



Article

Interactions between Food Environment and (Un)healthy Consumption: Evidence along a Rural-Urban Transect in Viet Nam

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Abstract: There is limited evidence on food environment in low and middle-income countries (LMICs) and the application of food environment frameworks and associated metrics in such settings. Our study examines how food environment varies across an urban-peri-urban-rural gradient from three sites in North Viet Nam and its relationship with child undernutrition status and household consumption of processed food. By comparing three food environments, we present a picture of the food environment in a typical emerging economy with specific features such as non-market food sources (own production and food transfers) and dominance of the informal retail sector. We combined quantitative data (static geospatial data at neighborhood level and household survey) and qualitative data (in-depth interviews with shoppers). We found that across the three study sites, traditional open and street markets remain the most important outlets for respondents. Contrary to the common concern that urban households are the major consumers of processed foods, peri-urban and rural areas on average had higher consumption of ultra-processed foods than in urban areas. The low price levels of processed foods and the presence of processed foods even among the traditional convenience stores, those in closest proximity to the rural households, offer potential explanations of this result. Regarding undernutrition, low retail diversity and a household's dependence on own production have important implications for the high prevalence of child undernutrition in rural areas. Our findings add to the current discussion on the critical role of the food environment on nutrition, such as the potential link between economic marginalization and access to food, and the role of food supply channels in consumption of processed foods.

Keywords: food environment; food systems; rural-urban transect; processed food; healthy consumption; undernutrition; non-market food source; informal retail; Viet Nam



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1. Introduction

Countries across the world are still facing immense challenges in ensuring food and nutrition security, despite substantial progress in reducing hunger and undernutrition in the past decades [1]. To fight different forms of malnutrition, the central role of the food environment has been highlighted in several recent international reports [1–3], especially because food systems are essential to achieving the Sustainable Development Goals (SDGs), especially SDG2—zero hunger [4]. The food environment is defined as the physical, economic, political and socio-cultural interface where people interact with the wider food system to acquire, prepare and consume foods [2,3,5]. The United Nations Decade of Action on Nutrition 2016–2025 has put a “safe and supportive environments for nutrition at all ages” as one key action area and member states have been called to scale up research on the food environment [5].

Food environment research gained momentum in recent years within high-income countries (HICs) in response to the high prevalence of overweight, obesity and non-communicable diseases (NCDs) [6–8]. As low- and middle-income countries (LMICs) are fighting multiple burdens of malnutrition, characterized by the coexistence of undernutrition along with overweight and obesity [9,10], the food environment is gaining policy attention in such contexts [11]. Nevertheless, the number of studies on food environment in LMICs is still limited compared with that for high income countries. Even though the number of publications on the food environment in LMICs is increasing, they predominantly feature upper-middle-income countries and outcomes related to overweight and obesity [12].

Viet Nam, whose fast growth over the past 30 years has raised the country's status from one of the poorest nations into a lower middle-income country, demonstrates the nutrition transition story. Following the *doi moi* reforms in 1990s, the decline in consumption of mainly starchy staples and increases in consumption of meat, fish and dairy products helped to lower yet not eliminate the prevalence of undernutrition: The prevalence of child underweight declined from 31.9% in 2001 to 17.5% in 2010, stunting from 43.3% in 2000 to 29.3% in 2010 [13]. Meanwhile, data from Viet Nam started showing unhealthy food consumption patterns such as high consumption of ultra-processed foods (including instant noodles) and sweetened non-alcoholic beverages [14]. These nationwide statistics, however, mask sub-group differences. Notably, there are large differences between rural and urban areas. While some urban provinces have virtually eliminated undernutrition, underweight and stunting remain a problem in rural areas, especially among ethnic minority communities [15]. Pronounced differences in food consumption between rural and urban residents have also been observed: for example, urban residents spent less on rice and more on livestock products [16]. Research on the food environment can play an important role in explaining such differences and in drawing relevant recommendations. Common with several LMICs, Vietnam's food environment across the country displays the features of traditional and mixed food systems, where the co-existence of both formal and informal markets is typical [2].

The objective of this study is to examine how food environment varies across an urban-peri-urban-rural gradient from three sites in North Viet Nam, and its relationship with consumption and nutrition outcomes. In examining food environment, we focused on food availability. We were motivated by the challenge of covering diverse food sources that exist in LMICs, such as the co-existence of formal and informal food markets, as well as non-market-based food sources like own production [17]. We also looked at how food availability is linked to the personal food environment dimensions, namely accessibility, affordability and desirability. Personal food environment domains have received less attention in the literature [17]. To identify potential food environment factors that play a key role in consumption and nutrition outcomes, we focused on two main outcome variables: under-five child undernutrition status and household consumption of processed food. The former fills a global research gap in food environment research where there is an overrepresentation of overweight and obesity [12,18]. The latter joins the growing pool of research on over-nutrition and fills a gap in healthy consumption research in Viet Nam. Our study is among the first to report processed food consumption in Viet Nam, due to the lack of a database for nutritional compositions of processed food and a dedicated section on processed food in most surveys.

This study contributes to the nascent body of food environment research in LMICs in several ways. First, by looking at the food environment across an urban-peri-urban-rural gradient (using data from three different sites in North Viet Nam) our study provides detailed information about the food environment in an emerging economy in transition. Second, by employing a mixed methods approach that combines static geospatial data at neighborhood level and observational data (household survey and stakeholder qualitative in-depth interviews), we were able to look at household level consumption and explore its relationship with various food environment domains. Third, we cover the elements and

typologies characteristic of food environment in LMICs such as non-market food sources (own production and food transfers) and dominance of the informal retail sector, providing evidence that can capture the food source typologies within LMICs environment.

The rest of the paper is structured as follows. Section 2 provides a literature review of food environment research in LMICs, starting with a summary of food environment frameworks in the context of LMICs. Section 3 presents the methodology of the study. Section 4 presents the key results, which address the three research questions:

- How does the external food environment dimension, notably the availability of various types of retail outlets, the role of nonfood sources and relative prices, vary across the urban-peri-urban-rural transect?
- How is availability linked to the personal food environment dimensions of accessibility, affordability and desirability of food vendors?
- Can differences in availability, accessibility and affordability of food help explain the consumption of processed food and child malnutrition?

Section 5 discusses and concludes.

2. Literature Review

2.1. Food Environment Conceptual Framework

The food environment entails the spaces where food acquisition occurs, and the series of opportunities and constraints that influence people's food acquisition and consumption. For this paper, we use the recently consolidated food environment framework proposed by Turner et al. [17] (Figure 1). It inherited several key concepts from the "availability, affordability, convenience and desirability" framework by Herforth and Ahmed [19] and supplements it with characteristics of the food environment in LMICs. This framework divides the food environment into external and personal domains. The key external dimension of "availability" also entails food sources important for LMICs such as home-grown foods, local community exchanges and informal vendors. The personal domain includes a set of individual level dimensions, including food accessibility, affordability, convenience and desirability. People's food acquisition and consumption are shaped by the interactions between these domains and dimensions.

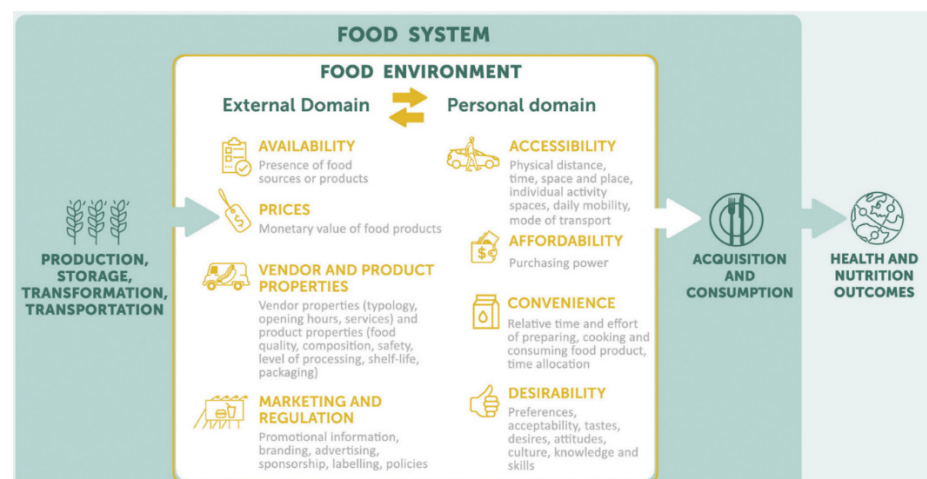


Figure 1. Food environment conceptual framework. Reprinted from ref. [17].

This framework discussed the interrelation between availability and accessibility. Availability refers to whether a vendor or product is present or not within a given context and precedes accessibility, which includes individual spaces such as distance, time, space and place, daily mobility and modes of transport. However, the framework did not discuss the interrelation between availability and other personal food environment dimensions such as affordability and desirability. In the result Section 4.2, we report some evidence

illustrating these relationships. We do not look at convenience separately, because this concept is usually conflated with accessibility in the literature. Herforth and Ahmed suggested that convenience “can be measured as the proximity of food outlets to homes and amounts and different types of food stores and restaurants in an area (density and variety)” [19]. Even in studies categorized by Turner et al. [17], “convenience” is used loosely. For example, convenience was referred to as “geography” or embedded in “convenience food” [20]. Although convenience can be measured in terms of preparation time of various kinds of foods, metrics of food preparation time within the food environment literature were not available [19].

2.2. Food Environment Research in LMICs

In this section, we reviewed the findings related to our focus on food availability and personal food environment dimensions, namely accessibility, affordability and desirability and indicated our contributions to the literature.

Regarding food availability, the food environment in LMICs is usually characterized by a wide variety of food outlets, with small-and medium-sized market-based vendors dominating across a number of settings. While formalization and supermarketization have been taking place in LMICs, they have yet to take over the role of the small and medium sized and informal sector in providing food [21,22]. For examples, in a study that covered 12 cities in China, large-sized stores only accounted for 2% of all food stores [23]. In Thailand, small/medium-sized market-based vendors and traditional markets mainly serve fruit and vegetables while retail format like supermarkets, supply modern foods such as processed foods [24,25]. Despite the importance of the small-scale outlets in LMICs, geo-coded datasets that cover the outlet diversity of the informal sector are limited [12]. With extended typologies, our study attempts to cover these smaller vendors. Another important component of food availability in LMICs is non-market sources, which include own production, wild food harvesting, and transfers, including gifts [12]. In their study that covered a 15-year time span in a rural community in Mexico, Chaudhari et al. found that subsistence activities remained significant for the local population despite increasing presence and use of retail stores for food [26]. In a former hunter-gatherer community in Namibia, the bush and government were considered the most important food sources [27]. Even in urban setting, non-market-based food sources may also be important, for example in the form of urban agriculture [28]. In this paper, we have combined household consumption and expenditure data with neighborhood environment characteristics to shed light on the role of non-market sources.

Availability should also be studied in relation to the accessibility dimension. Distance to food outlets is the first commonly used variable for accessibility. Liu et al. found that the proximity of local wet markets in China was positively associated with household dietary diversity, and a large positive caloric/fat intake effect on children from households of lower income [29]. However, in a more specific study in urban Nanjing, no correlations were found between geographical proximity to supermarkets and wet markets and household dietary diversity [30]. In a study in Brazil, the distance to supermarkets and fresh produce markets had positive impacts on fruit and vegetable consumption, but not on sugar sweetened beverages consumption [31]. Modes of transport is the second commonly used variable for accessibility. No clear pattern emerges from the literature. In a study on rural China, the authors found a positive association between public transport with dietary diversity, but a negative relationship between costs of access to food with dietary diversity [29]. Rural consumers had to spend a certain amount of money that could have been spent on food to travel to the nearest supermarkets to buy food. A study in peri-urban India mentioned the reliance on bus or walking to markets in the town to purchase vegetables, although accessibility was not considered the most important drivers of fruit and vegetable acquisition and consumption in the setting [32]. In our study, we collected both aforementioned measures: distance to the closet outlet (quantitative measurement) and mode of transport (qualitative observation).

