cook rice.”*

*Female Respondent, Central (south): I eat with light soup, palm soup, and peanut soup. So if I eat light soup today tomorrow I will eat palm soup and then the next day peanut soup.*

A few processed and packaged food were ubiquitous across the communities interviewed. These included bullion-type flavor cubes (such as *Maggie* or *Onga* cubes), tinned tomatoes, and imported rice. Other packaged foods mentioned include bread, tinned or powdered milk, beverages like tea or Milo (a sweet cocoa drink powder), sunflower oil (as a substitute for locally processed palm oil) and tinned fish or meat. Consumers chose brands based on flavor, past use, and expiration dates. In communities in or near a major town center, these processed foods were more commonly mentioned. On the other hand, in some of the most remote communities, households often relied on tinned foods and bouillon cubes to fill the gap when other ingredients were not available.

*Female Respondent, North-East: In case you don’t get fish, what do you add to the soup? R: In that case we use Maggie cube.*

*Male Respondent, Oti (south): “Sometimes the fish for the stew, I mean the dry fish, is not available so if we don’t get dry fish then we buy the Tinapa (tinned sardines).”*

Although people lamented having to consume the same foods every day due to scarcity, when asked what they would like to consume more of, people often mentioned their favorite typical dish. All communities aspired to consume more rice, the most commonly consumed food that is usually packaged and imported. Many said they would like to consume more beans and more yam. *Milo*, bread, evaporated or powdered milk, and fruit are also occasionally mentioned as aspirational foods. While people often referred to their ethnic identity to explain why certain foods were eaten in a community, it was common for people to not eat those foods based on personal tastes and preferences.

Respondents’ conceptions of the nutritional quality of foods largely related to traditional concepts of health and wellbeing. Translations for the term “nutritious food” were akin to “foods that give strength” or “foods that give health”.

Respondents listed a number of foods they thought were nutritious, such as leafy greens, abedru, and various fruits. Fish was commonly described as beneficial while beef was sometimes described as harmful, and a number of people described skin reactions and other illnesses from eating pork.

Most commonly, foods were said to be nutritious because they give strength and energy, build the body, or build blood. The benefits were often described in functional terms, such as supporting one’s ability to work hard on the farm, make one’s body strong, or withstand or avoid illnesses. Abedru-and sometime *kontomire*-was described as a “blood tonic”;

*Female Respondent, Ashanti (south): “If you give birth and they tell you that you don’t have blood you can use both the abedru and the kontomire to prepare stew.*

There were also many references to the dangers of foods that produce *phlegm* in the body, and debates about which foods were more phlegm producing-cassava, yam, or cocoyam.

*Female respondent, Ashanti (south): “The maize-made foods are more nutritious because, you know, there is starch in cassava and we eat it a lot and it does...it produces lot of phlegm in our system.”*

Respondents discussed phlegm as something that can weaken the body, for instance worsening the effects of malaria infection. A health benefit commonly ascribed to fruits was relief of constipation and red palm oil was said to improve eyesight. These traditional concepts of health-relevant characteristics of food are prevalent in other parts of Africa and in Eastern medicinal traditions (Aberman & Roopnaraine, 2020; Bai & Song, 2012).

### 3.2 Intra-household allocation of food

Discussion of intra-household allocation explored whether any household members were given priority when food resources are scarce. Across all communities for both male and female respondents, children were prioritized when food was scarce. Eggs were commonly reserved for children, and other animal foods were sometimes prioritized for children. Households said they made sure children ate first because they could not withstand hunger like an adult; when hungry they would cry and could fall ill.

*Male respondent, Ashanti (south): “We will share the food small-small but if it is still not enough, we give all the food to the children and then we-the adults-will just get some bread and eat...Because when a child doesn’t eat she will cry and worry you and she will not even be able to sleep but being an adult if you don’t eat you can still sleep.”*

Alternatively, a few households said they prioritized animal proteins for the male head. It was typically considered necessary to serve men first as a sign of respect, though not in all cases. Notably, in the Oti communities all households said men were served first and a number of women said that in times of shortage they went without eating. In no households were women given priority for meals in terms of eating first or ensuring they eat animal proteins before others. Some women explained that these norms resulted in women eating less food:

*Female respondent, Volta (south): “I will serve my husband first. Then I will serve my children and serve my grandchildren as well and then I will eat the small that is left.”*

### 4 Nutritious food availability, access, and alternatives

All communities faced seasonal barriers to consuming some preferred nutritious foods (PNFs). Some said they simply stopped consuming fresh fruits and vegetables when they were unavailable on the farm. Others noted that market availability of these foods was limited some months of the year even if they could afford to purchase them.

Tomato, a key ingredient in most recipes especially in southern Ghana, becomes scarce and expensive during the dry season, and people switched seamlessly to packaged tomatoes in a tin or sachet. This allowed people, even in remote rural communities, to continue to cook with tomato throughout the year. Similarly, chili pepper, another essential ingredient in Ghanaian cooking throughout the country, is commonly used in dried form when the fresh version is not available. Consumers would only reluctantly substitute dried forms of vegetables (leafy greens and okra), except

in the north where the taste was more acceptable and dried forms were the most common substitute for fresh vegetables. Abedru is considered a wild food that people typically gather rather than produce or purchase. Fruits like mango, banana, orange, and avocado were enjoyed while in season, but people forgo them when they are not available through own production: these foods were rarely purchased.

