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Transforming Agriculture for Improving Food and Nutrition Security among Nigerian Farm Households

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ABSTRACT

The release by the Nigerian Federal Ministry of Agriculture and Rural Development (FMARD) of the Agricultural Transformation Agenda (ATA) in 2010 and its successor strategy document, the Agriculture Promotion Policy (APP), in 2016 as official policy strategy documents signals a shift in policymaker attention toward improving the performance of the agricultural sector in the country after decades of neglect. This paper discusses the potential effects of changes in agricultural production practices due to these adjustments in strategy on food consumption, and, hence, on food security and nutrition in Nigeria. We outline the theoretical linkages between changes in agricultural production patterns by farm households and their food consumption decisions.

We assess the most recently available anthropometric data to provide context for the current extent of food insecurity and malnutrition in the country. We identify apparent imperfections in the anthropometry data, such that the measures are far outside of ranges of international peer countries. This highlights the urgent need to implement a well-structured and managed anthropometry survey. Since one is currently scheduled for implementation in 2019, it is essential that protocols that limit measurement error are strictly adhered to. Despite the apparent errors in the anthropometry data, we identify general patterns that are likely reflective of conditions on the ground, such that there is more widespread malnutrition in northern than in southern Nigeria. Our results of estimation of the relationship between dietary diversity and the height-for-age z-score suggest a weak, but statistically significant and positive relationship between these variables. This implies that efforts to improve dietary diversity in Nigeria will plausibly reduce malnutrition and improve health outcomes.

We use dietary diversity as a proxy for food and nutrition security in our econometric estimation of the relationships between agricultural production, income, and food price factors, on the one hand, and food and nutrition security, on the other. Our estimation results show a strong, positive relationships between production diversity and household dietary diversity. These results are most likely due to the direct production-consumption linkage for on-farm produced food rather than an indirect income effect that is associated with changes in agricultural production conditions. Inclusion of food price data improved model performance, but the individual food price changes had differential effects on household dietary diversity. Off-farm employment and poultry ownership were found to be positively associated with household dietary diversity. The results in the aggregate imply that broader efforts to increase household assets and reduce poverty will improve household dietary diversity, and, hence, reduce food insecurity and malnutrition.

Keywords: Agriculture, transformation, food security, nutrition, Nigeria, Africa

1. INTRODUCTION

After decades of neglect, the Government of Nigeria began to reform the agricultural sector in 2011 following the strategic direction laid out in the Agricultural Transformation Agenda (ATA) of the Federal Ministry of Agriculture and Rural Development (FMARD) (FMARD 2016). The ATA's core purpose was to help Nigeria to refocus federal government policymaker attention to agriculture, and the strategy's main goal was to rebuild the agricultural sector (FMARD 2016). The current development strategy of the agricultural sector—denoted the Agriculture Promotion Policy (APP)—builds on and refines the strategic direction of the ATA. The APP was launched in 2016 and applies for the five-year period lasting until 2020. It aims at addressing two key challenges of Nigeria's agriculture: (1) to meet the food needs of a rapidly growing population with domestically produced food; and, (2) to transform the agricultural sector so that Nigeria becomes a successful exporter of agricultural products complying with international quality standards (FMARD 2016). Thus, agricultural transformation has been at the center of Nigeria's agricultural development policy plan since the beginning of the 2010s. Agricultural transformation is a process that leads to commercially oriented farming systems, higher productivity on farm, a diversified agricultural sector to serve the various demands in domestic and export markets, and hence, stronger linkages between agriculture and other sectors of the economy.

Yet, despite its vast agricultural potential, Nigeria imports food—mostly staple foods—worth billions of US dollars annually. Many Nigerians, and even a large proportion among the farming population, lack adequate food for a healthy diet and suffer from malnutrition. The Global Hunger Index ranks Nigeria at 84 out of 119 developing countries and considers its food and nutrition insecurity as 'serious' (von Grebmer et al. 2018). Nationwide, an estimated 34 percent of all children under five years are stunted. The prevalence of stunted children is higher in farm households, an estimated 38 percent of underfives living in farm households are stunted (see Section 3). This alarmingly high prevalence of chronic child undernutrition is largely caused by inadequate nutrient intake, often in combination with inappropriate feeding practices, suboptimal child care, and infection with parasitic diseases (such as malaria, helminthiasis, and schistosomiasis). The lack of diversity in individuals' diet—in particular, vegetables, fruits, pulses, and animal-source foods—often lead to micronutrient deficiencies (Ramakrishnan 2002; Ruel 2001) that can cause child stunting (Branca and Ferrari 2002; Walker et al. 2007) and reduce cognitive functioning (Black 2003; Clausen et al. 2005; Neuman et al. 2003). While the causal factors of malnutrition in Nigeria are many, Nigerians state that the single most common shock to their livelihoods is food price increases, which reduce food affordability (NBS et al. 2016). Households typically respond to food price shocks by reducing their food consumption and particularly the consumption of higher-value, micronutrient-rich foods (NBS et al. 2016; Headey et al. 2014). Yet even transitory food shortages can have irreversible nutritional consequences, especially for children.

The severity of Nigeria's malnutrition problem calls for urgent and decisive action among government and private sector stakeholders. Nutrition-specific interventions, such as micronutrient supplementation, breastfeeding promotion, and immunization, can make an important—though limited—contribution to reduce malnutrition substantially and sustainably (Bhutta et al. 2013; Ruel et al. 2013). Nutrition-sensitive interventions, including nutrition-sensitive agricultural policies, are also needed and are likely to have broader impacts since a large segment of the population is involved in agriculture. The Government of Nigeria has recognized the critical role that a transformed agricultural sector can play in improving food and nutrition security. The APP declares food security as one of four priorities of federal agricultural policy–in addition to import substitution, job creation, and economic diversification. Promotion of nutrition-sensitive agriculture to address child undernutrition and other forms of malnutrition is a principle of the agricultural policy (FMARD 2016).

To complement the APP and to guide the activities of the FMARD and the wider agricultural sector in Nigeria toward improved food and nutrition security, the Government of Nigeria launched the ten-year Agricultural Sector Food Security and Nutrition Strategy (AFSNS) in 2016 (FMARD 2017). The AFSNS emphasizes that nutrition-specific interventions, which address the immediate causes of malnutrition – inadequate nutrient intake and infectious diseases, are necessary but insufficient for achieving adequate nutrition at large (FMARD 2017). Nutrition-sensitive interventions, which are usually implemented at scale and address the underlying causes of malnutrition, including access to a diverse diet, are needed at least as much. The AFSNS notes that "the agricultural sector especially has a unique role to play because it is the source of food; it affects the incomes of the majority of the population; [and] it influences food prices" (FMARD 2017, p. ix). It further states that "ongoing efforts to transform the agricultural sector in Nigeria especially prioritize improved food security and nutrition as a fundamental outcome" (FMARD 2017, p. ix).

The recognition of agriculture's unique role and the apparent increased political commitment to address the malnutrition problem in Nigeria, however, lacks rigorous, research-based evidence that can help the government and its development partners in policy-making. Poorly designed agricultural transformation policies may not only be ineffective in reaching intended agricultural outcomes, such as agricultural specialization and productivity growth, but can also have adverse nutritional impacts, especially when the lack of rural market integration impedes increasing separability of production and consumption decisions in farm households (see Section 2). Both the APP and AFSNS emphasize the importance of research-based evidence for setting the policy agenda and point out the lack of policy relevance in much recent research (FMARD 2016, 2017). This paper aims at narrowing this gap in the research literature, and, hence, contribute to improved, evidence-based decision making in the ongoing agricultural reform process and ultimately to accelerate progress in reducing food insecurity and malnutrition in Nigeria.

The paper has two research objectives:

- First, we review regional prevalence estimates of chronic child undernutrition and examine the correlation between dietary diversity and children's long-term nutritional status in Nigeria. Given the importance of reliable estimates for designing targeted and effective policies and programs, the accuracy of available child nutrition estimates has been a frequent subject of debate among experts and policymakers in Nigeria. We re-estimate child nutrition indicators using the most recent anthropometric data from two different surveys and compare estimates of mean child nutrition indicators and child undernutrition prevalence rates at subnational levels. In addition to adopting the official classification of states into geopolitical regions in our analysis, we present estimates of mean nutrition indicators and malnutrition prevalence rates for all children and children living in farm households by the clusters of focus states of the Feed the Future (FtF) initiative of the United States Agency for International Development (USAID) in Nigeria.

  Our analysis confirms that available child anthropometry data are generally of poor quality, and derived child nutrition estimates are, therefore, likely to be inaccurate. The poor quality of child anthropometry data is also likely to contribute to weak correlations between child nutrition indicators and dietary diversity indicators. These results imply that updated and improved anthropometric data are urgently needed.

- The second part of the analysis focuses on household dietary diversity as measure of food and nutrition security. We econometrically estimate the effects of farm production diversification and food price changes on household dietary diversity among Nigerian farm households. The econometric estimation applies household panel data that cover a five-year period, namely from 2011 to 2016, which coincides with the lifetime of the ATA. Specialization of farm production, which typically accompanies agricultural commercialization, is indicative of advancing agricultural transformation. Production specialization tends to increase farm households' dependency on food purchases for meeting their dietary needs, and, hence, to raise the responsiveness of their food consumption to food price changes. Yet agricultural commercialization usually comes along with improved integration of rural markets into the wider economy that leads to more stable and lower food prices in local markets, at least in the long term. Disentangling these dietary diversity effects provides important evidence that can help policymakers and their development partners to better assess the potential implications of agricultural transformation policies on farm households' diets.

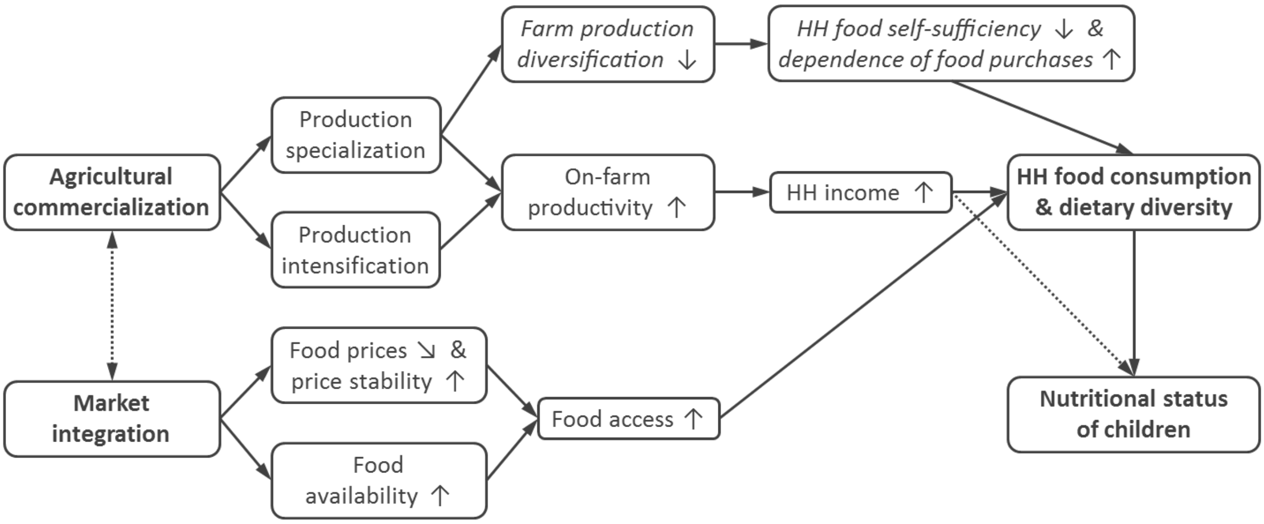
The estimation results suggest that farm production diversification remains an important strategy for farm households to meet their dietary needs. The significance of farm production diversity for household dietary diversity indicates that market failures that prevent farmers from separating farm production and household consumption decisions are persistent in rural Nigeria. The results also show differential effects of food prices on household dietary diversity. Declining real prices of local rice, white gari (cassava flour), and palm oil were associated with improved dietary diversity between 2011 and 2016, whereas declining real prices of imported rice were associated with reduced dietary diversity, possibly because of substitution effects in food consumption.