Affordability was the personal food environment dimension with the least coverage in LMICs food environment research [12]. Most papers have drawn insights from qualitative interviews. For example, in a study in rural Mexico, participants expressed concern about the affordability of foodstuffs such as meat, which was usually consumed only once a week, even when a butcher was available in the area [33]. In another study in Cape Town, South Africa, the urban poor were found to utilize the informal Spaza shops, which offers lower prices and smaller quantities, to compensate for insufficient income. Formal supermarkets were often utilized for big bulk spending at the end of the month [34]. In our paper, we combined results from qualitative household interviews with household's income data to explore how the varied affordability levels had different implications for households in three areas, in relation to availability of food products.

The desirability of food vendors and products is shaped by people's individual preferences, acceptability, tastes, desires, attitudes, culture, knowledge and skills. In the literature, there has been more attention paid to the desirability of food products. For example, it was found that non-traditional and non-local foods were considered prestigious by Indian adolescents [35]. Migrants in Cape Town, South Africa found traditional food from home to be more desirable than counterparts in the new city [36]. For this study, we focus on the desirability of food vendors by exploring households' preferences for certain types of food vendors, both informal and formal ones.

An essential line of research investigates the relationship between food environment factors and nutritional outcomes. Several studies use the consumption and nutritional status of children as an outcome. In a study in Kunming, China, adolescents who lived in the areas with higher numbers of fast food restaurants and convenience stores consumed more processed food but fewer fresh fruits and vegetables, thereby having a higher percentage of overweight [37]. Another study on children aged 6–17 years in China found that boys living in the second quartile of the proximity to the nearest grocery store had higher than those in the first quartile as they consumed more fast foods [38]. A significant positive relationship was found between convenience stores and body mass index (BMI) in Ghana as hypothesized [39]. The evidence seems to pivot towards the hypothesis that modern retail environment has a negative impact on youngsters' unhealthy consumption and over-nutrition status. Nevertheless, the absence of attention to child undernutrition is a striking omission within the literature [12]. Some suggestive evidence is available on how food environment can contribute towards undernutrition. For example, in their research on the urban food environment in China, Wang and Shi showed that density of wet markets within five kilometers positively influences 6–18 year children's nutritional intake [40]. Our study covers both under and over-nutrition issues to address the research gap in food environment and undernutrition research. We do not attempt to establish causality, but rather identify the key food environment characteristics that deserve further investigation.

The number of published studies on food environment that go beyond one setting is limited, as these studies require rich transect data. Disparities along an urban-rural-transect have been observed. For example, high-income cities in China tended to have lower densities of food stores and food service places compared with medium urbanized cities. High-income versus low-income, high urbanized versus low urbanized areas had significantly more large-sized supermarkets and fewer small/medium-sized markets [23]. A similar pattern was observed in Uganda, where formal food retail outlets had greater presence in the urban site, while informal food retail outlets were more prevalent in the rural site [41]. In the same study, more of the food items were made available by retail outlets in the urban setting when compared to the rural setting in both Uganda and South Africa. Besides descriptive results, there is also correlational evidence that the importance of food outlet availability in citizens' diets varies across the rural-urban transect. For example, the number of food outlets correlates with diverse diets in rural areas but not in urban areas in China [42]. Our study adds to this evidence pool by comparing the situations in three areas: urban, peri-urban and rural. We expect to see varied levels of market food source availability and dependence on non-market food sources across the

transect, with the rural area depends the most on non-market foods. As single-site studies have suggested, accessibility may pose the greatest problems for rural areas.

2.3. Methods to Study Food Environments

Multiple tools that complement each other are required to comprehensively capture the various dimensions of the food environment, but they have mostly been used independently [19]. In terms of quantitative approaches, the combination of methods in LMICs has been limited, with less than a fifth of reviewed papers using more than a single approach [12]. Among those using multiple approaches, Davies et al. used geographic information system (GIS) data and data collected from food shops to examine the widespread insufficient access to healthy food in smaller towns in the Brazil Amazon [43]. GIS data on distance to food establishments was combined with anthropometric measurement data among 348 children in China to find the relationship between BMI and proximity [38]. Anggraini et al. collected data on frequencies of purchase and women's food consumption and observed significant associations between frequencies of buying food from certain stores with consumption of specific foods [44].

Papers that use mixed methods, combining both quantitative and qualitative approaches are on the rise. In a study on local food environments in Mexico, the authors combined quantitative analysis of the density, proximity, food variety, quantity, quality, pricing and promotion of food outlet types, with in-depth qualitative research completed with families in the communities [45]. Carried out in South Delhi, the study by Finzer et al. examined relationships between consumer characteristics and fruit and vegetables purchasing by integrating a structured questionnaire and in-depth interviews [46]. Combining household survey, focus group discussion and participant-observation, a study in Mexico explored the increasing presence of retail food stores and a growing selection of processed foods amongst consumers [26].

3. Methodologies

3.1. Research Design

Our study learned from the best practices discussed in the previous section and adopted a mixed method research design framework. We first obtained quantitative data, which were a combination of static geospatial data and observational survey data. We then continued with qualitative data collection. The data were analyzed independently using a common conceptual framework and research questions. The analysis results were integrated and brought together in the overall interpretation. Table 1 summarizes the data collection methods for the study.

Table 1. Data collection methods.

Data Collection Method	Collected Variables	Nature of Data
Household questionnaire	Consumer knowledge, attitude and practices of food consumption	Quantitative/Observational
Neighborhood transect walk	GPS location of outlets Types of outlets Types of food groups on sale	Quantitative/Geospatial
Focus group discussions and in-depth interviews	Consumers' perception of food environment's key domains	Qualitative/Observational

Although the food environment can be studied at different scales, our available data make it the most appropriate to study the food environment at the community and household scale. To characterize the food environment in the three sites, we used descriptive statistics to reflect key features of household (personal) and neighborhood food environments (external). Whenever possible, comparative statistics are provided to

illustrate the urban-rural divergence. The qualitative interviewees were analyzed using deductive thematic approach, based on the main dimensions of the food environment.

3.2. Data

Our study uses data collected from 30 villages (In urban Cau Giay, the equivalent unit of village is ward. For simplicity, we referred to both wards and villages as “villages” in the paper) in the three districts of Cau Giay (urban site), Dong Anh (peri-urban site) and Moc Chau (rural site). The urban and peri-urban sites belong to the capital Hanoi, while the rural site is located in the mountainous province of Son La. The sites were pre-selected for in-depth study at part of the CGIAR program Agriculture for Nutrition and Health (A4NH) [47]. In each of the sites, 30 villages selected following a probability proportional to size (PPS) procedure were included in an overarching study that covers more surveys and questionnaires. The 10 villages from each site in this paper were a random subset of these 30 villages. Our data addresses some limitations of previous mixed methods studies. For example, a study that investigated the relationship between physical proximity and obesity risk admittedly suffered from a non-representative sample due to the phone survey method and the self-reported outcome variable (obesity) [48]. In our study, questionnaire data were collected via personal interviews and child anthropometric measurements were directly taken in the field. In combining quantitative and qualitative data, we also improved upon the research by Bridle-Fitzpatrick in 2015, which was conducted within a single city and a small sample of purposively selected socioeconomic status communities [45].

3.2.1. Quantitative Data

For the household surveys, 25 households from each village were randomly selected from the household list provided by village leaders. The person who was mainly responsible for household food purchase and/or preparation was the main respondent of the survey. Besides socio-demographic data, the survey covered food consumption, food shopping behavior, motives for food choice, nutrition knowledge and eating habits. During data collection, the GPS locations of the households were collected as means to control data quality and enumerators’ diligence. We later used this GPS data points to calculate the indicator for accessibility dimension.

To explore the external environment of the 30 research neighborhoods, geospatial mapping of different food outlets was conducted through a transect walk in the “food ecosystem” (rural to urban) to map food outlets. Where formal maps and data do not exist, transect walks are considered excellent tools for creating a record of a community’s environments [49]. In this walk, the researcher walked (or drove around in rural areas to cover the large distances) with a local guide within the administrative border of the 30 sampled villages, locating all the food retailers in the area and completing a database. The retailers were categorized into twelve groups; the definitions are listed in Appendix A. The resulting database (<https://cal.maps.arcgis.com/apps/MapJournal/index.html?appid=75b4657a6a0243bc963fe5e0e3e48d92>, accessed on 1 August 2021) includes all food retail stores and restaurants as well as direct producer-to-consumer marketing venues such as farmers’ markets and farm stands. To determine in-store food group availability, we walked through the outlet when this was allowed. When a store was closed, we consulted the local guide to complete the information. The eight food groups for which data were noted were: (1) grains, roots, and tubers, (2) flesh foods, (3) dairy and/or their alternatives, (4) eggs, tofu, nuts and seeds and legumes/beans, (5) oils, (6) fruits, (7) vegetables and (8) other processed foods like chips, candy and soda beverages.

To assess the issue of malnutrition, we calculated weight-for-height, height-for-age (length-for-age) and weight-for-age were interpreted by using the Z-score classification system. WHZs, HAZs and WAZs were calculated using the 2006 WHO child growth standards [50]. Prevalence of stunting, underweight, wasting and overweight of children under five were defined according to WHO classifications [51].

3.2.2. Qualitative Data

10–35-min semi-structured interviews were conducted with primary food shoppers in the three sites to gain further insight into the perceptions of the consumer's food environment. We applied a mixed sampling approach. In rural and peri-urban site, the participants were randomly selected from the previous participant list of the quantitative component. In urban site, we selected other respondents outside of the original quantitative sample, as most participants of the earlier quantitative research would work during the time of the interview or were mostly busy with preparations for the upcoming Lunar New Year. The total sample size was 56, comprising of 20 rural, 20 peri-urban and 16 urban respondents.

The interviewees responded to questions about multiple aspects of the food environment in a semi-structured interview. The interview guide covered five main issues: (1) availability, (2) accessibility, (3) affordability, (4) standards of products and (5) resident's needs concerning food outlets in their defined neighborhood.

3.3. Data Analysis

Data were mostly entered into CSPro data entry application during fieldwork using electric questionnaire forms. Paper-based questionnaires were manually checked by supervisors for potential errors and missing information before being entered into CSPro (United States Census Bureau, Suitland, MD, USA). Data were cleaned and analyzed using STATA and R software for descriptive statistics. The distances from households to outlet locations were measured with ArcGIS software (Esri, Redlands, CA, USA).

The analysis was mainly based on stratification by location (urban, peri-urban, rural). Statistical inference was done using Tukey-Kramer test at 5% significance level to test if the differences among the three sites are statistically significant.

4. Results

4.1. The External Food Environment across the Urban-Peri-Urban-Rural Transect

4.1.1. Market-Based Retail Outlets

Our data provide three measures of availability for market-based food sources: the presence of different types of food outlets; the presence of different types of food groups; and density of food outlets in the neighborhood (the number of food outlets per 1000 inhabitants). While the urban and peri-urban areas are now familiar with the presence of modernized food outlets, the rural area is still dominated by the traditional outlets. In Table 2, food outlets are divided into three sub-groups, including traditional food selling outlets, modern food shops and food service shops (cafés, diners and restaurants), in order to capture the modernization of the three study sites. In the urban and peri-urban areas surveyed, food outlets appear more diverse than those in the rural area (11 and 12 types, compared to 5 types, respectively). Traditional food selling outlets (convenience stores such as traditional grocery stores for food or drink) remain the most important outlets/sub-category, accounting for the highest percentage of food outlets in the rural area (93.9%) and quite high in the peri-urban (50.3%) and urban area (45.5%). Food service shops are recognized to be most common in the urban area (accounting for 49.2% of all food outlets in the area). This sub-group's relative presence compared to other type of outlets is lower in the peri-urban (41.0%) and lowest in the rural area (6.1%). Modern food shops are unavailable in the rural area.