Different from fruits and vegetables, staple foods are more consistently available. While people sometimes go without their favorite food at certain times of the year, the variety of different staple foods and harvest seasons allowed most households to switch between them rather than experiencing a significant “hungry” season.

*Male Respondent, Ashanti (south): “Normally I grow a variety of crops; I grow corn, I grow rice, cassava among others so that when one is out of season I can fall on the other.”*

Rice is both an aspirational food and a food that helps households cope with seasonal shortages and time constraints because it can be easily purchased and prepared in small amounts when other staples run out.

*Male Respondent, Central (south): “When there are seasonal challenges, I buy bags of rice to sustain us. Rice is always available, so I just buy it.”*

Substitution was often expressed as an effort to prepare flavorful food even when preferred ingredients were unavailable. For instance, consumers and market vendors in Central and Ashanti Regions noted that groundnut, palm nut, or egusi could be used when kontomire and other fresh vegetables were not available, depending on the preferred recipe. Palm nut soup was the most common substitution for scarce foods.

*Female Respondent, Ashanti (south): “If there is no money, we make palm nut soup but if there is money we use abedru, kontomire, and groundnut.”*

Similarly, abedru and kontomire were substituted when fish was not available across all regions except for North-East.

In North-East, when *tizet*-the main northern staple food, a dough usually made from millet-was not available, a bean-based version was substituted. Unlike in the south, tomatoes were sometimes considered optional in northern cooking.

*Male Respondent, North-East: We don’t have it [okra and tomatoes] all through the year; there are times we hardly even get some from the market to buy. [Instead], we can use dry powdered okra, or dried powdered baobab leaves (tukara) for soup. For tomatoes, even if we don’t have it, we can still prepare the soup.*



#### 4.1 Household keep-sell decisions

All households interviewed produced food crops, keeping some for home-consumption and selling some. Households balanced competing priorities of keeping enough food for the year and meeting urgent cash needs. These decisions were framed in terms of their subsistence needs rather than profit considerations, lamenting the sale of produce that they would rather keep for home consumption. Quantities produced played a strong role in these decisions: after a household produced sufficient quantities to meet home consumption needs, they would sell the rest. *Female Respondent, North-East*: “Often we sell what we have more of; other times, we look at how much of the crop we need ourselves and then sell some of it.” In cases of highly perishable foods, like fresh vegetables and plantain, people kept what they could consume immediately and sold the excess. In Central Region, a couple of respondents owned refrigerators—a rare asset among rural residents—which made them less likely to sell the fresh foods they produced as it could be stored for longer.

The top cash needs addressed with the sale of produce are food, school fees and school-related expenses, clothes and shoes, sundry items such as soap and household products, medical expenses, and investments in property, such as housing or land. In the north, gendered patterns to these priorities arose, wherein women were responsible for purchasing sundries and milling grain but were not necessarily allocated funds for these expenses or allowed to sell food stocks themselves, creating tension related to keep or sell decisions.

### 5 Market environment

The food outlets patronized by the sampled households included community-based food hawkers and kiosks, small rural markets, and larger markets that included butchers, cold stores, millers, and other specialty sellers. Many people relied on community-based kiosks as a convenient source of food or to fill the gap before for the next trip to their usual market. Products were consistently more expensive in these kiosks but the convenience encouraged people to patronize them. Kiosks largely stocked less-perishable products such as tinned foods (tomatoes, mackerel, corned beef, bouillon cubes, powdered milk, Milo, oil, salt) and dried fish. But some kiosks also sold locally produced fresh foods, such as fresh tomatoes and abedru. In addition, some remote communities purchased foods such as fresh fish or bread from mobile vendors when they drove through periodically selling these products.

Communities weighed various factors when deciding which market in the vicinity to patronize. While large markets often have better prices and more options, the time and cost of travel could be a barrier. People said they would forgo trips to the market when they did not have sufficient money to buy their preferred foods or buy foods in sufficient

quantities to warrant the time and cost of travel. Instead, they would patronize local sellers to fill immediate food needs. Another consideration for a market trip or the choice of market was convenience or having multiple tasks to undertake at the market; if people were passing through for other reasons they would stop to purchase some food items and people preferred to undertake selling and buying in the same trip, especially in remote communities.

Consistent with the food consumption data reported in Table 1, all households reported that they purchased some foods to supplement what they grow themselves. Respondents listed rice, fish, tomato, oil, okra, chili pepper, and cowpea as foods they typically purchased. In addition, consumers purchased many packaged and processed foods, and more of the foods they produced at home when stocks ran out.

While most foods in the market were sold with relatively little processing or value addition, there were some exceptions. Groundnut was commonly processed into paste, cassava was processed into gari (dried cassava flakes), fruits were cut for convenience or peeled for esthetics, fish vendors often smoke, dry and/or grind the fish themselves. Chili pepper is dried and ground in the off season. Most of this processing was undertaken by either consumers or by market sellers.

#### 5.1 Patterns of sales and availability

We discerned patterns of food sales and availability distinct from our a priori sampling categories: north/south and remote/central. Archetypal rural markets—those primarily serving rural communities wherein agriculture is the primary livelihood but not necessarily corresponding to the “distance to market” measure of remoteness used in our sampling—have demand patterns closely connected to farmer production patterns and decisions about whether to keep or sell the produce. While more urbanized markets—those located in large towns or tertiary cities wherein a higher proportion of the population derive their incomes outside of primary agricultural production—have demand patterns somewhat de-linked from agricultural seasons. We refer to these urbanized markets as “rurban”.