The paper proceeds as follows: In Section 2, we briefly conceptualize the main linkages between agricultural transformation and food and nutrition security. Our analysis of child nutrition estimates and correlations between child nutrition indicators and dietary diversity is presented in Section 3. In Section 4, we describe the data and methods used in the econometric analysis, and, in Section 5, we present and interpret the estimation results. We offer concluding remarks in Section 6.

2. LINKAGES BETWEEN AGRICULTURAL TRANSFORMATION AND FOOD AND NUTRITION SECURITY

Agricultural transformation is characterized by commercialization of farming systems and is often driven by urbanization and growing demand for food and other agricultural products from economic growth and a growing population (Ecker 2018). At the farm household level, increased commercialization is typically accompanied by specialization in the production of a few profitable crops or livestock products and production intensification (Figure 2.1). Production specialization and intensification usually increases on-farm productivity and household income from farming. Higher income allows households to spend more on food consumption and to afford a more diversified diet, increasing households' food and nutrition security. Improved food availability within a household and increased household dietary diversity tend to improve the nutritional status of individual household members. Higher income also allows households to spend more on basic health services and improving living conditions that can contribute to improved nutritional status.

Figure 2.1. Pathways from agricultural transformation to nutrition outcomes at the farm household level



Source: Own representation.

On the other hand, farm production specialization also leads to reduced production diversity at the farm household level and declining levels of household food self-sufficiency (Fafchamps 1992; Pingali and Rosegrant 1995).[1] This may be accompanied by reduced dietary diversity if the sacrificed diversity of foods consumed from own-production is not compensated for with market purchases. Especially in remote areas in Africa, farm households face severe market failures and high transportation costs, which commonly cause seasonal shortages of diversified foods in the local market and high prices of nutritious foods. Thus, agricultural commercialization and farm production specialization, especially into non-food 'cash crops,' can have adverse nutritional effects.

In addition to the direct production-consumption linkage, agricultural transformation can improve household food and nutrition security through enhanced access to food. Agricultural commercialization is usually accompanied by integration of rural food and agricultural markets into the wider economy. This tends to stabilize local food prices, reduce local food prices over time, and increase the availability of diverse foods in the local market. Improved access to marketed foods allows households to increase their food consumption and diversify their diets.

[1] Note that specialization at the farm household level usually leads to agricultural diversification at the sector level.

However, the link between household food security and individual nutrition—especially among young children—is not straightforward (Ecker and Breisinger 2012). Individual food and nutrient intake and dietary adequacy depend on the distribution of food within the household and the care given to meet individual dietary needs. Both intermediate determinants are influenced by characteristics and habits of the household decision maker and the person responsible for meal preparation and child feeding (Ruel and Menon 2002; Smith et al. 2003; Thomas 1990). The nutritional status of an individual is also determined by the individual's health status (and vice versa) that influences physiological nutrient requirements and interacts with the utilization of nutrients from food. For example, parasitic and diarrheal diseases cause nutrient losses through blood and stool and reduce nutrient absorption, necessitating higher nutrient intake and, thus, more food to cover the losses, if such compensation is possible at all (Katona and Katona-Apte 2008; Stephenson et al. 2000). At the same time, poor nutrition weakens the human immune system and, therewith, increases the risk of disease and illness (Black et al. 2003). Young children's nutritional status is also directly determined by the mother's nutritional and health status through the physical and social mother-child relationship.

3. CHILD UNDERNUTRITION AND DIETARY DIVERSITY IN NIGERIA

From a development perspective, malnutrition among young children is of particular concern.[2] This is because prevalence rates of most nutritional deficiencies are highest in early life due to high physiological needs. Interventions have been found to be most cost-effective if targeted at young children (and pregnant women). Moreover, the nutritional status of children is crucial for the economic prosperity of the next generation due to the life-long effects of poor early age physiological development on labor productivity (Bryce et al. 2008; Engle et al. 2007; Horton et al. 2010). Thus, the prevalence of malnutrition is a key indicator of underdevelopment (UN 2016).

3.1 Child nutrition measurements and data quality

The overall nutritional status of individuals is typically determined based on anthropometric measurements. The most commonly used anthropometric indicators for young children are height-for-age z-score (HAZ), weight-for-height z-score (WHZ), and weight-for-age z-score (WAZ). The common child age range is 0 to 59 months (or 6 to 59 months). Children are classified as stunted (too short relative to their age) if their HAZ is below –2; they are classified as wasted (too light relative to their height) if their WHZ is below –2; and they are classified as underweight if their WAZ is below –2. Children are classified as severely stunted, wasted, or underweight if their HAZ, WHZ, or WAZ, respectively, is below –3. The three indicators capture different dimensions of undernutrition: stunting indicates chronic undernutrition, while wasting indicates acute undernutrition. Stunting reflects a process of failure to reach linear growth potential as a result of suboptimal nutrition or poor health. Wasting implies a recent or continuing current and severe process of weight loss, which is often associated with acute starvation or severe disease. Thus, HAZ is a long-term nutrition indicator, and WHZ is a short-term nutrition indicator. In contrast, weight-for-age reflects body mass relative to chronological age and is influenced by both the height of the child (height-for-age) and her or his weight (weight-for-height). The composite nature of WAZ makes interpretation of its estimates complex (WHO 1995). Given the development perspective of this paper, the analysis here focuses on chronic child undernutrition using the HAZ score.

The analysis in this section uses the latest child anthropometry data in Nigeria from two different, nationally representative surveys. Both surveys include all children aged 0 to 59 months in the sample households. The first data source is the Nigeria Demographic and Health Survey (DHS) 2013 (NPC 2013). DHSs are internationally standardized surveys that are most commonly used to determine the nutritional status of children and the prevalence of malnutrition in developing country populations around the world. The second data source is the post-harvest round of the third wave of the Nigeria General Household Survey (GHS-W3-PH), conducted in 2016 (see Section 3, for description of the survey). The DHS 2013 sample is designed to yield estimates of key nutrition and health indicators—including child anthropometry—that are representative for rural and urban areas, for each of the six geopolitical regions of Nigeria, and for each of the 36 states and the Federal Capital Territory (FCT) Abuja. The GHS is designed to yield estimates for poverty and other key socio-economic indicators that are representative for urban and rural areas and at the level of the geopolitical regions.

The accuracy of published child nutrition estimates derived from recent DHSs in Nigeria—and especially from the DHS 2013—has been questioned (e.g., Assaf et al. 2015; Benson et al. 2017). In particular, the high prevalence rates of child wasting (and hence the prevalence rates of child underweight) in several states and some geopolitical regions, as reported in the DHS 2013 report (NPC and ICF International 2014) are outside any reasonable range as compared to international peer countries. For example, child wasting is estimated to affect 41.7 percent of children in Kaduna state and 39.7 percent in

[2] Malnutrition includes both undernutrition and overnutrition, leading to overweight and obesity. This paper focuses on undernutrition.

Kano state, which both are located in the North West region. The prevalence rate of child wasting in the entire North West region is estimated at 27.1 percent. According to the WHO severity index for malnutrition in emergency situations, a wasting rate of 10 percent or higher indicates an emergency, and 15 percent or higher an emergency of 'critical' severity (WHO 1995).

To explore potential sources of error in the child nutrition estimates, we re-estimated the child HAZ, WHZ, and WAZ values and respective undernutrition prevalence rates using an improved z-score estimation procedure developed by Leroy (2011) and slightly different cutoff values for defining biologically implausible z-scores. We obtain estimates that are very similar to the estimates presented in the Nigeria DHS 2013 report, and therefore can exclude estimation errors as the explanatory factor for the extreme measures.

However, our estimations also reveal very high standard deviations (SDs) for all three child nutrition indicators in the total sample of more than 24,000 children (Table 3.1). Even after dropping children with biologically implausible values from the sample, the SD is 2.03 for HAZ, 1.58 for WHZ, and 1.42 for WAZ. SDs above 1.95 for HAZ, 1.50 for WHZ, and 1.46 for WAZ provide strong indication of poor anthropometric data quality (Mei and Grummer-Strawn 2007). Out of 52 countries with a DHS between 2005 and 2014, there are only three other countries with SDs for HAZ at or above 2, namely Albania, Benin, and Egypt. Each of these countries is likely to have serious data quality problems in anthropometric measures (Assaf et al. 2015). Even quite modest random errors in anthropometric measurements, as are associated with an increased SD, can more than double the true prevalence rate of undernutrition (Grellety and Golden 2016). Systematic measurement errors resulting from non-compliance with anthropometric measurement and standardization protocols (de Onis et al. 2004; Ulijaszek and Kerr 1999), for example, can lead to a systematic over- or underestimation of the true prevalence rate, depending on the direction of the bias. Additional checks of the DHS data, as well as personal communications with nutrition experts in Nigeria, did not provide any hints on potential sources of measurement error or bias in the nutrition information in the 2013 Nigeria DHS.

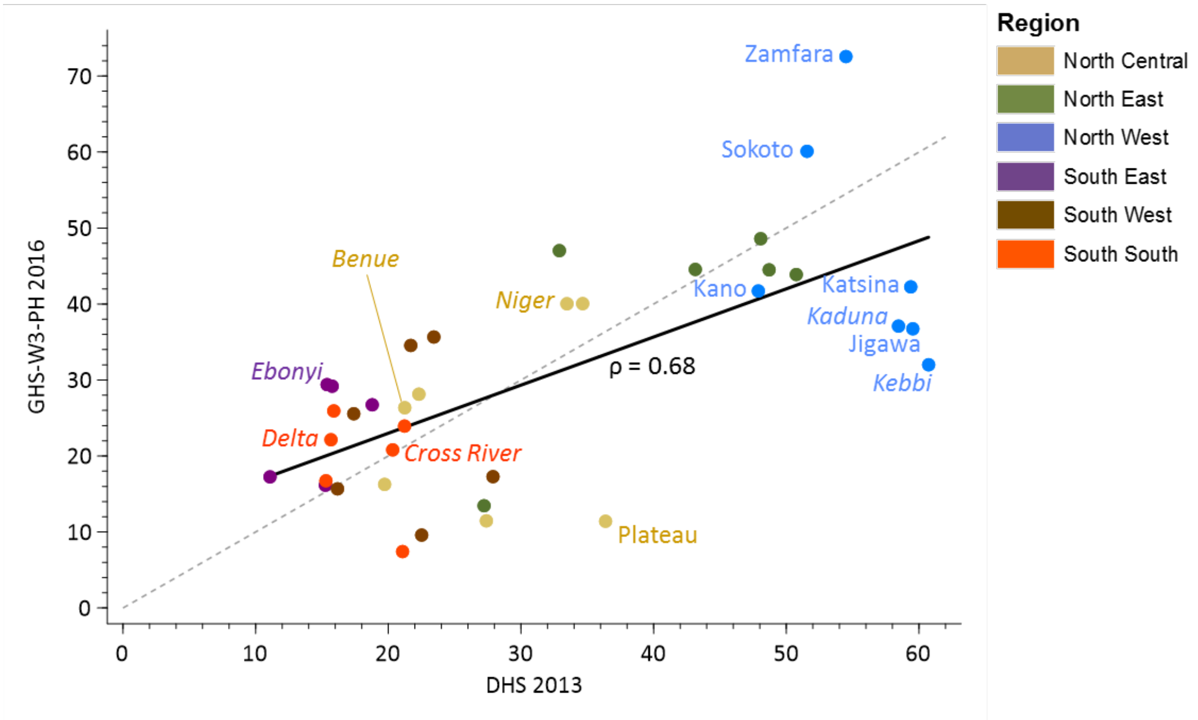
Table 3.1. Overview of child nutrition indicator and child undernutrition prevalence estimates