Table 2. Count and density of food outlets, by outlet type and area.

Food Destination	Rural			Peri-Urban			Urban		
	No. of Food Outlets	Density (per 1000 Inhabitants)	%	No. of Food Outlets	Density (per 1000 Inhabitants)	%	No. of Food Outlets	Density (per 1000 Inhabitants)	%
Traditional food selling outlets	46	9.7	93.9	145	3.6	50.3	120	10.3	45.5
Convenience stores (traditional grocery stores for food or drink)	0	0	0	23	0.6	8.0	8	0.7	3.0
Convenience stores (traditional independent small grocery stores)	43	9.1	87.8	77	1.9	26.7	49	4.2	18.6
Informal street markets (small-scale street vendors and pop-up semi-permanent stands)	2	0.4	4.1	37	0.9	12.8	60	5.1	22.7
Informal street markets (mobile vendors)	0	0	0	2	0.1	0.7	3	0.3	1.1
Formal open markets (wet markets)	1	0.2	2.0	6	0.2	2.1	0	0	0
Modern food shops	0	0	0	25	0.6	8.7	14	1.2	5.3
Convenience stores (new style)	0	0	0	4	0.1	1.4	7	0.6	2.7
Bakery	0	0	0	10	0.3	3.5	6	0.5	2.3
Specialized shops (fruit & vegetable shops)	0	0	0	11	0.3	3.8	1	0.1	0.4
Food service shops	3	0.6	6.1	118	3.0	41.0	130	11.1	49.2
Street bars	1	0.2	2.0	30	0.8	10.4	2	0.2	0.8
Restaurants and dinners	0	0	0	11	0.3	3.8	13	1.1	4.9
Casual dining restaurants	2	0.4	4.1	64	1.6	22.2	99	8.4	37.5
Cafés	0	0	0	13	0.3	4.5	16	1.4	6.1
Total	49	10.3	100.0	288	7.2	100.0	264	22.4	100.0

Regarding density measure, with 22 food destinations available per thousand inhabitants, the urban food environment exhibits the highest food outlet density. The rural area offered ten food destinations available per thousand inhabitants, characterized by a limited variety in which traditional independent small grocery stores make up the major share. The peri-urban area had seven food destinations available per thousand inhabitants, a surprisingly low number when compared to the number of food destinations available in the urban and rural areas.

Regarding the presence of different types of food groups, Appendix B Tables A2–A9 show the percentage of each defined food group available per outlet type across the three areas. Grains, roots and tubers are more common in traditional grocery stores, formal open markets, bakeries and new style convenience stores in urban and peri-urban areas. The low share of outlets selling grains, roots and tubers in the rural area (32.6%) is likely explained by a high dependence on household production. Traditional independent small grocery stores in the rural area were the main provider of fresh produce. In the urban area, all the new style convenience stores carried fresh produce such as vegetables, fruits and flesh foods. Most notably, unhealthy foods like chips, candy and sugared beverages appeared in many convenience stores, both traditional and new-style, across the three areas.

4.1.2. Non-Market Food Sources

We attempted to quantify the role of non-market food sources, by using the difference between the reported monetary expenditure and the calculated value of food consumption as a proxy for self-subsistence (Table 3). On average, only 60% of the food costs by the rural household is included in the reported food expenditure. The rest may stem from their own production or non-monetary transactions such as from friends and family members. For peri-urban households this figure is about 77% and for urban households it is 100%. The differences may also reflect some measurement errors: the value of food consumption, when broken into smaller components, was likely to be more accurate than the reported food expenditure. Under the assumption that the measurement errors do not vary across the three sites, the differences between the reported food expenditure and value of food consumptions were still statistically significant across the three sites. We saw a gradual decrease in the role of non-market food sources across the rural-urban gradient.

Table 3. Average weekly household income and food expenditure (in thousand VNDs), by area.

Site	Value of Food Consumption	Reported Food Expenditure	Percentage of Reported Expenditure in the Total Value
Rural (<i>n</i> = 238)	1356 ^a (753)	515 ^a (428)	40.0 ^a (26.8)
Peri-urban (<i>n</i> = 233)	1604 ^b (819)	1052 ^b (576)	76.7 ^b (65.0)
Urban (<i>n</i> = 246)	1839 ^c (1048)	1664 ^c (1184)	108.0 ^c (105.0)

Note: standard deviations in parentheses. If the numbers are different in ^{a,b,c}, the differences are statistically significant using Tukey's tests, $\alpha = 0.05$.

In Table 4, we reported the average proportion of consumption that comes from household's own production for some of the main foods. Apparently, rural households derive a majority of their own consumption from own production. Peri-urban households also depend on own production for their consumption, albeit to a lesser extent. Meanwhile, urban households seem to depend almost entirely on market-based food sources for their food.

Table 4. Average percentage of consumption from own production, by type of food and area.

Food Item	Rural		Peri-Urban		Urban	
	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>
Rice	58.4	189	29.7	183	1.8	54
Sticky rice	64.3	97	10.7	56	0	18
Dark green leafy vegetables	84.4	205	37.3	190	2.0	56
Other vegetables	62.4	181	10.9	151	0	51
Fruits	64.1	191	6.7	178	0	51
Unprocessed meat	37.9	226	3.16	171	0.7	49
Eggs	31.4	179	9.14	181	2.0	51

Note: The number of observations changes by food item as it indicates the number of households that consume the respective item.

4.1.3. Relative Prices of Processed Foods

Unsurprisingly, prices of processed foods varied across the transect. We compared the relative prices of processed foods across three areas, using the rice price as reference in Table 5. These prices were collected from the household surveys where the respondents reported the prices they paid for food items. Rural households paid significantly less than their urban and peri-urban counterparts for several foods such as biscuits, cakes and ice-cream. If price is an indication of the quality of food that households consume, this suggests that rural area residents usually buy food of poorer quality. Our qualitative

observation ruled out the case of third-degree price discrimination. For example, while in the urban area ice creams consumed are usually packaged and of brand names, the “ice-creams” consumed in rural areas are mostly home made with high water and ice content that help keep the prices low. Meanwhile, some processed foods such as breads and sugared milk beverages were relatively cheaper in urban areas than in rural and peri-urban areas, possibly thanks to higher supply and lower transport costs. There were no significant differences among relative price levels of other food items.

Table 5. Price of processed food relative to rice (times), by area.

Food Item	Rural (n = 205)	Peri-Urban (n = 228)	Urban (n = 229)
Breads (bakery)	3.04 ^a (2.89)	2.88 ^a (1.70)	1.94 ^b (1.21)
Biscuits (cookies)	9.47 ^a (4.85)	8.76 ^a (4.79)	14.59 ^b (7.35)
Cakes and pastries	9.35 ^a (5.01)	11.76 ^{a,b} (7.24)	13.38 ^b (5.22)
Sweets (chocolate, candies, etc)	4.34 ^a (3.55)	6.06 ^a (4.05)	5.18 ^a (2.84)
Chips and similar snacks (“bim bim”)	3.89 ^a (1.27)	4.12 ^a (0.87)	3.40 ^b (0.62)
Soft drinks	1.55 ^{a,b} (0.83)	1.91 ^b (1.09)	1.35 ^a (0.51)
Ice-cream	5.01 ^a (2.32)	6.44 ^b (3.19)	8.80 ^c (3.26)
Sausages	5.46 ^{a,b} (2.47)	7.04 ^a (2.93)	5.73 ^b (2.29)
Pressed, spiced meats	8.43 ^a (2.92)	7.93 ^{a,b} (3.85)	7.15 ^b (2.58)
Salted/Cured/Smoked meats	13.98 ^a (9.76)	8.57 ^a (6.04)	10.33 ^a (2.93)
Other processed meat (chicken nuggets, sausages, burger)	11.15 ^a (5.33)	5.37 ^b (2.83)	6.51 ^{a,b} (3.52)
Canned vegetables and fruits	3.82 ^a (1.01)	3.22 ^a (2.99)	2.61 ^a (0.87)
Instant noodles	3.82 ^a (1.28)	4.02 ^a (1.51)	3.63 ^a (1.39)
Canned or dehydrated soups, stews and pot noodle	4.92 ^a (0.86)	3.11 ^a (1.66)	5.81 ^a (1.13)
Sugared breakfast cereals	3.85 ^{a,b} (0)	6.43 ^a (2.65)	3.71 ^b (1.79)
Sugared milk beverages	7.56 ^a (1.27)	7.54 ^a (2.33)	5.90 ^b (1.43)
Infant formulas and other baby food	34.99 ^a (14.81)	22.44 ^b (15.23)	29.07 ^a (10.23)

Note: standard deviations in parentheses. If the numbers are different in ^{a,b,c}, the differences are statistically significant using Tukey’s tests, $\alpha = 0.05$.

4.2. Linkage between Availability and Personal Food Environment Dimensions

Personal food environment dimensions can interact with external food environment domains to shape food acquisition and consumption [17,52]. In this section, we look at how personal dimensions, such as accessibility, affordability and desirability, qualify food availability across the three areas.

4.2.1. Availability and Accessibility

We use proximity to food destinations (the distance from one household to the closest food outlet) as one measure of accessibility. Not surprisingly, urban consumers, who are exposed to the largest diversity of food destinations, also have the most convenient access to these outlets compared to peri-urban and rural ones. Table 6 shows the average distances from a household to the closest available food destinations in the commune. For urban households, the average distances ranged from as little as 81 m (to reach the nearest casual dining restaurant) to about 2.5 km (to reach the nearest beer corner). The figures for peri-urban households ranged from 164 m (to reach the nearest traditional independent small grocery store) to about 7 km (to reach an informal street market). Meanwhile, rural study households need to cover a distance of nearly 2.5 km to reach the nearest traditional convenience store. In the urban area, there are seven types of food outlets located within a distance of less than 500 m, including street markets and convenience stores. Six types of food outlets in the peri-urban area are located less than 2 km away from households. The nearest informal street market, for example, is on average less than 300 m away. By contrast, in rural area only traditional independent small grocery stores are located less than 2.5 km away—a reasonable distance that a household can reach on a daily basis.

Table 6. Mean household (hh) distance value to the closest food retail outlet (meters), by area.

Food Outlet	Mean hh Distance from Closest Retail Outlet, by Area		
	Rural (n = 79)	Peri-Urban (n = 29)	Urban (n = 103)
Traditional food selling outlets			
Convenience stores (traditional grocery stores for food or drink)	-	2729 ^b	445 ^a
Convenience stores (traditional independent small grocery stores)	2432 ^b	164 ^a	91 ^a
Informal street markets (small-scale street vendors and pop-up semi-permanent stands)	13,896 ^b	229 ^a	270 ^a
Informal street markets (mobile vendors)	-	7196 ^b	1849 ^a
Formal open markets (wet markets)	9270 ^b	1178 ^a	-
Modern food shops			
Convenience stores (new style)	-	3142 ^b	434 ^a
Bakery	-	2138 ^b	1355 ^a
Specialized shops (fruit and vegetable shops)	-	4084 ^a	2071 ^a
Food service shops			
Street bars	16,494 ^c	354 ^b	2488 ^a
Restaurants and diners	-	6113 ^b	262 ^a
Casual dining restaurants	8307 ^b	153 ^a	81 ^a
Cafés	-	485 ^b	137 ^a

Note: standard deviations in parentheses. If the numbers are different in ^{a,b,c}, the differences are statistically significant using Tukey's tests, $\alpha = 0.05$.