In rural markets, sales are less responsive to price changes as consumers tend to have stocks at home from their own production when prices are low. And when stocks run out market prices are high and consumers have limited cash on hand so purchases remain low. Similarly, the prices farmers receive when they have produce to sell, especially for fresh produce, is low. Consumers near these markets tend to consume what they have produced until it is gone, and then only purchase for immediate needs. Alternatively, in *rurban* markets, sales and prices are less volatile across seasons.

For grains and legumes—such as maize, millet, cowpea, and groundnuts—supply increases at harvest time when farmers sell their produce in the market. Traders in the rural

markets report low sales during this time because most consumers meet their demand for these crops through own production. By the beginning of the next rainy season, farm households tend to run out of their own food stocks so market traders are able to sell more produce. Sales peak just before the next harvest. In contrast, traders in *rurban* markets said that sales of cereals and pulses peak just *after* the harvest when high quantities supplied lead to lower prices.

Leafy greens were rarely sold in rural markets; traders note that people grow their own rather than purchasing. Whereas garden egg, okra, tomato, and chili pepper were available in all markets. Traders reported more easily selling vegetables early in the rainy season or after the rains when customers are less likely to have them at home. Off-season vegetables were sourced from irrigating producers, or sometimes rainfed producers who harvest a bit earlier than others. After the rains end, traders start to sell dried and ground leafy greens and okra, especially in the north. In *rurban* markets, leafy greens were included in the list of vegetables for sale. Also, rarely, abedru and cabbage were sold in *rurban* markets.

A range of fruits were available in *rurban* markets, depending on their harvest season. Pineapple, watermelon, banana, avocado, orange, mango, and guava were found in the markets visited. Fruit sellers in *rurban* markets noted increased sales in the peak season when supply is high and sales are low. In rural markets, fewer fruits were found, and sales were very low throughout the year due to high prices in the off season and availability at home during the peak season.

While some form of dried or smoked fish was available across all markets, other animal foods were less common. Fresh fish, poultry, beef, and pork were only available across northern markets and in *rurban* markets in the south. Throughout all markets, sellers reported few customers purchasing fresh meat products, except directly after the main harvest season and for festive occasions. In the south, higher sales corresponded to the cocoa harvest, as cocoa is a common cash crop. While in the north, increased sales were tied to the harvest of major food crops like sorghum, maize, groundnut, yam, and rice. Eggs were rarely available in northern markets.

In all markets and among village sellers, commercially and locally processed food sales decreased when fresh foods such as fresh tomatoes, garden eggs, and leafy greens were highly available, as processed foods often serve as substitutes.

Overall, most traders described increases in sales during local festivals and funerals, while school is in session (due to both school catering and purchase of meals and snacks for schoolchildren), and at the beginning of harvest when more people have cash from crop sales.

Traders attributed changes in supply of foods overwhelmingly to the seasonality of production, for fresh foods in particular. Transport delays and poor-quality (or seasonally unpassable) roads are also a major cause of supply limitations, primarily for fish, poultry products and

processed foods. Wholesalers may fail to supply at times, either due to these transport problems or for unknown reasons. Traders in one northern market also expressed worry over ethnic tensions and conflicts that periodically limit food supply from producers in neighboring villages.

Most sellers across markets reported sourcing their fresh agricultural produce primarily from own production and from farmers in nearby communities, especially vegetables, leafy greens, and fruits. When local supplies dwindle, they may source from neighboring communities or more distant parts of Ghana. In the off-season, tomato and chili pepper were primarily sourced from Burkina Faso through itinerant traders. Cereals, grains, and pulses were often sourced from major markets in North-East and Ashanti Regions, and sometimes from neighboring countries. Fresh fish, poultry, and eggs were typically sourced from wholesalers in the larger urban markets. Small, dried fish were usually sourced from wholesalers in Ashanti. Fresh meat (beef, goat, and sheep) was usually sourced from the north.

Markets represented a mix of traditional and modern value chains. While commercially processed food was ubiquitous throughout markets, the food supply system for fresh foods continued to utilize traditional practices and technologies. Perishability and lack of storage facilities constitute the main business challenge identified by traders of fresh agricultural produce. Limited or poor-quality facilities constrain the sale of fresh produce; rather than save unsold produce for the next day, traders are forced to drastically drop prices of leafy greens in the afternoon to avoid wastage. Transportation and associated costs constituted the greatest business expense for traders. These costs included payments to porters to load and unload the goods, payments made at police checkpoints, and the cost of damaged or spoiled goods due to bad roads or vehicle breakdowns. Associated challenges included delays in restocking produce.

## 6 Discussion

The preceding analysis of consumer behaviors and preferences and marketing patterns provide deep contextual understanding of the challenges and drivers of consumption of nutritious foods. The next step in the VCN method is to fit the outcomes of this analysis onto a supply–demand typology (low demand and supply, high demand and supply, low demand and high supply, high demand and low supply) to summarize the outcomes and facilitate the identification of complementary interventions and policies. Depending on where the constraints are for these foods—demand, supply, or in the value chain—we can diagnose corresponding investments. For the purposes of this analysis, supply and demand were evaluated based on market vendors' estimations of availability for sale throughout the year, household IDI responses provide information on sourcing, preferences,

and substitutions, and analysis of secondary consumption data provides insights into consumption.