	Total		Rural		Urban	
	DHS 2013	*GHS-W3-PH 2016*	*DHS 2013*	*GHS-W3-PH 2016*	*DHS 2013*	*GHS-W3-PH 2016*
Child nutrition indicators						
Height-for-age z-score (HAZ)						
Mean	-1.37	-1.20	-1.62	-1.30	-0.94	-0.99
Standard deviation (SD)	2.03	2.10	2.06	2.19	1.91	1.90
Weight-for-height z-score (WHZ)						
Mean	-0.65	-0.23	-0.62	-0.20	-0.69	-0.28
Standard deviation (SD)	1.58	1.58	1.61	1.65	1.53	1.43
Weight-for-age z-score (WAZ)						
Mean	-1.25	-0.84	-1.38	-0.89	-1.03	-0.75
Standard deviation (SD)	1.42	1.44	1.42	1.50	1.40	1.31
Prevalence rates (%)						
Child stunting (HAZ<-2)	36.8	34.4	43.0	37.3	26.3	28.5
Severe child stunting (HAZ<-3)	21.0	19.8	25.6	22.0	13.1	15.3
Child wasting (WHZ<-2)	18.0	10.9	18.2	11.8	17.7	9.2
Child underweight (WAZ<-2)	28.5	19.1	31.7	21.1	23.1	15.0
Observations	24,221	2,802	15,816	2,076	8,405	726

Source: Own estimation, based on DHS 2013 and GHS-W3-PH 2016 data.

Next, to check the consistency of estimated subnational prevalence rates from different data sources, we compare state-level prevalence estimates derived from the DHS 2013 with those derived from the GHS-W3-PH 2016. Note that the child anthropometry data of the GHS-W3-PH 2016 are likely of poor quality, too. In the total sample of the GHS-W3-PH 2016 of about 2,800 children with biologically plausible anthropometric measurements, the SD is 2.10 for HAZ, 1.58 for WHZ, 1.44 for WAZ. Correlation analysis suggests that the prevalence rates from the two surveys are only moderately correlated for child stunting (Figure 3.1) and are uncorrelated for child wasting.[3] The correlation for child underweight rates has a coefficient between the correlation coefficients for child stunting rates and child wasting rates. At the national level, the child stunting rates from the DHS 2013 and GHS-W3-PH 2016 are within a plausible range for the total sample as well as the rural and urban samples (Table 3.1). This does not hold for the child wasting and underweight rates.

Figure 3.1. Correlation of state-level prevalence rates of child stunting



Source: Own estimation, based on DHS 2013 and GHS-W3-PH 2016 data.
Note: States in italics are FtF focus states.

At the state level, the largest discrepancies between the DHS 2013 and GHS-W3-PH 2016 child stunting rates occur for the North West region (Figure 3.1). Kebbi, Jigawa, and Kaduna states and Plateau state in the North Central region show differences in the prevalence of child stunting of more than 20 percentage points. There appears to be no systematic over- or underrating of the DHS estimates relative to the GHS-W3-PH estimates. The enormous differences in the child stunting rates of many states between the DHS 2013 and GHS-W3-PH 2016 cannot be explained by changes in children's living conditions, health environment, or any other developments between 2013 and 2016. As a point of reference, the national prevalence rate declined over the three years between the two surveys at an average annual rate of -0.80 percentage points (or 2.4 percentage points in total from 2013 to 2016) that is similar to the average annual rate of reduction between the 2008 and 2013 DHSs (-0.76 percentage points) (NPC and ICF International 2014). Moreover, within the same geopolitical region, such as in the North West region, some states show considerably higher prevalence rates in the DHS 2013 than the GHS-W3-PH 2016 (most

[3] See Figure A.1 in the Appendix.

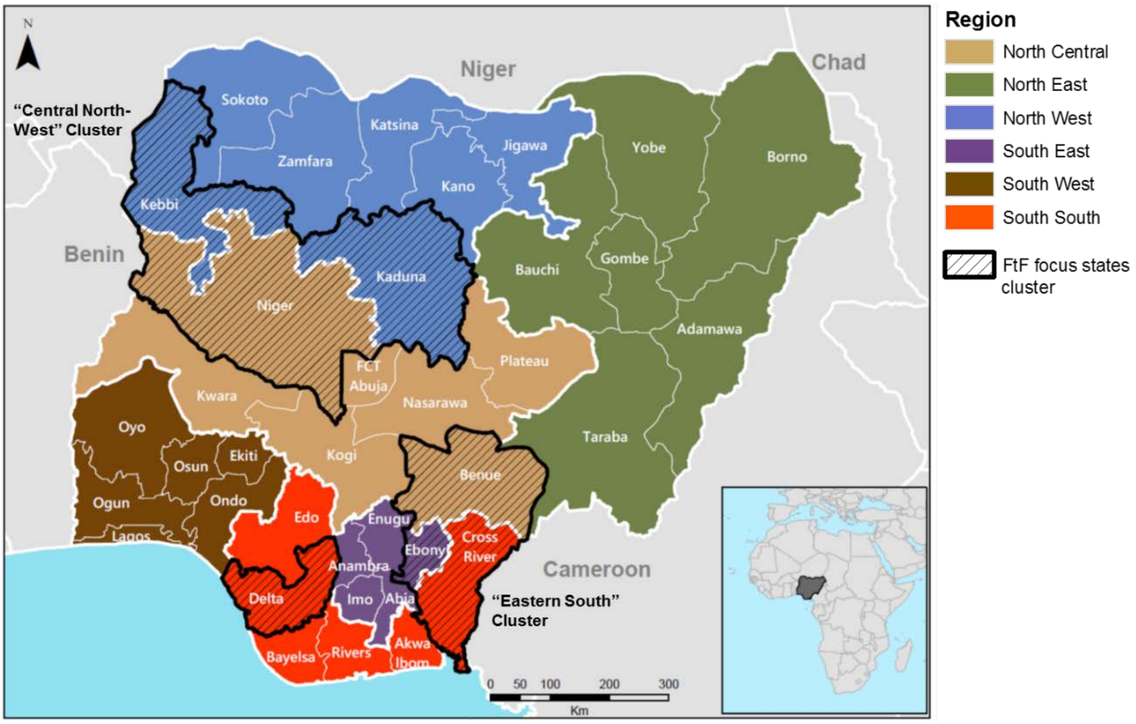
notably, Kebbi, Jigawa, Kaduna, and Katsina), and others considerably lower prevalence rates (Zamfara and Sokoto).

We conclude from these results that: (1) the most recent child nutrition estimates suffer from poor quality in the underlying survey data; (2) at the national level, child stunting rates are probably more reliable than child wasting rates; (3) child stunting rates at the state level are generally unreliable; and, (4) child stunting rates at the regional level are likely to be inaccurate for some regions, particularly the North West region.

3.2 Regional patterns of chronic child undernutrition

We now review the prevalence of chronic undernutrition among all Nigerian children and children living in farm households. [4] Keeping the generally poor quality of child nutrition data in mind, we caution against overinterpretation of the precise prevalence estimates. Using the DHS 2013 and GHS-W3-PH 2016 data, prevalence rates for child stunting and for severe child stunting by geopolitical region and for selected state clusters are presented. The state clusters are defined by the regional focus of development programs and projects supported by the FtF initiative of the USAID in Nigeria. The seven FtF focus states are Kebbi, Kaduna, and Niger, located in the Central North-West cluster; Benue, Cross-River, and Ebonyi in the Eastern South cluster; and, Delta in the South-South region (Figure 3.2). Because of similar agroecological conditions and to obtain estimates based on sufficient numbers of observations, the neighboring states are aggregated into the regional clusters. The Central North-West cluster has some of the main paddy rice-growing areas in Nigeria, and the Eastern South cluster has some of the main cassava-growing areas. Rice and cassava are the dominant staple food crops in Nigeria.

Figure 3.2. Geopolitical regions and Feed-the-Future focus states clusters



Source: Own representation.

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[4] We define farm households in the DHS and GHS samples as consistently as possible. For the DHS sample, we define farm households as households who cultivate agricultural land of at least 0.1 hectare, which is the lowest non-zero farm land size reported in the DHS 2013. According to the DHS 2013 data, farm households account for 49.5 percent of all households, 69.0 percent of rural households, and 23.8 percent of urban households. See Section 4.1 for the definition of farm households in the GHS and the household proportions in the GHS-W3 2016 data.

Regional prevalence rates of child stunting and severe child stunting, as well as regional means of child HAZ, show a distinct North-South gap in child nutrition. Chronic child undernutrition in its moderate and severe form is much more prevalent in the North than the South (Table 3.2). The higher concentration of child stunting in the North is consistent with regional patterns of other development indicators, including, most notably, poverty (Mahrt and Arndt 2018). The prevalence rates also suggest that stunting and severe stunting tend to be somewhat more prevalent among children living in farm households at the national level as well as for all geopolitical regions, except the South East region (Table 3.3). Yet, it should be noted that the child stunting rates among all children and children living in farm households are fairly close and likely within the margin of error. The prevalence of child stunting and severe child stunting in the Feed the Future clusters in the Central North-West and the Eastern South shows rates that are between the prevalence rates of the overlapping geopolitical regions. Given that some of the FtF focus states are among the states with likely inaccurate child stunting rates (Figure 3.1), child stunting rates at the FtF-cluster-level are likely to be inaccurate, too.

Table 3.2. Regional prevalence of chronic child undernutrition

	Stunting prevalence, %		Severe stunting prevalence, %		Height-for-age z-score (HAZ)				Observations	
					DHS 2013		*GHS-W3-PH 2016*			
	DHS 2013	*GHS-W3-PH 2016*	*DHS 2013*	*GHS-W3-PH 2016*	**Mean**	**SD**	**Mean**	**SD**	*DHS 2013*	*GHS-W3-PH 2016*
Total	36.8	34.4	21.0	19.8	-1.37	2.03	-1.20	2.10	24,221	2,802
Region										
North Central	28.8	24.2	13.9	11.5	-1.05	1.88	-0.63	2.22	3,771	378
North East	42.2	41.3	23.7	24.3	-1.47	2.09	-1.54	2.15	4,835	579
North West	54.9	45.8	36.0	29.9	-2.17	2.04	-1.65	2.24	7,074	979
South East	15.3	23.4	5.4	11.2	-0.48	1.64	-0.74	1.79	2,238	291
South South	17.8	20.7	8.2	7.9	-0.50	1.87	-0.55	1.76	3,000	295
South West	21.9	21.5	7.9	8.6	-0.79	1.66	-0.82	1.61	3,303	280
Feed the Future clusters										
Central North-West	49.5	35.9	32.8	20.6	-1.98	2.14	-1.31	2.01	2,167	258
Eastern South	19.1	25.8	8.0	12.9	-0.70	1.68	-0.85	1.89	1,518	199
Delta	15.7		9.3		-0.38	2.12	-0.50		554	44

Source: Own estimation, based on DHS 2013 and GHS-W3-PH 2016 data.
Note: Prevalence rates are reported if the estimates are based on at least 50 observations.