Physical distance was not the only factor that hindered rural residents' access to food. The roads through mountainous areas were not well maintained and considered dangerous especially during the rainy season. Interviewees in rural areas, especially those living in communities with very bad or rocky roads, due to mobility disabilities and low incomes without ownership of a motorbike, claimed to have worse access to food than those with paved roads. The rural district had two main formal open daily markets but both markets were hard to reach due to the large distance and difficulty in getting there. Meanwhile, even though the interviewees in the peri-urban and urban area were satisfied with the number of food outlets in their communes and their access to them, some mentioned that out of curiosity or for diversity in their meal, they would sometimes like to shop at outlets outside their own communes.

4.2.2. Availability and Affordability

The varied affordability levels had different implications for households in three areas, in relation to availability of food products. For example, in the rural area, 65% (13/20) of the interviewed participants expressed that although meat is available in their neighborhood (60% of the store sold fresh products), it was too expensive to consume as much as they would like. In most communes, meat (mainly pork) costs around 100–110 thousand VNDs per kilo, while one participant indicated his willingness to pay only between 50–80 thousand VNDs per kilo. This is consistent with the household survey result that most households had meat as their priority to improve their diet if their income improves.

To assess the purchasing power of the households, we first used their reported income as a proxy. Figure 2 describes how income is distributed across the three sites, according to 10 intervals of income (with 1 representing the lowest income level and 10 representing the highest income level). We saw a clear gradient from urban-rural, where about a third of the surveyed urban households had a monthly income of the highest level (more than 20 million VNDs (860 USD)). About the same proportion of the rural households had the lowest level of income (less than 3 million VNDs—128 USD). As the income data were collected by a scale-based question, we could not calculate the income per capita, although we had data on the number of household members. The number of household members in each site was similar, at 4–5 members per household.

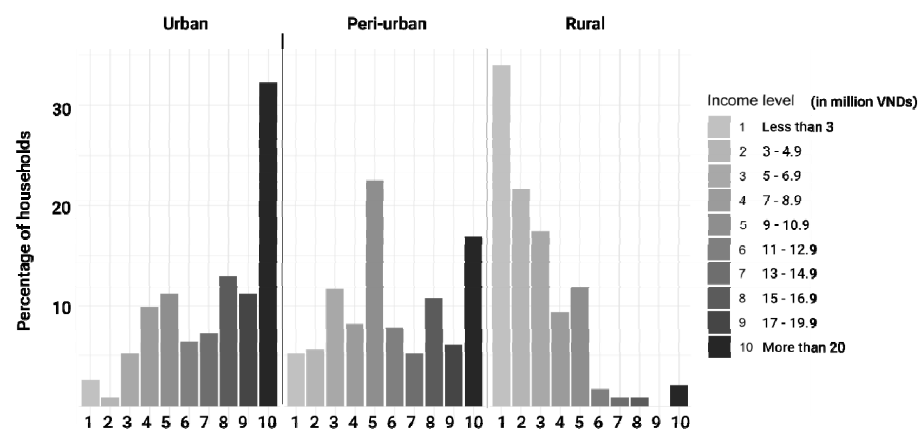


Figure 2. Monthly household income distribution, by income level and area.

In peri-urban area, large differences were observed in the perception regards the cost of the food. There was a mix of people who experienced their groceries to be expensive, reasonable and even cheap. Those indicating the food was expensive admitted that they just did not earn enough. Nevertheless, according to at least one respondent who worked for the health center:

“These people may find the food expensive, but would often grow a lot themselves, making them less depending on the market sources for food”. (Respondent 4, peri-urban, interviewed in February 2019)

This suggests the role of non-market food sources in easing the affordability issue for households.

In the urban area, a large majority (14 out of 16) of the interviewees described the price of their groceries as “reasonable” and shopped at the street markets. However, the weather and seasonality were considered to play a major role in the price fluctuations. At the time of the interviews, it was almost time for the Lunar new year (Tết), and some interviewees indicated that food prices would rise as a result.

The general sentiment is the cost of food at the supermarket was pricey, especially since the quality was not perceived to be better:

“I don’t like the supermarket because I bought expensive glass noodles there and the quality is not better than at the market. At home I read about the brand online and saw that it’s produced in my hometown, which I know is very dirty.” (Respondent 9, urban, interviewed in January 2019)

The two remaining respondents, who both lived in the same commune, considered the price of their groceries as “very expensive”. One of them shopped at a new style convenience store, the other at the supermarket. Nevertheless, they enjoyed the fact that prices at the convenience store and the supermarket were considered to be fixed, with little changes in fresh produce per season.

4.2.3. Availability and Desirability of Food Vendors

Across the three areas, the choice of food vendors depends on various factors. Using the household survey data, we examined the stated reasons for the most frequent type of outlets used by households in each area. Most consumers in the urban district obtained the majority of food from formal open markets (more than 50% of the households) and informal street markets (31.7% of the households). The top reasons for selecting formal open markets is habit, variety and convenience. The top reasons for selecting informal street markets are similar, although availability of healthy foods and food quality were also mentioned. In the peri-urban district, most households obtained the majority of their food from informal street markets (51.7% of the households) and formal open markets (44.4% of the households). The top reasons for selecting the open markets (both formal and informal) are habit, food quality, reputation, convenience, food safety and personal contact. Households in the rural area obtained most of food from informal street markets (41.6% of the households) and traditional convenience stores (39.9% of the households). The top reasons for selecting the convenience store and informal open markets are similar with those listed by the urban and peri-urban respondents, although the availability of credit was also an important reason.

In-depth interviews with respondents revealed some additional insights. When asked about why they still prefer open markets to supermarkets, urban respondents noted the need to resist temptation offered by the range of available products at the supermarkets:

“You come for water but then you want to buy everything that is around. You want to buy chocolate and then you buy dark chocolate, white chocolate and other candy, and then you need to pay much more.” (Respondent 9, urban, interviewed in January 2019)

In the peri-urban area, sometimes, the availability of local vendors actually prompted households to go to a further location to get a better deal, as explained by a respondent:

“I don’t want to go the market at this community because I want to bargain I am afraid of what other people think of me and think that I am cheap, therefore, I go to the market 2 km away from here where people don’t know me so I can bargain for a better price.” (Respondent 2, peri-urban, interviewed in February 2019)

4.3. Consumption and Nutrition Outcomes across the Transect

In this section, we first provide statistics on processed foods and nutritional status across the transect. Afterwards, we discuss the food environment dimensions that would help explain the differences across the three sites.

4.3.1. Consumption of Processed Foods

Processed foods include foods extracted and purified from unprocessed or minimally processed foods in order to produce culinary and/or food industry ingredients. The processes applied here are both physical and chemical processes that radically change the nature of the original foods, such as pressure, milling, refining, hydrogenation and hydrolysis and use of enzymes and additives [53]. Across the three areas, the most frequently

consumed ultra-processed foods are instant noodles, sugared milk beverages and bread. The percentage of rural consumers having instant noodles (80%) was significantly higher than those of urban and peri-urban households. Yet, while the majority of urban and peri-urban households consumed bread, only 29% of rural consumers did so during the week before the interview (Table 7).

Table 7. Share of households who consumed a certain food item in the past 7 days, by area.

Food Groups and Items	All	Rural (n = 238)	Peri-Urban (n = 236)	Urban (n = 249)
Instant noodles	71.4	80.2 ^b	70.3 ^a	63.9 ^a
Sugared milk beverages	57.5	54.2 ^a	62.7 ^a	55.8 ^a
Breads (bakery)	53.5	29.4 ^c	60.6 ^b	69.9 ^a
Pressed, spiced meats	48.5	33.6 ^b	58.9 ^a	53.0 ^a
Chips and similar snacks	40.7	50.4 ^b	38.1 ^a	33.7 ^a
Infant formulas and other baby food	31.4	10.1 ^c	36.9 ^b	46.6 ^a
Ice-cream	31.3	25.6 ^b	33.5 ^{a,b}	34.5 ^a
Soft drinks	29.5	46.6 ^b	22.0 ^a	20.1 ^a
Cakes and pastries	28.8	20.2 ^b	30.9 ^a	34.9 ^a
Sweets (Chocolate, candies, etc)	27.8	34.0 ^b	25.0 ^a	24.5 ^a
Biscuits (cookies)	24.1	16.0 ^b	27.1 ^a	28.9 ^a
Sausages	23.6	15.5 ^b	28.8 ^a	26.5 ^a
Other processed meat including chicken nuggets, sausages, burgers, fish sticks	7.3	1.7 ^c	7.2 ^b	12.8 ^a
Sugared breakfast cereals	6.9	1.3 ^b	7.6 ^a	11.6 ^a
Canned or dehydrated soups, stews and pot noodle	4.8	10.9 ^b	1.3 ^a	2.4 ^a
Salted/Cured/Smoked meats	4.7	5.0 ^a	3.0 ^a	6.0 ^a
Mayonnaise	4.7	0.0 ^b	1.7 ^b	12.0 ^a
Canned vegetables and fruits	1.7	1.7 ^a	0.8 ^a	2.4 ^a
Jams (preserves)	1.5	0.4 ^b	0.4 ^b	3.6 ^a

Note: if the numbers are different in ^{a,b,c}, the differences are statistically significant using Tukey's tests, $\alpha = 0.05$.

Based on the weekly amount reported by households, we calculated the total weekly consumption (in kilograms) of processed food per capita of a household (Table 8). Peri-urban and rural areas on average had higher consumption of ultra-processed foods than urban area, although the differences were not statistically significant. This result is contrary to the common hypothesis that urban households consume more processed foods than their rural counterparts do, due to modernization and supermarketization. In our setting, the presence of processed foods in the traditional outlets, which are in closest proximity to the rural households, might offer an explanation of this result.

Table 8. Consumption of processed food per week.

Area	Total Consumption of Processed Food per Capita (in kg)	Share of Processed Food Expenditure in Total Food Expenditure
Rural (n = 238)	0.91 ^a (0.78)	0.16 ^a (0.12)
Peri-urban (n = 236)	0.93 ^b (0.92)	0.22 ^b (0.15)
Urban (n = 249)	0.81 ^c (0.78)	0.19 ^b (0.13)

Note: standard deviations in parentheses. If the numbers are different in ^{a,b,c}, the differences are statistically significant using Tukey's tests, $\alpha = 0.05$.

The surveyed households also spent a considerable share of their food budget on processed food, ranging from 16% (rural area) to 22% (peri-urban area). Although the rural

household consumed a higher amount of processed food (in total kilograms), processed foods took up a lower value share from lower total consumption. There could be two explanations for this: first, relative price levels of some processed foods are lower than those in urban and peri-urban area for some foods, as discussed before in 4.1.3. Second, rural households seem to eat different processed foods than their urban and peri-urban counterparts. Table 9 displays some foods where there are big gaps between the areas: sweets were consumed much more in peri-urban and rural areas than in the urban area. Snacks, soft drinks, instant noodles, canned food were consumed much more in rural area than in other areas. Meanwhile, several modern options seemed mostly important in urban area, such as chicken wings and sweetened breakfast cereals. Appendix C displays the consumption amount for all processed foods.

Table 9. Average consumption of some processed foods per week (in kg).

Area	Sweets	Chips and Similar Snacks	Soft Drinks	Chicken Wings, Hamburgers, etc.	Instant Noodles	Canned Food	Breakfast Cereal
Rural (<i>n</i> = 238)	0.159	0.255	1.01	0.009	0.659	0.048	0.071
Peri-urban (<i>n</i> = 236)	0.219	0.132	0.474	0.083	0.464	0.013	0.038
Urban (<i>n</i> = 249)	0.071	0.099	0.367	0.122	0.329	0.009	0.199

4.3.2. Nutritional Status of Children under 5 in the Household

Anthropometric measures of the children under 5 were available for calculations of different nutritional status indicators: stunting, underweight and wasted. Prevalence of stunting, underweight, wasting and overweight among children under age five were defined according to WHO classifications [51]. Stunting: a child whose length-for-age is below the -2 Z-score is stunted; below -3 Z-score is severely stunted. Underweight: a child whose weight-for-age is below the -2 Z-score is underweight; below -3 Z-score is severely underweight. Wasting: a child whose weight-for-length is below the -2 Z-score is wasted; below -3 Z-score is severely wasted.