### 6.1 Summary of combined results

Fruits and leafy greens are categorized as low supply (seasonal) and low demand in the north and south. They are preferred foods, however they are easily foregone or substituted when they are not in season. Tomato is in high demand in the south but less so in the north; supply is low (seasonal) throughout the country. Chili pepper is in high demand and low supply (seasonal) in north and south. However, for both tomato and chili pepper, modern and traditional processing ensure year-round consumption. There are also concerns about the safety of fresh vegetables related to pesticide residue and other contaminants. Furthermore, the short, localized supply chains exacerbate the seasonally limited availability. Supply and demand for *abedru* are low. It is a highly nutritious *wild* vegetable that is a preferred food in the south but consumed in small amounts. It is occasionally traded but more often gathered from kitchen gardens or from the wild.

Legumes (cowpea and bean) and seeds (egusi and bungen) are categorized as low demand and high supply. They are often used as substitutes when fresh vegetables are not available or animal foods are not affordable, and so are not consumed regularly or in sufficient amounts. Legumes are not highly preferred (i.e., inferior good), but often consumed outside the home from prepared-food vendors.

Fresh meat, poultry, and fish are in low demand and supply, except meat which is in higher demand in the north. These animal foods are eaten in very small amounts, as their high cost makes them a luxury food, consumed by better-off consumers or during times of celebration. In *rurban* markets, cold stores carry fresh frozen fish and poultry and butchers for pork and beef are found throughout the north. Various types of dried or smoked fish are in high supply throughout the country, and, though they are highly preferred, we consider them low demand. While these fish

are a more affordable substitute for fresh animal proteins and they are a ubiquitous addition to recipes throughout the country, they are typically consumed in very small amounts compared to nutritional requirements. Intra-household allocation most commonly affects animal foods. Eggs experience low demand throughout our study sites and are in high supply in the south but low supply in the north. In the south they are consumed in slightly higher amounts and more commonly available in markets. In the north they are more likely to be consumed from home production than purchased. Households in all communities said they prioritize eggs for children when they had them, though quantities consumed are very low, especially in the north. Women in these study sites commonly reported forgoing animal foods, especially in Oti communities.

### 6.2 Mapping results to a supply–demand typology

Based on the combined results, this section demonstrates how promising interventions can be identified and mapped to different stages along the value chain, as presented in Fig. 4, to address specific of supply, demand, and value chain constraints of nutritious foods, in order to improve diets. While not part of this analysis, cost-effectiveness, political feasibility, or other possible contextual constraints should also be considered when using this approach for program design.

Increasing consumption of low demand and high supply foods—such as dried fish, eggs, seeds, and legumes—can be promoted through concerted efforts to increase nutrition knowledge and practices and enhance the nutrient density of local recipes. For instance, approaches to promote wider consumption of eggs have been promoted in Ghana and elsewhere and can build on positive perceptions of these foods as highly nutritious and good for children (Marquis et al., 2018; Morris et al., 2018). Modalities for scaling-up and intensifying nutrition education nation-wide could include enhanced community-based nutrition messaging and school curricula on nutrition. In addition, targeting younger populations will have a greater likelihood of influencing diet preferences that are still developing (Thow et al., 2018, 149).

Supply of nutritious foods → Nutritious value along the supply chain → Demand for nutritious foods

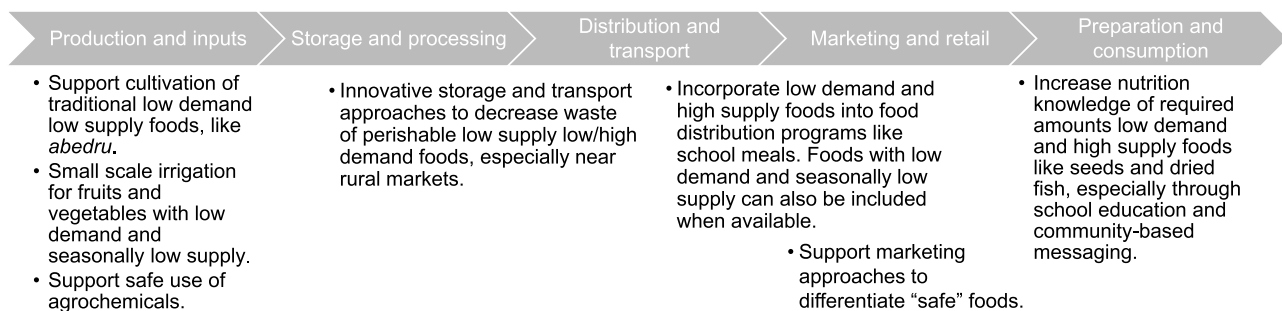


Fig. 4 Summary of promising supply, demand, and value chain interventions identified through VCN analysis. Source: Authors’ presentation of results

Low demand and high supply foods can be systematically incorporated into food distribution programs such as school meals to enhance diets of school-age children. Even low demand and low supply foods that are characterized by seasonally limited availability like leafy greens and fruits can be incorporated into distribution programs when they are available. Consistent demand for these foods also has the potential to incentivize more and year-round production of these foods. Related research shows that distribution programs can be effective for stimulating local markets and improving children's nutrition, if implementation challenges like highly variable market prices can be addressed in the program design (Gelli et al., 2019).