Table 3.3. Regional prevalence of chronic child undernutrition among farm households

	Stunting prevalence, %		Severe stunting prevalence, %		Height-for-age z-score (HAZ)				Observations	
					DHS 2013		*GHS-W3-PH 2016*			
	DHS 2013	*GHS-W3-PH 2016*	*DHS 2013*	*GHS-W3-PH 2016*	Mean	SD	Mean	SD	*DHS 2013*	*GHS-W3-PH 2016*
Total	42.6	38.3	25.6	23.3	-1.60	2.07	-1.34	2.18	14,551	2,046
Region										
North Central	29.6	24.7	14.2	11.5	-1.09	1.87	-0.55	2.29	2,087	235
North East	44.6	42.3	26.0	24.6	-1.53	2.18	-1.60	2.07	3,707	471
North West	57.4	46.0	38.4	30.4	-2.26	2.03	-1.62	2.32	5,148	852
South East	13.6	25.9	2.9	13.3	-0.51	1.51	-0.85	1.82	1,137	224
South South	20.6	23.6	10.0	11.7	-0.73	1.79	-0.71	1.73	1,470	171
South West	26.0	24.1	10.3	10.9	-0.98	1.70	-1.07	1.50	1,002	93
Feed the Future clusters										
Central North-West	52.0	33.5	35.6	19.0	-2.12	2.09	-1.13	2.12	1,332	188
Eastern South	19.5	25.7	8.5	13.1	-0.73	1.70	-0.83	1.92	1,124	187
Delta	19.3		9.6		-0.73	1.91			161	22

Source: Own estimation, based on DHS 2013 and GHS-W3-PH 2016 data.
Note: Prevalence rates are reported if the estimates are based on at least 50 observations.

3.2 Association of dietary diversity and long-term child nutrition

Dietary diversity is generally a strong predictor of dietary quality and a good measure of food and nutrition security in developing country populations. Dietary diversity indicators are typically constructed as the simple count of different food groups or food items consumed over a given reference period. Validation studies show that dietary diversity indicators are consistently and strongly associated with household calorie consumption (Ruel 2003) and adequate micronutrient content or density of children's and women's diets. Other studies also confirm a positive association between dietary diversity indicators and the nutritional status of children and women as measured by anthropometry (Ruel et al. 2013).

To check if the general association between dietary diversity and child nutrition also holds in the case of our data, we perform pairwise (linear) correlations. From the DHS 2013 data, we constructed a 'child dietary diversity score' (CDDS) and correlate it with the HAZ of the same child. The CDDS reports the number of different food groups (out of seven food groups) fed to a child aged 6 to 23 months in the 24 hours prior to the survey interview (NPC and ICF International 2014).[5] From the GHS-W3-PH data, we constructed two household-level dietary diversity indicators. The first indicator is referred to as the 'household food variety score' (HFVS) and counts the number of different food items consumed within the household by all family members in the seven days prior to the survey interview date. We consider 60 different food items.[6] The second indicator is referred to as 'household dietary diversity score' (HDDS) and counts the number of different food groups consumed within the household by all family members in the seven days prior to the survey interview date. The HDDS is based on 12 food groups that correspond to the food groups of the score developed by the USAID-supported Food and Nutrition Technical Assistance

[5] The seven food groups are: animal milk and dairy products (including baby formula); cereals, starchy root tubers, and staple food products (including cereal-based baby food); vitamin A-rich vegetables and fruits; other vegetables and fruits; eggs; meat, fish, and seafood; and pulses, nuts, and seeds.

[6] The GHS food consumption module has 116 food and beverage categories. We aggregated similar food items and foods of the same source, such as local and imported rice to rice; shelled and unshelled maize to maize; cassava root and flour to cassava; white and yellow gari to gari; and fresh, frozen, smoked, and dried fish to fish.

(FANTA) project (Swindale and Bilinsky 2006).[7] We correlate both household-level dietary diversity indicators with the HAZs of the households' children aged 6 to 59 months as well as those aged 6 to 23 months. We drop infants aged 0 to 5 months from the samples because these children are exclusively breastfed (or at least should be exclusively breastfed according to standard infant and young child feeding practice guidelines).

Table 3.4. Correlation between children's height-for-age z-score and individual and household dietary diversity

	Child height-for-age z-score (HAZ)		
	DHS 2013	GHS-W3-PH 2016	
	Children age 6-23 months	*Children age 6-59 months*	*Children age 6-23 months*
Child dietary diversity score (CDDS)	0.043		
Household food variety score (HFVS)		0.092	0.109
Household dietary diversity score (HDDS)		0.098	0.116
Observations	7,808	2,598	753

Source: Own estimation, based on DHS 2013 and GHS-W3-PH 2016 data.
Note: The correlation coefficients are statistically significant at the 1% level.

Table 3.4 presents the correlation coefficients. All correlations are highly statistically significant at the 1% level, and consistently indicate a fairly weak association between dietary diversity and child HAZ. The correlation coefficient is about 0.04 for the CDDS and around 0.10 for the household-level dietary diversity indicators. Steyn et al. (2006) finds a correlation coefficient for HAZ and CDDS among South African children aged 1 to 3 years amounting to 0.15. In general, relatively low correlation coefficients between dietary diversity indicators and child nutritional status—and particularly child HAZ—are not unusual and can be explained by several factors:

- HAZ is an indicator of children's long-term nutritional status. Thus, it should be unresponsive to the diet consumed in the past few days. Moreover, the diet consumed in the past few days may not be representative of the diet consumed over longer periods in the past, given seasonality in food availability and changes in children's food preferences over time, for example.
- Children's nutritional status is also determined by (often unobserved) non-food factors, including their health status, the quality of care given by their parents, and applied feeding practices. Each of these add statistical noise to the correlation.
- Correlations across children can be expected to be generally low because of large genetic variations in children's body composition and usual physical growth, independent of their individual nutrition.
- In the case of household-level dietary diversity, children's food intake depends on the distribution of the food available for household consumption among the household members. This explains why correlation coefficients for household-level dietary diversity indicators can be expected to be lower than for child-specific dietary diversity indicators. However, we find that the coefficient for the CDDS is considerably smaller than the coefficients for the HFVS and HDDS. This result, as well as the generally weak correlation found between child HAZ and dietary diversity indicators, is likely a result of the poor-quality data underlying the child nutrition indicators.

The econometric analysis presented in the next sections uses household dietary diversity as a proxy indicator of food and nutrition security. Beyond the severe limitations of available anthropometry data for

[7] The HDDS food groups are cereals; starchy roots and tubers and plantains; vegetables; fruits; meat and poultry; fish and seafood; eggs; pulses, nuts, and seeds; milk and dairy products; edible oils and fats; sugars; spices and condiments (Swindale and Billinski, 2006).

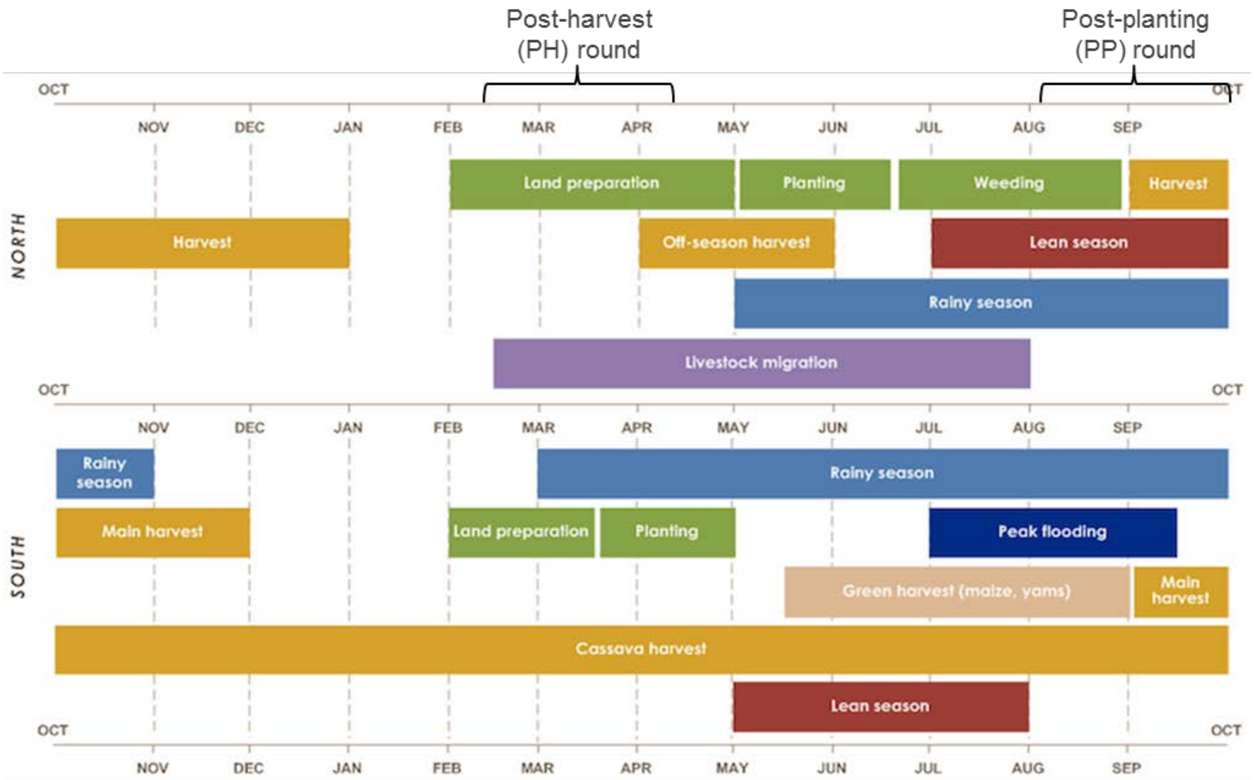
measuring child nutrition, there are good reasons from nutrition physiology and household economics to focus on dietary diversity. Good nutrition is not only important for physical growth—captured by anthropometric indicators—but also for cognitive functioning and development and for the implications it has for economic productivity and social skills (Black 2003; Clausen et al. 2005; Neuman et al. 2003). Moreover, psychological theories, such as Maslow's hierarchy of needs, and economic theories of demand suggest that households will only diversify into higher-value, micronutrient-rich foods, such as animal-source foods, vegetables, and fruits, when they have satisfied their calorie needs (Headey and Ecker 2013). Thus, household dietary diversity indicators capture aspects of economic means in food consumption relative to individual dietary needs, in addition to household food preferences.

4. DATA AND METHODS

4.1 Data and descriptive statistics

The econometric analysis uses data from the Nigeria General Household Survey (GHS). The GHS was implemented by the Nigeria National Bureau of Statistics (NBS) in collaboration with the Living Standards Measurement Study (LSMS) team of the World Bank as part of the LSMS Integrated Surveys on Agriculture (ISA) program. The GHS is a panel survey that tracks households over time. Households were surveyed six times, namely in three waves (2010-11, 2012-13, and 2015-16) with two rounds per wave to capture agricultural production and harvest information for Nigeria's main agricultural season. Data collection for the post-harvest (PH) rounds was conducted largely in March and April, and in August and September for the post-planting (PP) rounds (Figure 4.1).[8] The econometric analysis uses data on household food consumption and living conditions from the post-harvest rounds of the first wave (W1) and the third wave (W3), conducted in 2011 and 2016, respectively. Agricultural production data are obtained from the post-harvest rounds of each wave. Hence, the observation period of the analysis is five years and coincides with the lifetime of Nigeria's Agricultural Transformation Agenda (ATA).