Marked differences existed among the nutritional status of children under 5 years old across the three areas (Table 10). The rural area had the highest proportions of households whose children were stunted (30.4%), underweight (18.5%) and wasted (6.4%).

Table 10. Percentage of households whose children suffered from malnutrition, by area.

Area	Stunted	Underweight	Wasted
Rural (<i>n</i> = 644)	30.4	18.5	6.4
Peri-Urban (<i>n</i> = 359)	11.1	5.0	3.9
Urban (<i>n</i> = 385)	6.8	3.4	1.8

Causes of undernutrition in children under 5 are numerous, including poor access to food, unhealthy environments and access to and control of resources [54,55]. We identify some potential food environment dimensions contributing to undernutrition: First, the lack of retail diversity needs addressing. In our rural site, products such as dairy are not readily available, which can be accountable for the lower consumption of dairy products by the households: only about half of the rural households eat dairy products in the last week, compared to about 70% of the households in the rural and peri-urban areas. In the rural area, only 36% of the traditional independent small grocery stores carried dairy or

their alternatives, while this number was more than double as high in the peri-urban and urban area (Table 11).

Table 11. Food stores with dairy and/or their alternatives available (%).

Food Stores	Rural	Peri-Urban	Urban
Convenience stores (traditional grocery store for food and drink)	-	8.7	0.0
Convenience stores (traditional independent small grocery stores)	35.5	94.4	65.9
Formal open markets (wet markets)	-	100.0	-
Convenience stores (new style)	-	100.0	100.0

Our regression (in Appendix D) also shows that there is a negative correlation between food retail diversity in the village with the likelihood of having a stunted child in the household. We had a dataset with significant missing data when matching datasets, so we do not include this in the main results.

Second, we pay attention to rural households' dependence on own agricultural production. Agriculture can be linked to undernutrition in several ways: consumption of own production due to lack of market access; and consumption of more nutritious food from sales of agricultural produce and/or proximity to markets (market engagement) [56]. The limited market access means that the former pathway is important for households in our rural setting, but our data show that own production of high protein foods such as meat and eggs only accounted for 30%–40% of the total consumption. Although our data did not quantify the production diversity of the households, our qualitative observation displayed a poor diversity of agricultural production, especially when it comes to livestock. As diversity of agricultural production correlates with the diversity of food available for consumption for many households in LMICs [57], the low diversity of own production may explain the prevalence of undernutrition. Besides, there is evidence in the literature (mostly for Africa, however) that the effect of market engagement on nutrition measures is even larger than agricultural diversity per se [58]. We speculate that the lack of market access and income from agricultural produce for rural households plays a role in explaining child undernutrition.

5. Discussion and Conclusions

This paper investigates the food environment in Viet Nam, using multidisciplinary data from three study sites along the rural-peri-urban-urban transect. We found significant differences in food availability across the three sites. The urban area exhibits the highest food outlet density and variety of outlets, while the rural food environment is characterized by a limited variety in which traditional independent small grocery stores make up the major share. Urban and peri-urban households enjoy a closer proximity to food service shops than rural households. In the rural area, it is not surprising to see that food service shops are not close by, as households mostly eat at home, even consuming their own food and eating out is usually associated with higher income. Overall, this finding is therefore in line with other recent studies that highlight contextual differences of food environments by taking snapshots of urban and rural food environments [23,41,59].

To explore the linkage between availability, an external food environment dimension, and personal dimensions, we characterized households' accessibility, affordability and desirability of food vendors. Besides outlet availability, households in rural areas also have much more limited access to food stores and food selection due to physical and transportation constraints. The varied affordability levels had different implications for households in the three areas, in relation to availability of food products. Households in rural areas had financial constraints to purchase more expensive products such as meat, despite availability. In peri-urban area, home grown products helped to mitigate the dependence on markets. In urban area, high availability of food outlets translates into households' easy access to

affordable products. Across the three areas, preference for selection of food destinations depends on personal factors such as habit, convenience, relationship and sometimes the need to resist temptation of a broad selection of food. Traditional open and street markets remain the most important outlets for respondents across the three study sites, a finding consistent across a number of LMICs settings [23,34,60].

We are among the first to quantify the amount of processed food consumed by households across an urban-peri-urban-rural transect in Viet Nam. Contrary to the common concern that urban households are the major consumers of processed foods due to modernization and supermarketization [61–63], we found that households in peri-urban and rural areas on average had higher consumption of ultra-processed foods than in urban area. This is revealing, considering the more recent acknowledgement that the risk of double burden of malnutrition is starting to concentrate among people with low incomes in rural areas [64] and rising rural body-mass index is the main driver of the global obesity epidemic in adults [65]. The low price levels of processed foods, as well as lower quality of processed foods in rural area may help to explain the higher consumption in rural areas. The presence of processed foods even among the traditional convenience stores, those in closest proximity to the rural households, also offers a potential explanation of this result. There is therefore a need to improve upon our results with additional data, such as market prices (instead of household-reported prices) and a segmentation of processed foods based on the quality and nutritional values. Future work can also explore more quantitatively the relationship between processed food consumption and other food environment characteristics. For example, refrigerator ownership, a proxy for convenience, was found to be connected with increased capacity to store higher nutrient foods such as dairy among Vietnamese households [66]. Chinese consumers would reduce their purchases of processed food from the locations where food safety incidents had occurred [67].

We also attempted to identify food environment dimensions that is connected to child malnutrition. First, retail diversity is poor in areas with high prevalence of child undernutrition. There is evidence in the literature that can support this claim. In Kenya, it has been found that more retailer channels increased food variety, which leads to dietary diversity, which in turns helps lower child undernutrition [68]. In Zambia, expenditure in modern retailers was positively associated with height in children, mainly through higher consumption of meat and dairy [69]. Second, rural household's level of dependence on own production demands attention. Although household's subsistence farming may have various pathways of impact on child nutrition, recent evidence in rural northern Viet Nam has shown that the direct pathway via consumption of households' own food production did not have an effect on the child's malnutrition status. Instead, the indirect pathway via consumption of diverse food due to market access and/or sales of agricultural produce was found to be important in reducing the probability of children being stunted and underweight [70]. The lack of market access and monetization from agricultural produce for rural households, as well as low diversity of agricultural production is limiting the opportunities for improving nutritional status of their children. As we do not have sufficient data to back these speculative ideas, further work is needed to confirm these.

The study has several data limitations. The household survey was a multi-purpose questionnaire designed for several purposes and serving different components of an overarching research program (The CGIAR Agriculture for Nutrition and Health A4NH in Viet Nam). It did not cover the broad spectrum of the food environment domains that ideally should be covered, for example marketing, which is an important component of the external food environment that can be manipulated to address healthier consumption [71], or convenience, which is in need of clear indicators to distinguish it from the concept of accessibility. Besides, household GPS locations were collected mainly as means to control data quality and enumerators' diligence, rather than to collect the exact address of the household. Some enumerators had to conduct surveys in a central location in the village instead of at respondents' house. The exact location of the household was then unknown and excluded from the analysis. We therefore ended up with fewer valid data points for

our estimation of proximity and for inputs into the regressions. This caused potential selection bias in Table 5 (distance from a household to the closest food retail outlet). As the food environment has been considered a predictor of child overweight in a number of settings [37,38], our lack of statistical significance points to the need for more research with a larger sample size for a more affirmative conclusion.

Our operationalization of proximity could be improved. First, we only covered the outlets within the administrative boundary of the surveyed villages. For example, in the urban site there might be a wet market only 2 km away from the household but, being located in another administrative boundary, the wet market fell out of the scope of the transect walk. In the literature, the same approach has been used for larger administrative areas such as a city [30]. Alternative approaches that future studies can consider for smaller administrative areas include mapping outlets within walking distance from respondents' home [31,72]. Second, the straight-line distances do not take into account the cost and time required to reach the food destination, consequently not representing accessibility to food destinations. This consideration is especially important for the rural site, where road conditions are poor especially in rainy seasons. The accessibility gap is therefore even greater than what the numbers convey. We used qualitative interviews to supplement for this drawback. Future studies can quantify the accessibility dimension better by bringing in temporality of the food system, e.g., accounting for seasonal changes and mobility of food vendors over time [73]. It has also been suggested that the framework by Turner et al. (2018) should be complemented with how stable the food environment characteristics are against seasonal fluctuations and variations in climate [18].

Future research would benefit from more detailed analysis of processed food consumption. Due to the absence of a food composition table for processed food in Viet Nam, we could not break down the total amount into more detailed nutritional values, which would allow a more meaningful comparison among the areas. More detailed nutritional value calculations would also enable us to assess how much macronutrients and micronutrients obtained by a household is derived from processed foods, for example average dietary contribution of ultra-processed foods (expressed as a percentage of the total caloric value of the diet) [74].

The scope of this study is limited. Processed food consumption has been strongly linked to weight gain and many prevalent non-communicable diseases including diabetes, hypertension, coronary heart disease [64]. This study did not collect data on such health outcomes to cover the causal pathways of how food environment dimensions can influence health outcomes. Additionally, although food system outcomes cover not only nutritional and health but also socio-economic and environmental dimensions, our study only focuses on how food environment influences consumption outcomes. A companion paper under the same overarching study has attempted to compare environmental impacts of diets and food choices among the three sites and suggested a trade-off between nutritional and environmental outcomes [75]. Future research is challenged to find solutions regarding the food environment that helps to improve diet quality without sacrificing environmental goals.

Implications for Policies and Practices

In the last 10 years, policies in Vietnam to develop the retailing system have focused on “modernization” of food outlets, especially in urban areas and parts of peri-urban areas, by expansion of supermarkets, opening of convenience stores, upgrading of wet markets in modern style, and reduction of informal wet markets. One of the reasons for this plan is to improve food safety and diversify the retailing system. Some studies have shown the inadequacy of the reformed retail system, especially “modernization” of traditional markets, to shopping habits and purchasing power of Vietnamese [72]. Moreover, in addition to benefits of the retail diversity that the system offers, attention has been paid to the potential trade-offs between the expanded modern retail system and increased consumption of unhealthy products (like processed foods). In our study, we observed both reservations towards supermarkets for the range of unhealthy foods on offer, and

the prevalence of unhealthy food even in traditional convenience stores in the rural area. This is similar to a finding in Zambia [76] suggesting that modern retailers are not the only drivers of dietary transitions. This observation necessitates a redirection of attention to both traditional and so-called modern outlets to ensure food providers in all locations are offering healthy foods to local populations. National and international responses to undernutrition and obesity should be integrated and the focus undernutrition should be broadened, to enhance access to healthier foods in poor rural and urban communities [65].

The research shows a high consumption of unhealthy foods (processed foods) across three sites and the high availability of those foods in many convenience stores, both traditional and new style. In rural area, the low price of a number of processed foods, such as biscuits, cakes and ice-creams and the close access to convenience shops selling these unhealthy foods is a worrying observation. This pattern has been observed in food deserts in high-income countries, where low-income neighborhoods typically have access to fast food chains and outlets selling ultra-processed food. As Viet Nam has been experiencing an upward trend in consumption of processed food, consumers will be unlikely to reduce purchasing those foods in the near future without extra measures [77]. Solutions that target both consumers and retailers, such as nutrition labeling, can help to improve the transparency in communicating about the nutritional values of processed foods. Other initiatives that target unhealthy processed foods directly could be beneficial, such as taxation on sugar sweetened beverages (SSB). It has been projected that a 10% SSB tax will reduce SSB consumption by 11.4% in Vietnam, and that consumers will switch to substitutes, leading to an increase in the consumption of milk, beer, dried tea and wine by 1.7% [78]. As the food processing sector, as well as retailers and distributors of processed food can generate employment, policies should take into full account the broad spectrum of associated costs and benefits involved in targeting processed foods.