Supply-side interventions are particularly important for seasonal vegetables and fruits. Cultivation of abedru can be promoted in the south to increase supply. Our analysis of consumer preferences shows that fruits and vegetables are preferred foods but that seasonally high prices and food contamination concerns are significant constraints to the stability of consumption. Small-scale irrigation for vegetables—especially leafy greens—and fruit tree varieties with variable ripening periods are examples of production-focused interventions that could alleviate the highly seasonal supply of critical nutrient-rich foods. Other research shows that both women and men should be explicitly engaged in irrigation initiatives to support vegetable production for home use (Theis et al., 2018). Such approaches can also smooth out income and effective demand over the year, potentially stimulating rural markets. Concerns about agro-chemical contamination of fresh vegetables also drives preferences for own-consumption or purchase of these foods. Vegetable market development can be supported by addressing these safety concerns.

Finally, concerted efforts to decrease waste of leafy greens, fresh fruits, and other perishable supply-constrained nutrition foods would benefit producers, vendors, and consumers. Road infrastructure, mobile cold storage, and other innovative approaches can be strategically developed to increase the availability of these foods, especially in rural markets. Measures to increase the efficiency of value chains and decrease waste have been suggested as a mechanism to address affordability and availability issues (Gelli et al., 2017; Parmar et al., 2017).

## 7 Implications for Ghana and beyond

In addition to demonstration of the VCN method, these results have important implications for Ghana and food systems research more broadly. In Ghana, agriculture sector investment is dominated by activities such as subsidized inputs for grains and commercial vegetables (not commonly consumed by the rural poor), grain storage facilities, and extension support for grain production (Ghana MoFA, 2017). While this approach may increase incomes from the sale of produce, it will not address

the seasonal constraints to nutritious diets unless combined with some type of irrigation (plus demand-side interventions), especially for households in communities near rural markets, as well as farmers constrained by land size or limited labor. A different approach should be developed to support these households to produce nutritious foods all year. While also considering opportunities to enhance production and processing of locally preferred nutritious foods near *rurban* markets.

Processed packaged foods are available throughout Ghana, even in the most remote communities. Industrially processed foods are used to bridge seasonal gaps of nutritious food availability, as are traditionally processed foods. Processing of tomato and chili pepper allows consumers to enjoy their preferred flavors and benefit from the micronutrients year-round. However, increased consumption of ultra-processed foods like bouillon cubes when fresh foods are unavailable represents an emerging challenge of the globalizing food system as well as an opportunity for developing more nutritious local and shelf-stable alternatives. For instance, an initiative by the University of Ghana entailed product development research to replace bouillon cubes with healthy alternatives (University of Ghana, University of California-Davis, 2019). Attempts to incorporate small-holder farmers into supply chains for industrial processing of vegetables and fruits have not been highly successful (Boamah et al., 2019), but new technologies applied to *traditional* processing and supply chains should be explored, to potentially benefit both diets and livelihoods.

More broadly, our analysis supports application of a more nuanced conceptualization of *market access* than the oft-applied, and oft-critiqued (Chamberlin & Jayne, 2013), measures such as distance, time, cost to get to the market. As discussed elsewhere, distance to market not a good measure of “remoteness” in our study sites (see Chamberlin, 2012; Chamberlin & Jayne, 2013). Some communities designated as *central* were in fact extremely isolated from traditional food markets, due to the quality of roads connected to the community and characteristics of the reference market. Combining market access indicators with those that considers the variety and consistency of food supplied can enhance research on how producer-consumers engage with the market and implications for health diets (INDDEx Project, 2018; Pingali & Ricketts, 2014).

Finally, the menu of policy interventions arising from the VCN analysis should not be viewed as individual approaches to pick and choose from. Together they provide a set of complementary interventions across different value chains, regions, and demographics. On its own, investments in irrigation for vegetable production will be difficult to sustain if produce cannot be transported to a market with unmet demand. Approaches that miss out on critical food system constraints, including food system governance, are likely to show minimal or short-lived benefits (Boamah et al., 2019).

## Annex 1: Survey population characteristics

**Table 2** Key characteristics of households surveyed for secondary dataset, by north/south

Characteristic	All (n = 2626)		North (n = 755)		South (n = 1062)	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Years of education of head of household	4.27	5.38	2.56	4.70	5.45	5.37
Age of head of household	45.00	13.15	44.32	12.67	44.24	12.93
Percentage of expenditures spend on food	59.70	15.39	64.52	15.59	56.30	14.81
Per capita expenditures (log)	7.53	0.54	7.50	0.52	7.59	0.51
Dependency ratio	1.69	0.92	1.70	0.52	1.79	1.02
Household is polygamous	0.01	0.10	0.01	0.08	0.01	0.10
Female headed household	0.23	0.42	0.12	0.32	0.31	0.46
Urban	0.07	0.26	0.05	0.22	0.09	0.29
Owns livestock	0.64	0.48	0.74	0.44	0.55	0.50
Expenditures below poverty line	0.22	0.41	0.24	0.43	0.20	0.40

Source: Author's calculations from secondary data

## Annex 2: selection of preferred nutritious foods list

To choose a basket of foods with high potential to improve diets, we triangulated analyses on food preferences and availability in local food environments for foods rich in missing (according to analysis of 7-day recall consumption data) nutrients, yielding a list of high-potential preferred nutritious foods (PNFs). These foods are presented with their key nutrients in the table below and used to determine which

foods to focus on in the value chain analysis. We considered differences in preferences between north and south, as well as more localized preferences by region: Ashanti, Oti, Central, and North-East. Some PNFs, including tomato, chili pepper, and okra, were preferred across all study regions, suggesting these foods enjoy wide acceptability to consumers throughout the country. Other foods were specific to particular localities. For example, egusi seed and bitter leaf are more widely consumed in the Oti region while bungu seed and cowpea leaf are consumed in the North-East region Fig. 5.