Figure 4.1. Seasonal calendar of a typical agricultural year in Nigeria



Source: FEWSNET (2013).

The sub-sample of survey households used for the analysis is made up of farm households that were surveyed in both the first and third wave and both rounds of each wave, producing a balanced sample. The Nigeria NBS defines farm households as households that engaged in agricultural activities such as crop farming, livestock rearing, and other agricultural and related activities (NBS 2016). According to this definition, farm households accounted for 47.5 percent of all Nigerian households, 69.7 percent of rural households, and 14.2 percent of urban households in 2011–2016. Such households were selected for the

[8] 'Post-harvest' and 'post-planting' refer to the seasons of rain-fed cereal production.

agricultural part of the GHS. We follow this broad definition, but limit the sample to farm households that cultivated agricultural crops during both waves, dropping pure livestock-raising households and households that exited or entered farming between 2011 and 2016. The resulting sample of 2,537 farm households is 57.0 percent of all households that completed the GHS in both waves and both rounds.

We combine the GHS data with market price data for selected foods that were collected by the NBS and are available from the Nigeria Data Portal (NBS 2018). We use state-level prices for local rice, imported rice, white gari (cassava flour), brown beans, palm oil, tomatoes, and beef. These food items have complete and realistic price data for all states in the database, are commonly consumed and marketed in Nigeria, can be expected to show similar price trends to other common, non-considered foods, and cover a wide range of nutritional values. Because we are particularly interested in long-term price effects on dietary diversity and because the Nigeria Data portal provides monthly state-level food prices only until December 2010 and from January 2016 onward, we matched the December 2010 prices with the W1 household data and the January 2016 prices with the W3 household data, assuming that the food prices in December and January of the same season are similar. We deflated all prices to March 2016 levels, using the official price deflators provided with the GHS data.

Table 4.1. Summary statistics and mean difference tests

	Wave 1 (2011)		Wave 3 (2016)		Mean difference	
	Mean	SD	Mean	SD	Percent	Sign.
Household food variety score (HFVS, max=60)	13.2	4.5	15.4	5.2	16.4	***
Household dietary diversity score (HDDS, max=12)	7.76	1.93	8.28	1.88	6.7	***
Farm production diversity indicators						
Number of cultivated crops (max=42)	3.20	1.48	3.35	1.53	4.7	***
Simpson crop diversity index	0.74	0.32	0.78	0.29	4.6	***
Number of cultivated crop groups (max=8)	2.08	0.93	2.12	0.92	2.1	*
Simpson crop group diversity index	0.68	0.34	0.71	0.32	4.0	***
Per capita expenditure (NGN/day; log)	5.93	0.63	5.55	0.64	-6.4	***
Household size (number of persons)	6.39	3.12	6.29	3.31	-1.6	
Sex of household head (0=male, 1=female)	0.11	0.31	0.15	0.36	41.8	***
Age of household head (years)	50.3	14.8	53.6	14.3	6.4	***
Education level attained by household head†						
Primary education (0=no, 1=yes)	0.45	0.50	0.43	0.50	-2.7	
Secondary or higher education (0=no, 1=yes)	0.18	0.39	0.20	0.40	11.7	*
Non-agricultural employment (0=no, 1=yes)	0.56	0.50	0.57	0.50	1.6	
Farm size (sq.m.; log)	9.11	1.62	9.23	1.44	1.3	***
Livestock ownership						
Ruminants: cattle/sheep/goats (0=no, 1=yes)	0.54	0.50	0.52	0.50	-2.9	
Poultry (0=no, 1=yes)	0.49	0.50	0.49	0.50	1.0	
Prices ('00 NGN/kg), at state level (N=37)						
Local rice	1.21	0.22	0.98	0.18	-19.1	***
Imported rice	1.68	0.22	1.43	0.24	-14.6	***
White gari	1.08	0.18	0.79	0.20	-26.5	***
Brown beans	1.34	0.25	1.42	0.30	6.2	
Palm oil	2.43	0.11	1.81	0.15	-25.6	***
Tomatoes	1.51	0.52	1.34	0.51	-11.3	
Beef	6.86	1.02	5.86	0.68	-14.6	***

Source: Own estimation, based on GHS-W1 and GHS-W3 data and NBS food price data. All prices expressed in March 2016 Naira.
Note: ***, **, * Per a two-sided *t*-test, mean difference is statistically significant at the 1%, 5%, and 10% level, respectively.
† The reference value indicates no formal education.

Table 4.1 shows summary statistics of all household-level variables and state-level prices by survey wave as used in the estimation model presented in the next subsection. The table also shows percent changes in the means of variables between the first and third GHS wave and significance levels for the mean differences, obtained from two-sided t-tests. The mean estimates indicate that dietary diversity among Nigeria's farm households significantly increased on average between 2011 and 2016. The larger average percent change of the mean HFVS than of the mean HDDS suggests that farm households diversified their diet within the same food group rather than adding a new food group to their diet. Yet, it should be noted that this result is also influenced by the length of the reference period of the dietary diversity indicator. Because households tend to consume larger numbers of different foods and food groups over a longer period, means of dietary diversity indicators increasingly converge to the indicators' maximum value with expanding food consumption recall periods, and their standard deviations shrink accordingly. As this measurement issue is more pronounced for indicators with few food group categories than many categories, the HFVS is our preferred dietary diversity indicator in this analysis. Nevertheless, all estimations in this analysis are performed with both indicators to check the robustness of the estimation results.

Table 4.1 also shows estimates for four different farm production diversity indicators. The number of cultivated crops and the number of cultivated crop groups are simple counts of the different crops or crop groups that a farm household cultivated during the main agricultural season. The crop (group) categories are defined to be consistent with the food (group) categories of the HFVS (and HDDS). The crop-count indicator considers 42 different crops, and the crop-group-count considers 8 different crop groups.[9] The Simpson diversity indices (Simpson 1949) for farm household i are calculated as:

(1) $$\lambda_i = 1 - \sum_{j=1}^{R} s_{ij}^2 ,$$

where R is the number of cultivated crops or crop groups, and s is the share of the farmland area cultivated with crop or crop group j. Hence, R is equivalent to the crop-count and crop-group-count indicators, which measure the richness of crop cultivation. In addition, the Simpson diversity indices account for the evenness of land allocation to different crops and crop groups. The Simpson diversity indexes take values between 0 and 1, with 0 indicating monoculture and 1 indicating infinite diversity.

The estimates for all farm production diversity indicators consistently show that production diversity on household farms has increased between 2011 and 2016 on average—rather than declined. Thus, most Nigerian farmers did not begin to specialize their production during the ATA lifetime. The apparent lack of agricultural transformation may be explained by an absence of an enabling economic environment. Farm households may face severe market failures that do not allow them to separate agricultural production from food consumption decisions. Because they lack access to diverse foods, farm households may have diversified their production in order to increase their dietary diversity. Maintaining or even increasing farm production diversity can come at a potentially high cost of sacrificing farm profits that are typically associated with production specialization and agricultural commercialization (Dillon and Barrett 2017; Morduch 1995). Because most farm households suffer from food and nutrition insecurity, they are likely to prioritize meeting their dietary needs through own-production over farm income generation in an environment with uncertain agricultural marketing opportunities and poor access to food from market purchases.

Table 4.1 shows that real food prices for staple foods, palm oil, and beef declined between 2011 and 2016 on average, while the real prices of common, more nutritious pulses and vegetables, such as brown beans and tomatoes, did not change (statistically) significantly. Prices declined most for local staple

[9] The crop groups are cereals; starchy roots and tubers and plantains; vegetables; fruit crops; legumes and tree nuts; oil crops; spice crops; and (non-food) cash and fiber crops (including cocoa and sugarcane).

crops and palm oil, both of which are standard components of Nigerian diets. Household real income, as measured by real household expenditure per capita deflated to March 2016 price levels, declined over the five-year period, too. The loss in real income is probably largely due to the last recession of Nigeria's economy that started in 2015 (IMF 2016).

The estimates for farm household characteristics indicate some interesting patterns. The share of households headed by women increased between 2011 and 2016, and the increase in the mean age of the household head falls much short of five years. This may be a result of male household heads moving out of farm households and migrating to cities for finding jobs in other sectors of the economy. However, the share of households whose members generate income from employment in non-agricultural activities did not change significantly. The farm size of the surveyed farm households increased between 2011 and 2016, possibly because they took over farm land from other households exiting agriculture.

4.2 Estimation methodology

The econometric analysis applies two regression models to estimate the effects of farm production diversification and food price changes on household dietary diversity using household panel data. The first model is a random-effects (RE) model which assumes that the model parameters are random. The second model is fixed-effects (FE) model, where the model parameters are fixed at the household level. FE models help in controlling for time-constant, unobserved heterogeneity across households.

The RE model has the following specification (in its complete form):

(2) $$\mu_{ist} = \alpha_0 + \beta\lambda_{ist} + \gamma X_{ist} + P'_{st}\delta + Z'_{ist}\zeta + \varphi D_{ist} + L_s{}'\varrho + \varepsilon_{ist} \,,$$

where i refers to the household, s refers to the state, and t refers to the survey year. μ denotes the household dietary diversity indicator, and λ denotes the farm production diversity indicator. Total household expenditure per capita (as a proxy indicator of household income) enters the model in logarithmic form through X. The vector P identifies food prices. The vector Z identifies farm household characteristics, including household size (as an indicator of household economies of scale), sex, age, and formal education of the household head (as the main decision maker in the households). It also contains farm characteristics that may affect household food consumption, including farm size (as an indicator of farm economies of scale) and ownership of common livestock types. To capture households' integration into the non-agricultural labor market, the vector Z includes a dummy variable that indicates whether any family member living in the households is employed or self-employed outside the agricultural sector. The variable D measures the linear distance of the household location to the nearest city or town with 20,000 inhabitants or more. It serves as proxy indicator for household distance to major consumer markets and controls for transportation costs that influence price differences between local markets and major markets, where the food prices included in the model were measured. The vector L includes a set of dummy variables for all states in Nigeria, except FCT Abuja (serving as the reference state), and captures regional differences in infrastructural endowment and socio-political conditions. The constant term is α_0. The model parameters to be estimated are β, γ, δ, ζ, and ϱ. The error term is ε. Standard errors are clustered at the household level, relaxing the usual requirement that the observations be independent (within clusters).

The FE model has a similar (complete) specification:

(3) $$\mu_{ist} = \alpha_0 + \beta\lambda_{ist} + \gamma X_{ist} + P_{st}{}'\delta + Z_{ist}{}'\zeta + \psi_i + \varepsilon_{ist} \,.$$

Household fixed-effects enter the model through ψ. All variables are identical to the RE model, except for the market distance variable, which drops from the model because of exact collinearity. Standard errors are clustered at the household level in the FE model as well.

The variables are introduced stepwise into the estimation equations of the RE and FE models to examine the robustness of the relationship of most interest—that is, the association between changes in household dietary diversity and farm production diversity—due to the expansion of predictor variables of dietary diversity. The models that have the HFVS as the dependent variable have, correspondingly, one of the single-crop-based production diversity indicators as an independent variable; and the models that have the HDDS as the dependent variable have one of the crop-group-based production diversity indicators as an independent variable.