Traditional markets (including formal open markets and informal street markets) are common food outlets across the rural-urban transect. In our research, a large proportion of these outlets have supplied healthy foods. Traditional markets have been recently given much attention in the development strategy with a vision to 2030 by Ministry of Industry and Trade. However, investments to upgrade those food outlets have generally decreased as compared with previous time [79]. The role of the central government and local authority in developing policies that aims at upgrading and developing traditional markets is very important, for example in improving the hygiene conditions and organizational capacity of such markets. In addition, campaigns for awareness raising and behavior change for consumers need to be done and improved to increase a demand and a willingness to consume safe and nutritious foods with a higher price. As we observed that most of households often buy food in shops close to home and particularly in the rural area, far distances to food outlets and poor infrastructure (especially roads) are barriers for local consumers to access nutritious foods, the government should continue to prioritize investments in improving the transportation system in poor areas to increase food access.

Our research indicates higher purchasing power of urban consumers in comparison to peri-urban and rural counterparts via higher level of monthly household income. While urban households depend almost entirely on market-based food sources for their food, a quite large proportion of food expenditure in peri-urban and rural households is from their own production. This has important implications when income shocks hit. The ongoing COVID-19 pandemic, which has generally reduced income of Vietnamese households, illustrates this. The pandemic has disrupted food supply chains due to social distancing campaigns and lockdowns or closer surveillance of many traditional markets [80,81]. This situation might lead to changes in food consumption structure amongst the three sites, especially negatively affecting the urban poor who mainly depend on informal food systems (e.g., increased prices of food, unready for online shopping, supermarkets are not suitable) [82] and peri-urban and rural producers as well (e.g., increased prices of agricultural inputs and food processing materials) [80]. Rural households' income has been reduced by 35%–40%, causing a reduction in expenditure and the high dependence on

savings account or money borrowed from friends or relatives to cover their basic needs (including food) [80,83]. Smallholder households whose main income sources come from non-farm activities were most negatively affected [80]. In its attempts, the government should continue with quick responses to the COVID-19, while simultaneously ensuring the central role of the food environment and consumers' right of food access.

By 2025, Vietnam aims to reduce the childhood malnutrition and stunting rate to less than 20% and the obesity rate among children to less than 12%. Future policies such as the National Nutrition Strategy 2021–2030 can use the evidence provided in this paper to advocate for better food environment and nutrition-sensitive approach integrated into the new strategy. Increasing diversity of the retail environment in rural areas can lead to better diet diversity, which in turn may lower the prevalence of malnutrition. For example, specialized outlets that sell more nutritious foods, such as dairy products, would help rural households to improve their dietary diversity score, which is usually lower than their peri-urban and urban counterparts due to less regular consumption of dairy products. Increasing access to a larger diversity of sellers can also be achieved through transport system improvement, which serves the dual role of increasing market access to generate more household income to improve malnutrition. As the economic and food system impacts of COVID-19 are likely to worsen the nutritional indicators across the Asia-Pacific region, continued work on food environment research is needed to provide more timely and dynamic evidence to inform strong policies [84]. These policy efforts will support progress on all SDGs, beyond SDG2 on ending hunger [85].

In peri-urban and rural area, the extra source of agricultural products produced and rapidly supplied by local people themselves plays an important role in contribution for nutrition and health improvement. Part of this produce is sold in traditional food outlets in the areas. However, the recent reduction of agricultural areas is observed in peri-urban areas due to the urbanization process and the development of industrial zones raising concerns about food provision for inner citizens and livelihoods of peri-urban farmers [86]. Therefore, local planning policy should consider the maintaining of food supply to urban areas, such as setting aside agricultural zones.

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Appendix A

Table A1. Classification of Outlets.








Type of Food Outlet	Definition
Convenience stores (traditional grocery stores for food or drink)	Small format store that sells only one or two ranges of products and is typically privately owned.
	
Convenience stores (traditional independent small grocery stores)	Small non-chain grocery store that is typically independently owned and operated. Sells mostly processed foods and beverages of popular brands and common foodstuffs.
	
Informal street markets (small-scale street vendors and pop-up semi-permanent stands)	Vendor who sells from a table, stand, cart, or stall that can be moved, but generally stays in one place during the day. Typically selling: banh tieu (donuts), sausages, Banh Mi (sandwiches), broken rice cake and raw meat like pork and chicken.
	
Informal street markets (mobile vendors)	Small-scale vendors operating on foot, bike/motorbike/truck who move around during the day. Temporary sale of food in unexpected places for a limited time.
	

Table A1. Cont.

Type of Food Outlet	Definition
Formal open markets (wet markets)	A market formally established by local authorities feature diverse vendors selling a variety of fresh food products often on a tiny space (1–5 m ²). Vendors do not need a business license nor a store setup.
	
Convenience stores (new style)	Small, modern store with 1–2 cash registers selling convenience food, typically franchised. Other characteristics: self-service, clear price tag, employees run the store.
	
Bakery	Sells (and sometimes produces) flour-based foods baked in an oven such as bread, cookies, cakes, pastries, and/or pies.
	
Specialized shops (fruit and vegetable shops)	Mainly sells fresh produce, e.g., fruit, vegetables, or both.
	
Local beer corner (“Bia hoi”)	Place with small plastic furniture on street corners and drink home-brewed beer and many also serve fast food like grilled dried squid and fermented sausages.
	

Table A1. Cont.

Type of Food Outlet	Definition
Restaurants and diners 	Place where people pay to sit and eat. Meals are cooked and served on the premises and there is typically a wide range of menu options. Often with inside eating option.
Casual dining restaurants 	Typically provide table service, have a limited menu, and are affordable and fast. Typically selling: Pho, Banh mi, Rice with vegetables and meat, Bun cha, Bun Bo Nam Bo.
Cafés 	Sell coffee, tea, cakes, and sometimes sandwiches and light meals.

Appendix B

Table A2. Food outlets where grains, roots, and tubers are available (%).

Food Stores	Rural	Peri-Urban	Urban
Convenience stores (traditional grocery store for food and drink)	-	69.6	75.0
Convenience stores (traditional independent small grocery stores)	33.3	93.1	80.4
Informal street markets (small-scale street vendors and pop-up semi-permanent stands)	-	20.0	28.1
Formal open markets (wet markets)	-	100.0	-
Convenience stores (new style)	-	100.0	85.7
Bakery	-	100.0	100.0

Table A3. Food outlets with flesh foods available (%).

Food Stores	Rural	Peri-Urban	Urban
Convenience stores (traditional grocery store for food and drink)	-	4.3	-
Convenience stores (traditional independent small grocery stores)	60.0	19.7	10.6
Informal street markets (small-scale street vendors and pop-up semi-permanent stands)	-	50.0	38.5
Formal open markets (wet markets)	-	100.0	-
Convenience stores (new style)	-	100.0	100.0

Table A4. Food outlets with fruits available (%).

Food Stores	Rural	Peri-Urban	Urban
Convenience stores (traditional grocery store for food and drink)	-	4.3	37.5
Convenience stores (traditional independent small grocery stores)	30.0	5.5	12.7
Informal street markets (small-scale street vendors and pop-up semi-permanent stands)	-	25.0	64.9
Formal open markets (wet markets)	-	100.0	-
Convenience stores (new style)	-	100.0	100.0
Specialized shops (fruit and vegetable shops)	-	100.0	100.0

Table A5. Food outlets with vegetables available (%).

Food Stores	Rural	Peri-Urban	Urban
Convenience stores (traditional grocery store for food and drink)	-	4.3	25.0
Convenience stores (traditional independent small grocery stores)	53.4	9.6	14.9
Informal street markets (small-scale street vendors and pop-up semi-permanent stands)	-	35.0	36.8
Formal open markets (wet markets)	-	100.0	-
Convenience stores (new style)	-	100.0	100.0
Specialized shops (fruit and vegetable shops)	-	90.9	-

Table A6. Food outlets with eggs, tofu, nuts and seeds or legumes/beans available (%).

Food Stores	Rural	Peri-Urban	Urban
Convenience stores (traditional grocery store for food and drink)	-	4.3	37.5
Convenience stores (traditional independent small grocery stores)	45.0	51.4	29.8
Informal street markets (small-scale street vendors and pop-up semi-permanent stands)	-	20.0	14.1
Formal open markets (wet markets)	-	100.0	-
Convenience stores (new style)	-	100.0	100.0
Specialized shops (fruit & vegetable shops)	-	72.7	-

Table A7. Food outlets with chips, candy and soda available (%).

Food Stores	Rural	Peri-Urban	Urban
Convenience stores (traditional grocery store for food and drink)	-	73.9	0.0
Convenience stores (traditional independent small grocery stores)	78.0	98.6	93.7
Informal street markets (small-scale street vendors and pop-up semi-permanent stands)	-	5.0	1.7
Formal open markets (wet markets)	-	100.0	-
Convenience stores (new style)	-	100.0	85.7
Bakery	-	22.2	100.0

Table A8. Food stores with dairy and/or their alternatives available (%).

Food Stores	Rural	Peri-Urban	Urban
Convenience stores (traditional grocery store for food and drink)	-	8.7	0.0
Convenience stores (traditional independent small grocery stores)	35.5	94.4	65.9
Formal open markets (wet markets)	-	100.0	-
Convenience stores (new style)	-	100.0	100.0
Bakery	-	37.5	16.7

Table A9. Food stores with oils available (%).

Food Stores	Rural	Peri-Urban	Urban
Convenience stores (traditional grocery store for food and drink)	-	0.0	12.5
Convenience stores (traditional independent small grocery stores)	37.5	73.6	74.5
Informal street markets (small-scale street vendors and pop-up semi-permanent stands)	-	5.0	3.4
Formal open markets (wet markets)	-	100.0	-
Convenience stores (new style)	-	100.0	85.7

Appendix C

Table A10. Average Consumption of Processed Foods, by Food Item and Area.

Food Item	Rural	Peri-Urban	Urban
Breads (bakery)	0.212 ^a	0.606 ^b	0.617 ^b
Biscuits (cookies)	0.066 ^a	0.100 ^a	0.064 ^a
Cakes and pastries	0.050 ^a	0.134 ^a	0.075 ^a
Sweets (Chocolate, candies, etc)	0.159 ^a	0.219 ^{a,b}	0.071 ^b
Chips and similar snacks ("bim bim")	0.255 ^a	0.132 ^b	0.099 ^b
Soft drinks	1.015 ^a	0.474 ^b	0.367 ^b
Ice-cream	0.169 ^a	0.193 ^a	0.120 ^a
Sausages	0.089 ^a	0.178 ^a	0.120 ^a
Pressed, spiced meats	0.172 ^a	0.366 ^b	0.226 ^a
Salted/Cured/Smoked meats	0.037 ^a	0.021 ^a	0.014 ^a
Other processed meat (chicken nuggets, sausages, burger)	0.009 ^a	0.083 ^{a,b}	0.122 ^b
Mayonnaise	0 ^a	0.003 ^b	0.018 ^b
Canned vegetables and fruits	0.033 ^a	0.024 ^a	0.022 ^a

Table A10. Cont.