	Food   Region	South			North	Key Nutrients
		Ashanti	Oti	Central	North-East	
Fruit	papaya	6	4	5	1	Vit A*, Vit C*
	mango	5	5	3	9	Vit A*, Vit C
	orange	4	5	7	3	Vit A, Vit C*
	avocado	6	1	3	0	Vit A*, Vit C
	shea fruit	0	2	0	12	Vit A*, Vit C
	dawadawa fruit	0	2	0	10	Iron, Zinc, Vit A*, Vit C*
	pineapple	3	3	5	0	Vit A, Vit C
	baobab fruit	0	2	0	0	Iron, Vit A*, Vit C, Calcium
Vegetables	tomato	8	12	11	12	Vit A*, Vit C
	cocoyam leaves (kontomire)	6	9	8	0	Iron, Vit A*, Vit C
	amaranth (alefu)	1	1	0	3	Iron*, Vit A*, Vit C*, Calcium*
	roselle leaves (guant/bra)	0	0	0	12	Iron, Zinc, Vit A*, Vit C, Calcium
	okra leaves	0	0	0	1	Vit A*, Calcium
	jute/bush okra (ayoyo)	4	10	0	7	Iron, Vit A*, Vit C*, Calcium
	baobab leaves	1	1	0	4	Iron, Vit A*, Vit C*, Calcium, Zinc
	cowpea leaves	0	0	0	4	Iron, Vit A*, Vit C, Calcium
	bitter leaf	1	3	0	0	Iron, Vit A*, Vit C, Calcium
	garden egg	5	10	9	2	Vit C
	abedru	7	4	3	0	Iron*, Zinc*, Calcium*, Protein*
	chili pepper	10	13	10	9	Vit A*, Vit C*
	okra	6	13	5	11	Vit A, Vit C
Seeds and legumes	melon seed (egusi)	0	4	4	4	Iron, Zinc, Protein
	groundnut	10	12	7	12	Iron, Zinc, Protein
	cowpea	5	10	7	11	Iron, Calcium, Protein
	bambara beans	0	0	1	8	Iron, Zinc, Protein
	soybeans	0	1	0	6	Iron, Zinc, Calcium, Protein
Animal-source foods	eggs	3	3	8	6	Protein
	chicken	7	3	5	7	Iron, Zinc, Protein
	goat	1	3	3	2	Iron, Zinc, Protein
	beef	3	2	4	5	Iron, Zinc, Protein
	fish	10	13	11	12	Protein

**Fig. 5** Preferred nutritious foods, by region. Source: Authors; number of times a food was mentioned as preferred during IDIs. Nutrient content based on authors' calculations from West Africa FCT (Stadlmayr et al., 2012) figures, except abedru from Ogah (2015). Note: A food

is considered rich in key nutrients if 100 g contains greater than 10% of the recommended nutrient intake for the average adult. \*—denotes nutrient content equal to or greater than the recommended nutrient intake for the average adult per 100 g

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**Availability of data and material** Anonymized data is available upon request.

**Code availability** Not applicable.

## Declarations

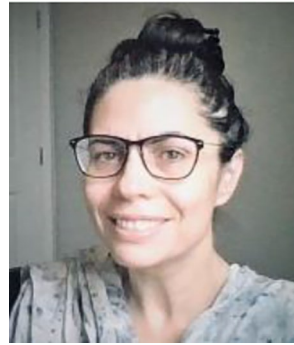
**Conflicts of interest/Competing interests** No conflicts to report.