5. ESTIMATION RESULTS

Tables 5.1 and 5.2 present the main estimation results of the RE and FE models having the household food variety score (HFVS) as dependent variable; and Tables 5.3 and 5.4 present the main estimation results of the RE and FE models for the household dietary diversity score (HDDS).[10] Parameter estimates for farm household characteristics (and the constant term) are omitted from the tables here, but are presented in the Appendix.[11]

The parameter estimates of the farm production diversity indicators in all regressions indicate a strong, positive effect of farm production diversification on household dietary diversity. This association is highly robust to the choice of the model estimator as well as the use of food/crop item-based and group-based dietary diversity and production diversity indicators. It is also highly robust to the use of the Simpson diversity index, instead of the simple crop (group) count as production diversity indicator, and hence the consideration of the evenness of land allocation to different crops (or crop groups) in addition to the richness of the crop cultivation on-farm. The estimation results of the completely specified models for the HFVS (Tables 5.1 and 5.2; Regressions 4) show that, between 2011 and 2016, cultivating an additional crop increased the number of consumed foods by 0.24-0.26, while raising the Simpson diversity index by 10 percentage points—by, for example, shifting toward a more even distribution of farmland among the cultivated crops—increased the number of consumed foods by around 0.06.

Farm production diversification can lead to increased household dietary diversity directly through the hypothesized pathway by which a more diverse food production improves farm households' immediate access to a more diverse diet on-farm. Another pathway is through changes in household income. Production diversification can lead to increases in farm income by, for example, adding crops that attain higher selling prices or achieving higher yields from current crops due to improved soil fertility and pest management that accrue from a more diverse intercropping pattern or an expanded crop rotation system (Ecker 2018). Regressions 2 and 3 provide suggestive evidence on the significance of this possible indirect income effect. The parameter estimates of the production diversity indicators remain nearly constant when introducing per capita expenditure into the estimation equations (controlling for farm household characteristics). This result suggests that such an indirect income effect is absent or negligibly small in our farm household sample and confirms that the production-consumption linkage is exclusively driven by the hypothesized direct effect of production for own-consumption.

The parameter estimates of the per capita expenditure variable indicate that there is a strong, positive income effect on household dietary diversity in the sample population. Hence, the loss in real income between 2011 and 2016 was likely associated with a considerable reduction in dietary diversity among Nigerian farm households. The size of the estimated income effect varies across model specifications: It becomes much stronger when controlling for price changes of common foods (Regressions 3 and 4). In the FE model, which (more plausibly) assumes that the income effect is non-random across households, the effect size rises by more than five-fold in the estimations for the HFVS and more than three-fold in the estimations for the HDDS. Moreover, when food prices are introduced into the estimation equations, the explanatory power of the estimation models (as implied by the R-squared values) surge from 0.05 or less to around 0.24 for the HFVS estimations and to around 0.14 for the HDDS estimations. These results highlight the need to account for food price changes, in addition to changes in real income (as proxied by total expenditures), and, hence, to separate income effects from actual price effects.

[10] The presented results are estimated from FE models (and RE models) without accounting for survey sample weights. The estimation results are similar to the estimation results obtained from the corresponding weighted-regressions, which are not presented in the paper but can be obtained from the authors upon request.

[11] See Tables A1.1-A1.4 in the Appendix.

Table 5.1. Main estimation results of the random-effects model for the household food variety score

	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)	(4a)	(4b)
Number of cultivated crops (max=42)	0.372***		0.286***		0.288***		0.239***	
	0.044		*0.048*		*0.047*		*0.044*	
Simpson crop diversity index		1.015***		0.712***		0.781***		0.564***
		0.217		*0.222*		*0.212*		*0.201*
Per capita expenditure (NGN/d; log)					1.541***	1.547***	2.700***	2.711***
					0.108	*0.109*	*0.122*	*0.123*
Prices ('00 NGN/kg)								
Local rice							-2.181***	-2.394***
							0.764	*0.767*
Imported rice							2.048***	2.032***
							0.664	*0.667*
White gari							-0.553	-0.549
							0.541	*0.543*
Brown beans							0.316	0.253
							0.490	*0.490*
Palm oil							-4.669***	-4.591***
							0.356	*0.358*
Tomatoes							-1.089***	-1.034***
							0.291	*0.291*
Beef							0.100	0.075
							0.134	*0.134*
Market distance (km)			-0.010***	-0.010***	-0.007**	-0.008**	-0.005*	-0.005*
			0.003	*0.003*	*0.003*	*0.003*	*0.003*	*0.003*
Farm household characteristics	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Governorate	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-sq. (within)	0.017	0.007	0.025	0.020	0.017	0.013	0.241	0.237

Source: Own estimation, based on GHS-W1 and GHS-W3 data and NBS food price data. The sample includes 2,537 households, with each one observation in 2011 and 2016.
Note: NGN = Nigerian Naira.
***, **, * Coefficient is statistically significant at the 1%, 5%, and 10% level, respectively. Standard errors (shown in italics) are clustered at the household level.

Table 5.2. Main estimation results of the fixed-effects model for the household food variety score

	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)	(4a)	(4b)
Number of cultivated crops (max=42)	0.425***		0.329***		0.330***		0.255***	
	0.065		*0.070*		*0.070*		*0.063*	
Simpson crop diversity index		1.366***		0.984***		1.020***		0.600*
		0.345		*0.350*		*0.349*		*0.322*
Per capita expenditure (NGN/d; log)					0.480***	0.495***	2.504***	2.521***
					0.154	*0.154*	*0.178*	*0.178*
Prices ('00 NGN/kg)								
Local rice							-2.100***	-2.300***
							0.758	*0.762*
Imported rice							2.008***	2.005***
							0.666	*0.670*
White gari							-0.623	-0.621
							0.543	*0.546*
Brown beans							0.298	0.251
							0.488	*0.489*
Palm oil							-4.530***	-4.454***
							0.366	*0.370*
Tomatoes							-1.072***	-1.015***
							0.289	*0.289*
Beef							0.135	0.108
							0.135	*0.136*
Farm household characteristics	No	No	Yes	Yes	Yes	Yes	Yes	Yes
R-sq.	0.018	0.007	0.047	0.042	0.051	0.046	0.243	0.239

Source: Own estimation, based on GHS-W1 and GHS-W3 data and NBS food price data. The sample includes 2,537 households, with each one observation in 2011 and 2016.
Note: NGN = Nigerian Naira.
The model parameters are fixed at the household level.
***, **, * Coefficient is statistically significant at the 1%, 5%, and 10% level, respectively. Standard errors (shown in italics) are clustered at the household level.

Table 5.3. Main estimation results of the random-effects model for the household dietary diversity score

	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)	(4a)	(4b)
Number of cultivated crop groups (max=8)	0.151***		0.102***		0.095***		0.085***	
	0.028		*0.029*		*0.028*		*0.027*	
Simpson crop group diversity index		0.298***		0.202**		0.221***		0.173**
		0.085		*0.087*		*0.084*		*0.082*
Per capita expenditure (NGN/d; log)					0.592***	0.596***	0.912***	0.917***
					0.043	*0.043*	*0.048*	*0.048*
Prices ('00 NGN/kg)								
Local rice							-0.637*	-0.663**
							0.325	*0.324*
Imported rice							0.735***	0.728***
							0.242	*0.243*
White gari							0.037	0.022
							0.238	*0.238*
Brown beans							-0.461**	-0.460**
							0.196	*0.196*
Palm oil							-1.430***	-1.404***
							0.142	*0.142*
Tomatoes							-0.341***	-0.339***
							0.116	*0.116*
Beef							0.001	-0.004
							0.053	*0.053*
Market distance (km)			-0.005***	-0.005***	-0.004***	-0.004***	-0.003**	-0.003**
			0.001	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*
Farm household characteristics	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Governorate	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-sq. (within)	0.007	0.007	0.022	0.022	0.020	0.021	0.135	0.135

Source: Own estimation, based on GHS-W1 and GHS-W3 data and NBS food price data. The sample includes 2,537 households, with each one observation in 2011 and 2016.
Note: NGN = Nigerian Naira.
***, **, * Coefficient is statistically significant at the 1%, 5%, and 10% level, respectively. Standard errors (shown in italics) are clustered at the household level.

Table 5.4. Main estimation results of the fixed-effects model for the household dietary diversity score

	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)	(4a)	(4b)
Number of cultivated crop groups (max=8)	0.171***		0.120***		0.117***		0.101***	
	0.039		*0.041*		*0.041*		*0.039*	
Simpson crop group diversity index		0.503***		0.404***		0.420***		0.319***
		0.123		*0.124*		*0.123*		*0.119*
Per capita expenditure (NGN/d; log)					0.256***	0.267***	0.801***	0.810***
					0.062	*0.061*	*0.073*	*0.072*
Prices ('00 NGN/kg)								
Local rice							-0.580*	-0.600*
							0.319	*0.318*
Imported rice							0.712***	0.697***
							0.242	*0.242*
White gari							-0.030	-0.057
							0.238	*0.238*
Brown beans							-0.463**	-0.452**
							0.195	*0.194*
Palm oil							-1.363***	-1.322***
							0.145	*0.145*
Tomatoes							-0.334***	-0.337***
							0.115	*0.116*
Beef							0.023	0.017
							0.053	*0.053*
Farm household characteristics	No	No	Yes	Yes	Yes	Yes	Yes	Yes
R-sq.	0.007	0.008	0.032	0.033	0.039	0.040	0.137	0.138

Source: Own estimation, based on GHS-W1 and GHS-W3 data and NBS food price data. The sample includes 2,537 households, with each one observation in 2011 and 2016.
Note: NGN = Nigerian Naira.
The model parameters are fixed at the household level.
***, **, * Coefficient is statistically significant at the 1%, 5%, and 10% level, respectively. Standard errors (shown in italics) are clustered at the household level.

The parameter estimates of the food prices show differential effects of food price changes on household dietary diversity that are consistent across all model estimations. The declines in real prices of local rice and palm oil were associated with increased dietary diversity between 2011 and 2016. The reduction in the consumption costs for local rice and palm oil likely allowed consumers to add new food items to their diet. In contrast, declining prices of imported rice were associated with reduced dietary diversity. This is likely due to substitution effects such that declining prices of imported rice incentivized consumers to demand more of this rice and relinquish the consumption of several other foods whose prices are not captured in the models. Tomato price changes have also significant dietary diversity effects, with declining prices contributing to greater diversity in household diets. The parameter estimates of white gari and beef prices are statistically insignificant in all estimation models, despite considerably declining prices between 2011 and 2016 (Table 4.1). A possible explanation is that the consumption decision for these foods was largely independent of their prices—though probably for opposite reasons. Gari is the cheapest staple food and a standard component of many Nigerian diets. Beef, in contrast, is relatively expensive and is—if at all—rarely consumed by most people. The parameter estimates of brown bean prices are statistically insignificant in the estimations for the HFVS and significant and negative in the estimations for the HDDS. This result may be explained by different subcomponents of dietary diversity that the indicators capture: Increasing prices of brown beans may lead consumers to exclude them from their regular diet, and, because brown beans are the most—and often only—regularly consumed pulse (nut or seed), excluding brown beans also mean reducing the HDDS by this food group altogether. The exclusion of brown beans shows up in the HDDS but not in the HFVS, because, for example, they are substituted by foods from other, already consumed food groups, such as cereals or vegetables.