Food Item	Rural	Peri-Urban	Urban
Instant noodles	0.659 ^a	0.464 ^b	0.329 ^c
Canned or dehydrated soups, stews and pot noodle	0.048 ^a	0.013 ^{a,b}	0.009 ^b
Sugared breakfast cereals	0.071 ^{a,b}	0.038 ^a	0.199 ^b
Sugared milk beverages	0.806 ^a	1.110 ^b	0.774 ^a
Jams (preserves)	0.002 ^a	0.005 ^a	0.010 ^a
Infant formulas and other baby food	0.040 ^a	0.325 ^b	0.267 ^b

Note: the values marked with the same letter are not significantly different at $p < 0.05$.

Appendix D

Table A11. Effect of Food Environment Dimensions on Underweight Status.

Average Marginal Effect	Probability of Having an Underweight Child
Density of food outlets	0.00 (0.01)
Diversity of food outlets	−0.08 ^{**} (0.03)
Food expenditure per capita	−0.00 ^{**} (0.00)
Household size	−0.00 (0.01)
Knowledge score	−0.00 (0.00)
Age of household head	−0.00 (0.00)
Observations	108
Pseudo_R-squared	0.447

Cluster robust standard errors in parentheses; ^{**} $p < 0.05$.

References

1. FAO; IFAD; UNICEF; WFP; WHO. *The State of Food Security and Nutrition in the World 2019. Safeguarding against Economic Slowdowns and Downturns*; FAO: Rome, Italy, 2019; Volume 10.
2. HLPE. *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*; FAO: Rome, Italy, 2017.
3. FAO. *Influencing Food Environments for Healthy Diets*; FAO: Rome, Italy, 2016.
4. Fanzo, J. Healthy and Sustainable Diets and Food Systems: The Key to Achieving Sustainable Development Goal 2? *Food Ethics* **2019**, *4*, 159–174. [[CrossRef](#)]
5. FAO; IFAD; UNICEF; WFP; WHO. *The State of Food Security and Nutrition in the World 2018. Building Climate Resilience for Food Security and Nutrition*; FAO: Rome, Italy, 2018; ISBN 9789251305713.
6. Caspi, C.E.; Sorensen, G.; Subramanian, S.V.; Kawachi, I. The local food environment and diet: A systematic review. *Health Place* **2012**, *18*, 1172–1187. [[CrossRef](#)] [[PubMed](#)]
7. Gamba, R.J.; Schuchter, J.; Rutt, C.; Seto, E.Y.W. Measuring the Food Environment and its Effects on Obesity in the United States: A Systematic Review of Methods and Results. *J. Community Health* **2015**, *40*, 464–475. [[CrossRef](#)]
8. Lytle, L.A.; Sokol, R.L. Measures of the food environment: A systematic review of the field, 2007–2015. *Health Place* **2017**, *44*, 18–34. [[CrossRef](#)] [[PubMed](#)]
9. Popkin, B.M.; Adair, L.S.; Ng, S.W. Global nutrition transition and the pandemic of obesity in developing countries. *Nutr. Rev.* **2012**, *70*, 3–21. [[CrossRef](#)] [[PubMed](#)]
10. Popkin, B.M.; Hawkes, C. Sweetening of the global diet, particularly beverages: Patterns, trends, and policy responses. *Lancet Diabetes Endocrinol.* **2016**, *4*, 174–186. [[CrossRef](#)]
11. Global Panel on Agriculture and Food Systems for Nutrition. *Food Systems and Diets: Facing the Challenges of the 21st Century*; Global Panel on Agriculture and Food Systems for Nutrition: London, UK, 2016; ISBN 9780995622807.
12. Turner, C.; Kalamatianou, S.; Drewnowski, A.; Kulkarni, B.; Kinra, S.; Kadiyala, S. Food Environment Research in Low- and Middle-Income Countries: A Systematic Scoping Review. *Adv. Nutr.* **2020**, *11*, 387–397. [[CrossRef](#)]

13. Le Nguyen, B.K.; Le Thi, H.; Nguyen Do, V.A.; Tran Thuy, N.; Nguyen Huu, C.; Thanh Do, T.; Deurenberg, P.; Khouw, I. Double burden of undernutrition and overnutrition in Vietnam in 2011: Results of the SEANUTS study in 0-5–11-year-old children. *Br. J. Nutr.* **2013**, *110*, S45–S56. [[CrossRef](#)]
14. Nguyen, T.T.; Hoang, M. V Non-communicable diseases, food and nutrition in Vietnam from 1975 to 2015: The burden and national response. *Asia Pac. J. Clin. Nutr.* **2018**, *27*, 19–28.
15. Vietnam National Institute of Nutrition; UNICEF; Alive & Thrive. *Nutrition Surveillance Profiles 2013*; Vietnam National Institute of Nutrition: Hanoi, Vietnam, 2014.
16. World Bank Group. *World Bank Transforming Vietnamese Agriculture: Gaining More from Less*; Vietnam Dev. Rep. 2016; World Bank Group: Washington, DC, USA, 2016.
17. Turner, C.; Aggarwal, A.; Walls, H.; Herforth, A.; Drewnowski, A.; Coates, J.; Kalamatianou, S.; Kadiyala, S. Concepts and critical perspectives for food environment research: A global framework with implications for action in low- and middle-income countries. *Glob. Food Sec.* **2018**, *18*, 93–101. [[CrossRef](#)]
18. Constantinides, S.V.; Turner, C.; Frongillo, E.A.; Bhandari, S.; Reyes, L.I.; Blake, C.E. Using a global food environment framework to understand relationships with food choice in diverse low- and middle-income countries. *Glob. Food Sec.* **2021**, *29*, 100511. [[CrossRef](#)]
19. Herforth, A.; Ahmed, S. The food environment, its effects on dietary consumption, and potential for measurement within agriculture-nutrition interventions. *Food Secur.* **2015**, *7*, 505–520. [[CrossRef](#)]
20. Fuster, M.; Messer, E.; Houser, R.F.; Deman, H.; De Fulladolsa, P.P.; Bermudez, O.I. Local Notions of Healthy Eating and National Dietary Guidelines: A Comparison in Vulnerable Salvadoran Communities. *Food Foodways* **2013**, *21*, 288–314. [[CrossRef](#)]
21. Reardon, T.; Hopkins, R. The supermarket revolution in developing countries: Policies to address emerging tensions among supermarkets, suppliers and traditional retailers. *Eur. J. Dev. Res.* **2006**, *18*, 522–545. [[CrossRef](#)]
22. Wertheim-Heck, S.C.O.; Vellema, S.; Spaargaren, G. Food safety and urban food markets in Vietnam: The need for flexible and customized retail modernization policies. *Food Policy* **2015**, *54*, 95–106. [[CrossRef](#)]
23. Liao, C.; Tan, Y.; Wu, C.; Wang, S.; Yu, C.; Cao, W.; Gao, W.; Lv, J.; Li, L. City Level of Income and Urbanization and Availability of Food Stores and Food Service Places in China. *PLoS ONE* **2016**, *11*, e0148745. [[CrossRef](#)]
24. Kelly, M.; Seubsman, S.A.; Banwell, C.; Dixon, J.; Sleigh, A. Thailand’s food retail transition: Supermarket and fresh market effects on diet quality and health. *Br. Food J.* **2014**, *116*, 1180–1193. [[CrossRef](#)]
25. Banwell, C.; Kelly, M.; Dixon, J.; Seubsman, S.A.; Sleigh, A. Trust: The Missing Dimension in the Food Retail Transition in Thailand. *Anthropol. Forum* **2016**, *26*, 138–154. [[CrossRef](#)]
26. Chaudhari, L.S.; Begay, R.C.; Schulz, L.O. Fifteen years of change in the food environment in a rural Mexican community: The Maycoba project. *Rural Remote Health* **2013**, *13*, 2404. [[CrossRef](#)]
27. Heim, A. Food Environment Research among an Indigenous Community in Namibia—A New Approach to Explore Food Security of Rural People in Developing Countries. *J. Hunger. Environ. Nutr.* **2019**, *14*, 1–20. [[CrossRef](#)]
28. FAO. *Growing Greener Cities in Latin America and the Caribbean: An FAO Report on Urban and Peri-Urban Agriculture in the Region*; FAO: Rome, Italy, 2019.
29. Liu, J.; Shively, G.E.; Binkley, J.K. Access to variety contributes to dietary diversity in China. *Food Policy* **2014**, *49*, 323–331. [[CrossRef](#)]
30. Zhong, T.; Si, Z.; Crush, J.; Xu, Z.; Huang, X.; Scott, S.; Tang, S.; Zhang, X. The Impact of Proximity to Wet Markets and Supermarkets on Household Dietary Diversity in Nanjing City, China. *Sustainability* **2018**, *10*, 1465. [[CrossRef](#)]
31. Duran, A.C.; de Almeida, S.L.; do Latorre, M.R.D.O.; Jaime, P.C. The role of the local retail food environment in fruit, vegetable and sugar-sweetened beverage consumption in Brazil. *Public Health Nutr.* **2016**, *19*, 1093–1102. [[CrossRef](#)]
32. Surendran, S.; Selvaraj, K.; Turner, C.; Addanki, S.; Kannuri, N.K.; Debbarma, A.; Kadiyala, S.; Kinra, S.; Walls, H. Characterising the fruit and vegetable environment of peri-urban Hyderabad, India. *Glob. Food Sec.* **2020**, *24*, 100343. [[CrossRef](#)]
33. Kimoto, R.; Ronquillo, D.; Caamaño, M.C.; Martinez, G.; Schubert, L.; Rosado, J.L.; Garcia, O.; Long, K.Z. Food, eating and body image in the lives of low socioeconomic status rural Mexican women living in Queretaro State, Mexico. *Health Place* **2014**, *25*, 34–42. [[CrossRef](#)] [[PubMed](#)]
34. Peyton, S.; Moseley, W.; Battersby, J. Implications of supermarket expansion on urban food security in Cape Town, South Africa. *African Geogr. Rev.* **2015**, *34*, 36–54. [[CrossRef](#)]
35. Maxfield, A.; Patil, S.; Cunningham, S.A. Globalization and Food Prestige among Indian Adolescents. *Ecol. Food Nutr.* **2016**, *55*, 341–364. [[CrossRef](#)] [[PubMed](#)]
36. Hunter-Adams, J. Exploring Perceptions of the Food Environment Amongst Congolese, Somalis and Zimbabweans Living in Cape Town. *Int. Migr.* **2017**, *55*, 78–87. [[CrossRef](#)]
37. Hua, J.; Seto, E.; Li, Y.; Wang, M.C. Development and evaluation of a food environment survey in three urban environments of Kunming, China. *BMC Public Health* **2014**, *14*, 1–18. [[CrossRef](#)] [[PubMed](#)]
38. Zhang, J.; Xue Phd, H.; Ma, X.C.; Wang, Z.; Zhai, F.; Wang, Y.; Wang, H. Influence of proximities to food establishments on body mass index among children in China. *Asia Pac. J. Clin. Nutr.* **2016**, *25*, 134–141. [[CrossRef](#)] [[PubMed](#)]
39. Dake, F.A.A.; Thompson, A.L.; Ng, S.W.; Agyei-Mensah, S.; Codjoe, S.N.A. The Local Food Environment and Body Mass Index among the Urban Poor in Accra, Ghana. *J. Urban Health* **2016**, *93*, 438–455. [[CrossRef](#)]