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## References

- Aberman, N. L., & Roopnaraine, T. (2020). To Sell or Consume? Gendered Household Decision-Making on Crop Production, Consumption, and Sale in Malawi. *Food Security*, 12(2), 433–447.
- Andam, K. S., et al. (2018). The Transformation of Urban Food Systems in Ghana: Findings from Inventories of Processed Products. *Outlook on Agriculture*, 47(3): 233–43. <http://journals.sagepub.com/doi/10.1177/0030727018785918>. (May 16, 2019).
- Aryeetey, R., Oltmans, S., & Owusu, F. (2016). Food Retail Assessment and Family Food Purchase Behavior in Ashongman Estates, Ghana. *African Journal of Food, Agriculture, Nutrition and Development*, 16(4): 11386–403. <http://ajfand.net/Volume16/No4/Richmond15430.pdf>
- Bai, D., & Song, J. (2012). Plasma Metabolic Biomarkers for Syndrome of Phlegm and Blood Stasis in Hyperlipidemia and Atherosclerosis. *Journal of Traditional Chinese Medicine*, 32(4), 578–583.
- Berti, P. R. (2012). Intra-household distribution of food: a review of the literature and discussion of the implications for food fortification programs. *Food and Nutrition Bulletin*, 33, S163–S169.
- Boamah, E. F., & Sumberg, J. (2019). The Long Overhang of Bad Decisions in Agro-Industrial Development: Sugar and Tomato Paste in Ghana. *Food Policy*, 89(November): 101786. <https://linkinghub.elsevier.com/retrieve/pii/S0306919219306086>
- Chamberlin, J. (2012). 3 IFPRI Discussion Paper Its a Small World after All: Defining Smallholder Agriculture in Ghana. [http://www.bwpi.manchester.ac.uk/medialibrary/publications/working\\_papers/bwpi-wp-17112.pdf](http://www.bwpi.manchester.ac.uk/medialibrary/publications/working_papers/bwpi-wp-17112.pdf). <http://www.krepublishers.com/02-Journals/JHE/JHE-00-0-000-000-1990-Web/JHE-00-0-000-000-1990-1-Cover.htm>. <http://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N>
- Chamberlin, J., & Jayne, T. S. (2013). Unpacking the Meaning of ‘Market Access’: Evidence from Rural Kenya. *World Development*, 41(1), 245–264. <https://doi.org/10.1016/j.worlddev.2012.06.004>
- Coates, J., Rogers, B. L., Blau, A., Lauer, J., & Roba, A. (2017). Filling a dietary data gap? Validation of the adult male equivalent method of estimating individual nutrient intakes from household-level data in Ethiopia and Bangladesh. *Food Policy*, 72, 27–42.
- Downs, S. M., Ahmed, S., Fanzo, J., & Herforth, A. (2020). Food Environment Typology: Advancing an Expanded Definition, Framework, and Methodological Approach for Improved Characterization of Wild, Cultivated, and Built Food Environments toward Sustainable Diets. *Foods*, 9(4).
- Drewnowski A., et al. (2020). Shaping Physical, Economic, and Policy Components of the Food Environment to Create Sustainable Healthy Diets. *Food and Nutrition Bulletin*, 41(2\_suppl): 74S-86S.
- Ecker, O. (2018). Agricultural Transformation and Food and Nutrition Security in Ghana: Does Farm Production Diversity (Still) Matter for Household Dietary Diversity? *Food Policy*, 79(June), 271–282. <https://doi.org/10.1016/j.foodpol.2018.08.002>
- FAO. (2004). Human Energy Requirements: Report of a Joint FAO/WHO/UNU Expert Consultation, Rome, 17–24 October 2001. Rome.
- Fiedler, J. L., Lividini, K., Bermudez, O. I., & Smitz, M.-F. (2012). Household Consumption and Expenditures Surveys (HCES): A Primer for Food and Nutrition Analysts in Low- and Middle-Income Countries. *Food and Nutrition Bulletin*, 33(3 Suppl), S170–S184.
- GBD 2017 Diet Collaborators. (2019). Health Effects of Dietary Risks in 195 Countries, 1990–2017: A Systematic Analysis for the Global Burden of Disease Study 2017. *Lancet (London, England)* 393(10184): 1958. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6899507/> (January 11, 2022).
- Gelli, A., Hawkes, C., Donovan, J., Harris, J., Allen, S. L., De Brauw, A., et al. (2015). Value chains and nutrition: a framework to support the identification, design, and evaluation of interventions. Washington DC.
- Gelli, A., et al. (2017). Improving Diets and Nutrition through an Integrated Poultry Value Chain and Nutrition Intervention (SELEVER) in Burkina Faso: Study Protocol for a Randomized Trial. *Trials*, 18(1): 412. <https://trialsjournal.biomedcentral.com/articles/10.1186/s13063-017-2156-4> (January 11, 2021)
- Gelli, A., Donovan, J. A., Margolies, A., Aberman, N. L., Santacroce, M., Chirwa, E. W & Hawkes, C. (2018). *The Role of Food Systems and Value Chains to Improve Diets in Low Income Settings: Diagnostics to Support Intervention Design in Malawi*. International Food Policy Research Institute. Washington D.C. <http://cdm15738.contentdm.oclc.org/cdm/ref/collection/p15738coll2/id/132712>
- Gelli, A., Aurino, E., Folsom, G., Arhinful, D., Adamba, C., Osei-Akoto, I., & Alderman, H. (2019). A School Meals Program Implemented at Scale in Ghana Increases Height-for-Age during Midchildhood in Girls and in Children from Poor Households: A Cluster Randomized Trial. *The Journal of Nutrition*, 149(8): 1434–42. <https://academic.oup.com/jn/article/149/8/1434/5491288> (August 29, 2019).
- Ghana Ministry of Food and Agriculture. (2017). *Planting for Food and Jobs: Strategic Plan for Implementation (2017–2020)*. Ghana: Accra.
- Ghana Statistical Service, Ghana Health Service, and ICF International. (2015). Ghana Demographic Health Survey 2014. <https://dhsprogram.com/pubs/pdf/FR307/FR307.pdf>
- Gissing, S. C., et al. (2017). Drivers of Dietary Behaviours in Women Living in Urban Africa: A Systematic Mapping Review. *Public Health Nutrition*, 20(12), 2104–2113.
- Global Panel on Agriculture and Food Systems for Nutrition. (2016). *Food Systems and Diets : Facing the Challenges of the 21st Century*. London, UK: Global Panel on Agriculture and Food Systems for Nutrition.
- HLPE. (2017). *Nutrition and Food Systems: A Report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security*. Rome. [www.fao.org/cfs/cfs-hlpe](http://www.fao.org/cfs/cfs-hlpe) (October 29, 2020).
- INDDEx Project. 2018. Data4Diets: Building Blocks for Diet-Related Food Security Analysis. <https://inddex.nutrition.tufts.edu/data4diets> (January 21, 2022).
- Jayne, T. S., et al. (2016). Africa’s Changing Farm Size Distribution Patterns: The Rise of Medium-Scale Farms. *Agricultural Economics*, 47(S1): 197–214. <https://onlinelibrary.wiley.com/doi/full/10.1111/agec.12308> (January 24, 2022).
- Marquis, G. S., et al. (2018). An Agriculture–Nutrition Intervention Improved Children’s Diet and Growth in a Randomized Trial in Ghana. *Maternal and Child Nutrition*, 14(S3). <https://doi.org/10.1111/mcn.12677>
- Marshall, M. N. (1996). Sampling for Qualitative Research. *Family Practice*, 13(6): 522–25. <http://www.ncbi.nlm.nih.gov/pubmed/9023528>
- Modell, S. (2009). In Defence of Triangulation: A Critical Realist Approach to Mixed Methods Research in Management Accounting. *Management Accounting Research*, 20(3), 208–221.
- Monterrosa, E. C., et al. (2020). Sociocultural Influences on Food Choices and Implications for Sustainable Healthy Diets. *Food and Nutrition Bulletin*, 41(2\_suppl): 59S-73S.
- Morgan, E. H., Hawkes, C., Dangour, A. D., & Lock, K. (2019). Analyzing Food Value Chains for Nutrition Goals. *Journal of Hunger and Environmental Nutrition*, 14(4): 447–65. <https://www.tandfonline.com/doi/abs/10.1080/19320248.2018.1434106> (January 7, 2021).
- Morris, S. S., Beesabathuni, K., & Headey, D. (2018). An egg for everyone: pathways to universal access to one of nature’s most