Among the farm household characteristics, the parameter estimates that are statistically significant in all model estimations are those for non-agricultural employment and poultry ownership. A possible explanation for the positive dietary diversity effect of non-agricultural employment is that, between 2011 and 2016, households started to increasingly engage in non-agricultural economic activities that require them to move from home. The increased mobility came along with gaining (physical) access to and increased consumption of a larger variety of foods due to food purchases in markets on their way back from work, for example. Poultry ownership has a consistently positive effect on household dietary diversity, whereas the parameter estimate for ruminant ownership is far from being statistically significant in most estimations. A possible interpretation of this pattern in the results is that farm households start to raise chicken and other poultry to diversify their diet into animal-source foods, while engaging in cattle, sheep, or goat husbandry serves primarily to acquire assets for income generation and investment rather than as a source of food for own-consumption.

6. CONCLUSIONS

In 2011, the federal government of Nigeria began to reform the agricultural sector under the guidance of the Agricultural Transformation Agenda (ATA)—the development strategy of the agricultural sector for 2010–2015. The successor five-year strategy document—the Agricultural Promotion Policy (APP)—builds on the strategic direction laid out by the ATA. The APP aims at increasing agricultural production to meet the food needs of Nigeria's rapidly growing population and transforming agriculture from subsistence-oriented to commercial and export-oriented production (FMARD 2016). In 2016, the federal government also launched the ten-year Agricultural Sector Food Security and Nutrition Strategy (AFSNS) to complement the APP (FMARD 2017). The AFSNS declares improving food and nutrition security as a key priority for the agricultural sector. Both current strategy documents emphasize the importance of rigorous, research-based evidence for policy-making and point out the lack of recent policy-relevant evidence. This paper seeks to improve the evidence on the intersection of agricultural production and improved nutrition to guide the design of policies and programs in Nigeria.

Policy-relevant nutrition-related research in Nigeria is limited because of poor nutrition data quality in recent nationally and regionally representative surveys. Our descriptive analysis shows that child anthropometric indicators—the most common form of population-based nutrition indicators globally—from the latest Nigeria Demographic and Health Survey (DHS) in 2013 and the last wave of the Nigeria General Household Survey (GHS) in 2016 suffer from serious measurement errors or possibly even biases. Derived estimates of undernutrition prevalence are likely to be inaccurate, especially at subnational levels in the geopolitical regions and states in the north of the country, where food insecurity and undernutrition is most widespread. Thus, existing prevalence estimates are hardly suited for spatial targeting of nutrition-sensitive policies and programs, for example. Moreover, indicators of child nutritional status derived from these recent data are insufficiently accurate for use in analyses of the determinants of child undernutrition. The Federal Ministry of Agriculture and Rural Development and the Federal Ministry of Health in collaboration with international development partner organizations plan to implement a National Food Consumption and Nutrition Survey in 2019. To ensure that the data from this survey are of good quality and suitable for policy and research purposes, it is fundamental that measurement and standardization protocols for anthropometric and other nutritional and dietary indicators are followed strictly.

Our econometric analysis suggests that farm production diversification was the dominant strategy for Nigerian farm households to diversify their diet between 2011 and 2016. The linkage between farm production diversity and household dietary diversity is exclusively driven by the direct production-consumption effect and not by a possible indirect income effect that emerges from changes in agricultural production conditions associated with diversification. Seemingly against the strategic direction of the ATA, farm production diversity increased between 2011 and 2016, which suggest that most farmers did not participate in the planned transformation of agriculture from diverse subsistence-oriented production toward more specialized commercial production. The apparent lack of agricultural transformation may be explained by an absence of an enabling economic environment. Farm households may be faced with severe market failures that do not allow them to separate agricultural production from food consumption decisions. Because most farm households suffer from food and nutrition insecurity and lack economic and physical access to a diversified diet from food purchases, they prioritize meeting their dietary needs through own-production over farm income generation, even if it means sacrificing income gains that are typically associated with farm production specialization and agricultural commercialization. Thus, production specialization and commercialization appear to have been a too risky strategy for most Nigerian farm households in terms of their food and nutrition security at least over the period 2011 to 2016.

Our estimation results also show that the loss in real income that farm households experienced between 2011 and 2016 was associated with reduced household dietary diversity. The income loss likely occurred due to Nigeria's economic recession in 2015-2016 and coincided with declines in real prices of common foods. This result points to the importance of household income growth for improving dietary diversity, as well as the important role of social protection programs for mitigating the impact of income shocks on food and nutrition security during economic crises. The estimated dietary diversity effects of food price changes differed in direction and size across foods. Declines in local rice and palm oil prices were associated with increases in dietary diversity, whereas, likely because of reverse substitution effects, declining prices of imported rice were associated with reduced dietary diversity.

Taken together, our estimation results demonstrate that agricultural transformation policy critically influences food and nutrition security beyond the standard parameters of agricultural productivity and farm income. To design and implement effective policies and programs that are conducive to both Nigeria's agricultural transformation and food and nutrition security goals, policymaking should be more evidence-based and better supported by rigorous, policy-relevant research. Both require more carefully collected and publicly available data.

REFERENCES

Assaf, S., M.T. Kothari, and T.W. Pullum. 2015. *An Assessment of the Quality of DHS Anthropometric Data, 2005-2014*. Rockville, MD: ICF International.

Benson, T., M. Amare, M. Oyeyemi, and O. Fadare. 2017. *Study of the Determinants of Chronic Malnutrition in Northern Nigeria: With a Focus on Kebbi and Bauchi States*. NSSP Working Paper 44. Abuja, Nigeria: International Food Policy Research Institute (IFPRI).

Black, M.M. 2003. "Micronutrient Deficiencies and Cognitive Functioning." *Journal of Nutrition* 133 (11): 3927S-3931S.

Black, R.E., S.S. Morris, and J. Bryce. 2003. "Where and Why are 10 million Children Dying Every Year?" *The Lancet* 361(9376): 2226-2234.

Bhutta, Z.A., J.K. Das, A. Rizvi, M.F. Gaffey, N. Walker, N., et al. 2013. "Evidence-based Interventions for Improvement of Maternal and Child Nutrition: What Can Be Done and At What Cost?" *The Lancet* 382(9890): 452-477.

Branca, F., and M. Ferrari. 2002. "Impact of Micronutrient Deficiencies on Growth: The Stunting Syndrome." *Annals of Nutrition and Metabolism* 46(Suppl. 1): 8-17.

Bryce, J., D. Coitinho, I. Darnton-Hill, D. Pelletier, and P. Pinstrup-Andersen. 2008. "Maternal and Child Undernutrition: Effective Action at National Level." *The Lancet* 371 (9611): 510-526.

Clausen, T., K.E. Charlton, K.S. Gobotswang, and G. Holmboe-Ottesen. 2005. "Predictors of Food Variety and Dietary Diversity among Older Persons in Botswana." *Nutrition* 21 (1): 86-95.

de Onis, M., A.W., Onyango, J. van den Broeck, C.W. Chumlea, and R. Martorell. 2004. "Measurement and Standardization Protocols for Anthropometry Used in the Construction of a New International Growth Reference." *Food and Nutrition Bulletin* 25 (1, Suppl. 1): S27-S36.

Dillon, B., and C.B. Barrett. 2017. "Agricultural Factor Markets in Sub-Saharan Africa: An Updated View with Formal Tests for Market Failure." *Food Policy* 67: 64-77.

Ecker, O. 2018. "Agricultural Transformation and Food and Nutrition Security in Ghana: Does Farm Production Diversity (Still) Matter for Household Dietary Diversity?" *Food Policy* 79: 271-282.

Ecker, O., and C. Breisinger. 2012. *The Food Security System: A New Conceptual Framework*. IFPRI Discussion Paper 1166. Washington, DC: International Food Policy Research Institute.

Engle, P.L., M.M. Black, J.R. Behrman, M. Cabral de Mello, P.J. Gertler, et al. 2007. "Strategies to Avoid the Loss of Developmental Potential in more than 200 Million Children in the Developing World." *The Lancet* 369 (9557): 229-242.

Fafchamps, M. 1992. "Cash Crop Production, Food Price Volatility, and Rural Market Integration in the Third World." *American Journal of Agricultural Economics* 74 (1): 90-99.

FEWS NET. 2013. "Seasonal Calendar, Nigeria: Typical Year." Online: http://fews.net/west-africa/nigeria/seasonal-calendar/december-2013. Accessed September 10, 2018.

FMARD (Nigeria Federal Ministry of Agriculture and Rural Development). 2016. *The Agriculture Promotion Policy (2016–2020): Building on the Success of the ATA, Closing Key Gaps*. Abuja, Nigeria: Federal Ministry of Agriculture and Rural Development.

______. 2017. *Agricultural Sector Food Security and Nutrition Strategy 2016–2025*. Abuja, Nigeria: Federal Ministry of Agriculture and Rural Development.

Grellety, E., and M.H. Golden. 2016. "The Effect of Random Error on Diagnostic Accuracy Illustrated with the Anthropometric Diagnosis of Malnutrition." *PloS One* 11 (12): e0168585.

Headey, D., and O. Ecker. 2013. "Rethinking the Measurement of Food Security: From First Principles to Best Practice." *Food Security* 5 (3): 327-343.

Headey, D., O. Ecker, and J. Trinh Tan. 2014. "Shocks to the System: Monitoring Food Security in a Volatile World." In *Handbook on Food: Demand, Supply, Sustainability and Security*, edited by R. Jha, R. Gaiha, and A.B. Deolalikar, 41-71. Cheltenham, UK, and Northampton, MA, USA: Edward Elgar Publishing.

Horton, S., M. Shekar, C. McDonald, A. Mahal, and J.K Brooks. 2010. *Scaling Up Nutrition: What Will It Cost?* Washington, DC: World Bank.

IMF (International Monetary Fund). 2016. *Nigeria*. IMF Country Report No. 16/101. Washington, DC: International Monetary Fund.

Katona, P., and J. Katona-Apte. 2008. "The Interaction Between Nutrition and Infection." *Clinical Infectious Diseases* 46 (10): 1582-1588.

Mahrt, K., and C. Arndt. 2018. "Consumption Poverty in Nigeria: A Preliminary Assessment of the 2015-16 Nigeria General Household Survey." Unpublished manuscript.

Mei, Z., and L.M. Grummer-Strawn. 2007. "Standard Deviation of Anthropometric Z-Scores as a Data Quality Assessment Tool Using the 2006 WHO Growth Standards: A Cross Country Analysis." *Bulletin of the World Health Organization* 85: 441-448.

Morduch, J. 1995. "Income Smoothing and Consumption Smoothing." Journal of Economic Perspectives 9 (3): 103-114.

NBS (Nigeria National Bureau of Statistics), FMARD, and World Bank. 2016. *LSMS-Integrated Surveys on Agriculture General Household Survey Panel 2015/2016*. Abuja, Nigeria, and Washington, DC: National Bureau of Statistics and World Bank.

Neumann, C.G., N.O. Bwibo, S.P. Murphy, M. Sigman, S. Whaley, et al. 2003. "Animal Source Foods Improve Dietary Quality, Micronutrient Status, Growth and Cognitive Function in Kenyan School Children: Background, Study Design and Baseline Findings." *Journal of Nutrition* 133 (11): 3941S-3949S.

NPC (Nigeria National Population Commission) and ICF International 2014. *Nigeria Demographic and Health Survey 2013*. Abuja, Nigeria and Rockville, MD: National Population Commission and ICF International.

Pingali, P.L., and M.W. Rosegrant. 1995. "Agricultural Commercialization and Diversification: Processes and Policies." *Food Policy* 20 (3): 171-185.