40. Wang, R.; Shi, L. Access to food outlets and children's nutritional intake in urban China: A difference-in-difference analysis. *Ital. J. Pediatr.* **2012**, *38*, 1–7. [[CrossRef](#)]
41. Spires, M.; Berggreen-Clausen, A.; Xavier Kasujja, F.; Delobelle, P.; Puoane, T.; Sanders, D.; Daivadanam, M. Snapshots of Urban and Rural Food Environments: EPOCH-Based Mapping in a High-, Middle-, and Low-Income Country from a Non-Communicable Disease Perspective. *Nutrients* **2020**, *12*, 484. [[CrossRef](#)]
42. Wang, H.; Liu, C.; Fan, H.; Tian, X. Rising food accessibility contributed to the increasing dietary diversity in rural and urban China. *Asia Pac. J. Clin. Nutr.* **2017**, *26*, 738–747. [[CrossRef](#)] [[PubMed](#)]
43. Davies, G.; Frausin, G.; Parry, L. Are There Food Deserts in Rainforest Cities? *Ann. Am. Assoc. Geogr.* **2017**, *107*, 794–811. [[CrossRef](#)]
44. Anggraini, R.; Februhartanty, J.; Bardosono, S.; Khusun, H.; Worsley, A. Food Store Choice among Urban Slum Women Is Associated with Consumption of Energy-Dense Food. *Asia Pac. J. Public Health* **2016**, *28*, 458–468. [[CrossRef](#)]
45. Bridle-Fitzpatrick, S. Food deserts or food swamps?: A mixed-methods study of local food environments in a Mexican city. *Soc. Sci. Med.* **2015**, *142*, 202–213. [[CrossRef](#)]
46. Finzer, L.E.; Ajay, V.S.; Ali, M.K.; Shivashankar, R.; Goenka, S.; Sharma, P.; Pillai, D.S.; Khandelwal, S.; Tandon, N.; Reddy, K.S.; et al. Fruit and Vegetable Purchasing Patterns and Preferences in South Delhi. *Ecol. Food Nutr.* **2013**, *52*, 1–20. [[CrossRef](#)]
47. de Haan, S.; Huynh, T.T.T.; Duong, T.T.; Rubin, J. Defining the Benchmark Research Sites (Rural to Urban Transect) in Vietnam Flagship 1—Food Systems for Healthier Diets Agriculture for Nutrition and Health (A4NH) Program. Available online: <https://cgsp.space.cgiar.org/handle/10568/113150> (accessed on 4 August 2021).
48. Drewnowski, A.; Aggarwal, A.; Hurvitz, P.M.; Monsivais, P.; Moudon, A. V Obesity and Supermarket Access: Proximity or Price? *Am. J. Public Health* **2012**, *102*, 74–80. [[CrossRef](#)] [[PubMed](#)]
49. Neve, K.; Hawkes, C.; Brock, J.; Spires, M.; Squires, C.G.; Sharpe, R.; Battersby, J.; Chaboud, G.; Chung, A. *Understanding Lived Experience of Food Environments to Inform Policy: An Overview of Research Methods*; Centre for Food Policy: London, UK, 2021.
50. WHO. WHO Child Growth Standards. *Dev. Med. Child Neurol.* **2009**, *51*, 1002. [[CrossRef](#)]
51. WHO. WHO Interpretation Guide Nutrition Landscape Information System (NLIS) Country Profile Indicators; WHO: Geneva, Switzerland, 2010; p. 50.
52. UNSCN. *Investments for Healthy Food Systems—Implementing the Framework for Action of the Second International Conference on Nutrition*; UNSCN: Rome, Italy, 2016.
53. Monteiro, C.A.; Levy, R.B.; Claro, R.M.; de Castro, I.R.R.; Cannon, G. A new classification of foods based on the extent and purpose of their processing. *Cad. Saude Publ.* **2010**, *26*, 2039–2049. [[CrossRef](#)]
54. UNICEF. *Improving Child Nutrition: The Achievable Imperative for Global Progress*; UNICEF: New York, NY, USA, 2013; ISBN 978-92-806-4686-3.
55. Mbuya, N.V.N.; Atwood, S.J.; Huynh, P.N. *Persistent Malnutrition in Ethnic Minority Communities of Vietnam: Issues and Options for Policy and Interventions*; World Bank: Washington, DC, USA, 2019; ISBN 978-1-4648-1432-7.
56. Ruel, M.T.; Alderman, H. Nutrition-sensitive interventions and programmes: How can they help to accelerate progress in improving maternal and child nutrition? *Lancet* **2013**, *382*, 536–551. [[CrossRef](#)]
57. Fanzo, J. Strengthening the engagement of food and health systems to improve nutrition security: Synthesis and overview of approaches to address malnutrition. *Glob. Food Sec.* **2014**, *3*, 183–192. [[CrossRef](#)]
58. Nandi, R.; Nedumaran, S.; Ravula, P. The interplay between food market access and farm household dietary diversity in low and middle income countries: A systematic review of literature. *Glob. Food Sec.* **2021**, *28*, 100484. [[CrossRef](#)]
59. Wu, Y.; Xue Phd, H.; Wang, H.; Phd, C.S.; Du Phd, S.; Wang, Y. The impact of urbanization on the community food environment in China. *Asia Pac. J. Clin. Nutr.* **2017**, *26*, 504–513. [[CrossRef](#)] [[PubMed](#)]
60. Kelly, M. The Nutrition Transition in Developing Asia: Dietary Change, Drivers and Health Impacts. In *Eating, Drinking: Surviving: The International Year of Global Understanding—IYGU*; Jackson, P., Spiess, W.E.L., Sultana, F., Eds.; Springer International Publishing: Cham, Germany, 2016; pp. 83–90. ISBN 978-3-319-42468-2.
61. Popkin, B.M. Global nutrition dynamics: The world is shifting rapidly toward a diet linked with noncommunicable diseases. *Am. J. Clin. Nutr.* **2006**, *84*, 289–298. [[CrossRef](#)] [[PubMed](#)]
62. Wagner, K.H.; Brath, H. A global view on the development of non communicable diseases. *Prev. Med.* **2012**, *54* (Suppl. S1), S38–S41. [[CrossRef](#)]
63. World Health Organization. *Global Report on Urban Health: Equitable, Healthier Cities for Sustainable Development*; WHO: Geneva, Switzerland, 2016.
64. Popkin, B.M.; Corvalan, C.; Grummer-Strawn, L.M. Dynamics of the double burden of malnutrition and the changing nutrition reality. *Lancet* **2020**, *395*, 65–74. [[CrossRef](#)]
65. Bixby, H.; Bentham, J.; Zhou, B.; Di Cesare, M.; Paciorek, C.J.; Bennett, J.E.; Taddei, C.; Stevens, G.A.; Rodriguez-Martinez, A.; Carrillo-Larco, R.M.; et al. Rising rural body-mass index is the main driver of the global obesity epidemic in adults. *Nature* **2019**, *569*, 260–264. [[CrossRef](#)]
66. Heard, B.R.; Thi, H.T.; Burra, D.D.; Heller, M.C.; Miller, S.A.; Duong, T.T.; Simioni, M.; Jones, A.D. The Influence of Household Refrigerator Ownership on Diets in Vietnam. *Econ. Hum. Biol.* **2020**, *39*, 100930. [[CrossRef](#)]
67. Liu, A.; Niyongira, R. Chinese consumers food purchasing behaviors and awareness of food safety. *Food Control* **2017**, *79*, 185–191. [[CrossRef](#)]

68. Debela, B.L.; Demmler, K.M.; Klasen, S.; Qaim, M. Supermarket food purchases and child nutrition in Kenya. *Glob. Food Sec.* **2020**, *25*, 100341. [[CrossRef](#)]
69. Khonje, M.G.; Ecker, O.; Qaim, M. Effects of Modern Food Retailers on Adult and Child Diets and Nutrition. *Nutrients* **2020**, *12*, 1714. [[CrossRef](#)]
70. Genova, C.; Umberger, W.; Newman, S.; Peralta, A.; Zeng, D. *The Impact of Smallholder Vegetable Production on Child Nutrition in Rural Vietnam*; Australian Agricultural and Resource Economics Society: Vermont, Australia, 2019; Volume 63.
71. Downs, S.; Demmler, K.M. Food environment interventions targeting children and adolescents: A scoping review. *Glob. Food Sec.* **2020**, *27*, 100403. [[CrossRef](#)]
72. Wertheim-Heck, S.; Raneri, J.E.; Oosterveer, P. Food safety and nutrition for low-income urbanites: Exploring a social justice dilemma in consumption policy. *Environ. Urban.* **2019**, *31*, 397–420. [[CrossRef](#)] [[PubMed](#)]
73. Widener, M.J.; Shannon, J. When are food deserts? Integrating time into research on food accessibility. *Health Place* **2014**, *30*, 1–3. [[CrossRef](#)]
74. Baraldi, L.G.; Martinez Steele, E.; Canella, D.S.; Monteiro, C.A. Consumption of ultra-processed foods and associated sociodemographic factors in the USA between 2007 and 2012: Evidence from a nationally representative cross-sectional study. *BMJ Open* **2018**, *8*, e020574. [[CrossRef](#)]
75. Trinh, H.T.; Linderhof, V.; Vuong, V.T.; Esaryk, E.E.; Heller, M.; Dijkxhoorn, Y.; Nguyen, T.M.; Thi, T.; Huynh, T.; Hernandez, R.; et al. Diets, Food Choices and Environmental Impacts across an Urban-Rural Interface in Northern Vietnam. *Agriculture* **2021**, *11*, 137. [[CrossRef](#)]
76. Khonje, M.G.; Qaim, M. Modernization of African Food Retailing and (Un)healthy Food Consumption. *Sustainability* **2019**, *11*, 4306. [[CrossRef](#)]
77. Raneri, J.E.; Kennedy, G.; Nguyen, T.; Wertheim-Heck, S.; Do, H.; de Haan, S.; Nguyen, P.H. *Determining Key Research Areas for Healthier Diets and Sustainable Food Systems in Viet Nam*; IFPRI: Washington, DC, USA, 2019; Volume 127. [[CrossRef](#)]
78. Luong, L.; Vu, L.H. Impacts of excise taxation on non-alcoholic beverage consumption in Vietnam. *Sustainability* **2020**, *12*, 1092. [[CrossRef](#)]
79. Phu, V.V. Chợ Truyền Thống Đang Bị Bỏ Quên—Traditional Markets Are Being Neglected. Available online: <https://enternews.vn/cho-truyen-thong-dang-bi-bo-quen-149162.html> (accessed on 24 April 2021).
80. Tran, C.T.; Truong, T.T.T.; Nguyen, T.H.L.; Nguyen, T.T. Impacts of COVID-19 Pandemic on Smallholder Farmers and Vulnerable Rural People in Vietnam. Available online: <https://ap.fttc.org.tw/article/2676> (accessed on 4 August 2021).
81. World Bank. *World Bank East Asia and Pacific Economic Update, October 2020: From Containment to Recovery*; World Bank: Washington, DC, USA, 2020; ISBN 978-1-4648-1641-3.
82. Wertheim-Heck, S. The Impact of the COVID-19 Lockdown on the Diets of Hanoi’s Urban Poor. International Institute for Environment and Development. Available online: <https://www.iied.org/impact-covid-19-lockdown-diets-hanois-urban-poor> (accessed on 4 August 2021).
83. UNICEF. *Rapid Assessment on the Social and Economic Impacts of Covid-19 on Children and Families in Viet Nam*; UNICEF: Ha Noi, Viet Nam, 2020.
84. Farrell, P.; Rachmi, C.N.; Mulcahy, G.; Helble, M.; Thow, A.M. Food environment research is needed to improve nutrition and wellbeing in the Asia and the Pacific region. *Public Health Nutr.* **2021**. [[CrossRef](#)] [[PubMed](#)]
85. Furman, E.; Kaljonen, M. Sustainable Diets Enhance Progress on All Sustainable Development Goals. Available online: <https://www.un.org/en/sustainable-diets-enhance-progress-all-sustainable-development-goals> (accessed on 4 August 2021).
86. Pham, V.C.; Pham, T.T.H.; Tong, T.H.A.; Nguyen, T.T.H.; Pham, N.H. The conversion of agricultural land in the peri-urban areas of Hanoi (Vietnam): Patterns in space and time. *J. Land Use Sci.* **2015**, *10*, 224–242. [[CrossRef](#)]