- nutritious foods. *Maternal and Child Nutrition*, 14(S3). <https://doi.org/10.1111/mcn.12679>
- NCD Risk Factor Collaboration. (2019). Rising Rural Body-Mass Index Is the Main Driver of the Global Obesity Epidemic in Adults. *Nature*, 569(7755): 260–64. <http://www.nature.com/articles/s41586-019-1171-x>
- Nicholson, C. F., Monterrosa, E., & Garrett, J. L. (2021). Food Value Chain Interventions and Nutritional Outcomes: A Review of Evidence and Recommendations for Future Assessments. *Current Opinion in Biotechnology*, 70, 61–67. <https://doi.org/10.1016/j.copbio.2020.11.015>
- Ogah, M. (2015). Nutritional Value of Turkey Berry. University of Cape Coast.
- Parmar, A., Hensel, O., & Sturm, B. (2017). Post-Harvest Handling Practices and Associated Food Losses and Limitations in the Sweetpotato Value Chain of Southern Ethiopia. *NJAS - Wageningen Journal of Life Sciences*, 80, 65–74.
- Peña, I. D. L., Garrett, J., & Gelli A. (2018). Nutrition-Sensitive Value Chains from a Smallholder Perspective: A Framework for Project Design. 50.
- Pingali, P. L., & Ricketts, K. D. (2014). “Mainstreaming Nutrition Metrics in Household Surveys-toward a Multidisciplinary Convergence of Data Systems”. *Ann. N.Y. Academy of Sciences*, 1331, 249–254.
- Pitt, E., et al. (2017). Exploring the Influence of Local Food Environments on Food Behaviours: A Systematic Review of Qualitative Literature. *Public Health Nutrition*, 20(13), 2393–2405.
- Ragasa, C., Andam, K. S., Amewu, S., & Asante, S. (2019). Consumer Demand and Willingness to Pay for Safe Food in Accra, Ghana: Implications for Public and Private Sectors’ Roles in Food Safety Management. (January).
- Ridoutt, B., et al. (2019). Value Chains and Diet Quality: A Review of Impact Pathways and Intervention Strategies. *Agriculture (Switzerland)*, 9(9).
- Shannon-Baker, P. (2016). Making Paradigms Meaningful in Mixed Methods Research. *Journal of Mixed Methods Research*, 10(4), 319–334.
- Signorelli, S., Haile, B., & Kotu, B. (2017). *Exploring the Agriculture-Nutrition Linkage in Northern Ghana*. <http://ebrary.ifpri.org/cdm/singleitem/collection/p15738coll2/id/132235>
- Sobal, J., & Bisogni, C. A. (2009). Constructing Food Choice Decisions. *Annals of Behavioral Medicine*, 38(SUPPL.).
- Stadlmayr, B., et al. (2012). *West African Food Composition Table / Table de Composition Des Aliments D’Afrique de L’Ouest*. FAO.
- Theis, S., Lefore, N., Meinzen-Dick, R., & Bryan, E. (2018). What Happens after Technology Adoption? Gendered Aspects of Small-Scale Irrigation Technologies in Ethiopia, Ghana, and Tanzania. *Agriculture and Human Values*, 35(671–84), 2019. [https://doi.org/10.1007/s10460-018-9862-8\(March1](https://doi.org/10.1007/s10460-018-9862-8(March1)
- Thow, A. M. (2018). How Can health, agriculture and economic policy actors work together to enhance the external food environment for fruit and vegetables? a qualitative policy analysis in India. *Food Policy*, 77.
- Turner, C., et al. (2018). Concepts and Critical Perspectives for Food Environment Research: A Global Framework with Implications for Action in Low- and Middle-Income Countries. *Global Food Security*, 18, 93–101.
- Turner, C., et al. (2020). Food Environment Research in Low- and Middle-Income Countries: A Systematic Scoping Review. *Advances in Nutrition*, 11(2), 387–397.
- University of Ghana, University of California-Davis, Hellen Keller International. (2019). *Condiment Micronutrient Innovation Trial (CoMIT) Ghana*. In *Launching of Condiment Micronutrient Innovation Trial (CoMIT) Ghana*, Accra, Ghana.
- University of Ghana et al. (2017). *Ghana Micronutrient Survey 2017*. Accra, Ghana.
- WHO & FAO. (2004). *Vitamin and Mineral Requirements* (2nd Ed.). Geneva.



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