Ramakrishnan, U. 2002. "Prevalence of Micronutrient Malnutrition Worldwide." *Nutrition Reviews* 60 (Suppl. 5): S46-S52.

Ruel, M.T. 2001. *Can Food-based Strategies Help Reduce Vitamin A and Iron Deficiencies? A Review of Recent Evidence*. Washington, DC: International Food Policy Research Institute.

Ruel, M.T. 2003. "Operationalizing Dietary Diversity: A Review of Measurement Issues and Research Priorities." Journal of Nutrition 133 (11): 3911S-3926S.

Ruel, M.T., J. Harris, and K. Cunningham. 2013. "Diet Quality in Developing Countries." In *Diet Quality: An Evidence-Based Approach*, Volume 2, edited by V.R. Preedy, L.-A. Hunter, and V.B. Patel., 239-261. New York, NY: Humana Press.

Ruel, M. T., and P. Menon. 2002. "Child Feeding Practices are Associated with Child Nutritional Status in Latin America: Innovative Uses of the Demographic and Health Surveys." *Journal of Nutrition* 132 (6): 1180-1187.

Simpson, E.H. 1949. "Measurement of diversity." *Nature* 163: 688.

Smith, L.C., U. Ramakrishnan, A. Ndiaye, L. Haddad, and A. Martorell. 2003. *The Importance of Women's Status for Child Nutrition in Developing Countries*. IFPRI Research Report 131. Washington, DC: International Food Policy Research Institute.

Stephenson, L.S., M.C. Latham, and A. Ottesen. 2000. "Malnutrition and Parasitic Helminth Infections." *Parasitology* 121 (Suppl.): S23-S38.

Swindale, A., and P. Bilinsky. 2006. *Household Dietary Diversity Score (HDDS) for Measurement of Household Food Access: Indicator Guide*. Version 2. Washington, DC: Academy for Educational Development.

Thomas, D. 1990. "Intra-Household Resource Allocation: An Inferential Approach." *Journal of Human Resources* 25 (4): 635-664.

Ulijaszek, S.J., and D.A. Kerr. 1999. "Anthropometric Measurement Error and the Assessment of Nutritional Status." *British Journal of Nutrition* 82 (3): 165-177.

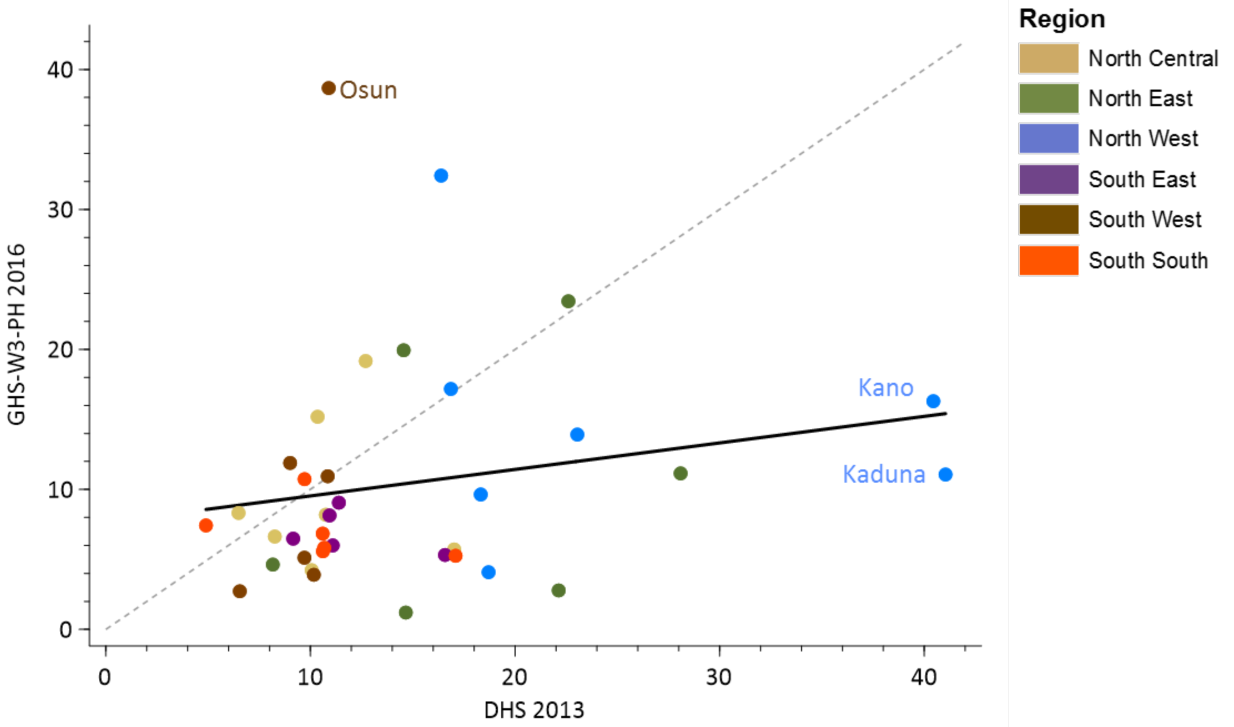
UN (United Nations). *The Sustainable Development Goals Report 2016*. New York, NY: United Nations.

von Grebmer, K., J. Bernstein, N. Hossain, T. Brown, T., N. Prasai, et al. 2018. *2017 Global Hunger Index: The inequalities of hunger*. Washington, DC: International Food Policy Research Institute.

Walker, S.P., T.D. Wachs, J.M. Gardner, B. Lozoff, G.A. Wasserman, et al. 2007. "Child Development: Risk Factors for Adverse Outcomes in Developing Countries." *The Lancet* 369 (9556): 145-157.

APPENDIX

Figure A.1. Correlation of state-level prevalence rates of child wasting



Source: Own estimation, based on DHS 2013 and GHS-W3-PH 2016 data.
Note: The correlation coefficient is statistically insignificant at any common level. Kaduna, Kano, and Osun states show differences in child wasting rates of more than 20 percentage points.

Table A.1. Estimates of farm household characteristics in the random-effects model for the household food variety score

	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)	(4a)	(4b)
Household size (number of persons)			0.139***	0.142***	0.267***	0.270***	0.372***	0.375***
			0.021	*0.021*	*0.023*	*0.023*	*0.024*	*0.024*
Sex of household head (0=male, 1=female)			0.299	0.277	0.278	0.256	-0.173	-0.193
			0.194	*0.195*	*0.184*	*0.185*	*0.180*	*0.180*
Age of household head (years)			0.006	0.006	0.006	0.006	-0.009**	-0.009**
			0.004	*0.004*	*0.004*	*0.004*	*0.004*	*0.004*
Education level attained by household head†								
Primary (0=no, 1=yes)			0.373**	0.381**	0.223	0.229	0.018	0.023
			0.151	*0.152*	*0.147*	*0.148*	*0.141*	*0.141*
Secondary or higher (0=no, 1=yes)			1.112***	1.105***	0.851***	0.843***	0.462***	0.453***
			0.186	*0.187*	*0.179*	*0.180*	*0.171*	*0.172*
Non-agricultural employment (0=no, 1=yes)			1.231***	1.259***	1.030***	1.057***	0.815***	0.836***
			0.126	*0.126*	*0.122*	*0.122*	*0.117*	*0.117*
Farm size (sq.m.; log)			0.075	0.161***	0.047	0.129**	-0.048	0.027
			0.054	*0.052*	*0.053*	*0.050*	*0.050*	*0.047*
Ruminant ownership (0=no, 1=yes)			0.201	0.236*	0.126	0.161	0.176	0.205
			0.139	*0.139*	*0.135*	*0.135*	*0.126*	*0.126*
Poultry ownership (0=no, 1=yes)			0.340***	0.398***	0.388***	0.445***	0.377***	0.425***
			0.125	*0.125*	*0.122*	*0.122*	*0.113*	*0.114*
Constant	18.169***	18.514***	14.958***	14.407***	5.726***	5.142***	9.470***	9.241***
	0.960	*0.959*	*1.024*	*1.016*	*1.204*	*1.200*	*1.756*	*1.756*

Source: Own estimation, based on GHS-W1 and GHS-W3 data and NBS food price data. The sample includes 2,537 households, with each one observation in 2011 and 2016.
Note: See Table 5.1.
***, **, * Coefficient is statistically significant at the 1%, 5%, and 10% level, respectively. Standard errors (shown in italics) are clustered at the household level.
† The reference value indicates no formal education.

Table A.2. Estimates of farm household characteristics in the fixed-effects model for the household food variety score

	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)	(4a)	(4b)
Household size (number of persons)			-0.024	-0.020	0.039	0.045	0.360***	0.366***
			0.055	*0.056*	*0.059*	*0.059*	*0.053*	*0.053*
Sex of household head (0=male, 1=female)			1.868***	1.933***	2.062***	2.131***	-0.180	-0.132
			0.518	*0.523*	*0.529*	*0.533*	*0.488*	*0.491*
Age of household head (years)			0.068***	0.069***	0.075***	0.077***	0.006	0.007
			0.012	*0.012*	*0.013*	*0.013*	*0.011*	*0.011*
Education level attained by household head†								
Primary (0=no, 1=yes)			0.306	0.342	0.290	0.324	-0.054	-0.025
			0.284	*0.286*	*0.284*	*0.286*	*0.252*	*0.255*
Secondary or higher (0=no, 1=yes)			0.839**	0.860**	0.899**	0.921**	0.387	0.402
			0.369	*0.375*	*0.370*	*0.375*	*0.331*	*0.334*
Non-agricultural employment (0=no, 1=yes)			0.795***	0.834***	0.807***	0.847***	0.710***	0.737***
			0.209	*0.209*	*0.208*	*0.209*	*0.192*	*0.192*
Farm size (sq.m.; log)			0.134*	0.218***	0.133*	0.215***	-0.017	0.060
			0.080	*0.076*	*0.080*	*0.076*	*0.073*	*0.068*
Ruminant ownership (0=no, 1=yes)			0.278	0.319	0.237	0.277	0.295	0.329
			0.227	*0.228*	*0.228*	*0.229*	*0.203*	*0.203*
Poultry ownership (0=no, 1=yes)			0.569***	0.595***	0.585***	0.612***	0.454***	0.473***
			0.192	*0.192*	*0.192*	*0.192*	*0.168*	*0.168*
Constant	12.938***	13.291***	7.227***	6.610***	3.670**	2.945*	5.326***	4.980***
	0.214	*0.262*	*1.005*	*1.000*	*1.584*	*1.587*	*1.776*	*1.785*

Source: Own estimation, based on GHS-W1 and GHS-W3 data and NBS food price data. The sample includes 2,537 households, with each one observation in 2011 and 2016.
Note: See Table 5.2.
The model parameters are fixed at the household level.
***, **, * Coefficient is statistically significant at the 1%, 5%, and 10% level, respectively. Standard errors (shown in italics) are clustered at the household level.
† The reference value indicates no formal education.

Table A.3. Estimates of farm household characteristics in the random-effects model for the household dietary diversity score

	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)	(4a)	(4b)
Household size (number of persons)			0.051***	0.051***	0.100***	0.101***	0.129***	0.130***
			0.009	*0.009*	*0.010*	*0.010*	*0.010*	*0.010*
Sex of household head (0=male, 1=female)			0.155**	0.152**	0.146**	0.142**	0.026	0.022
			0.072	*0.072*	*0.069*	*0.069*	*0.069*	*0.069*
Age of household head (years)			-0.001	-0.001	-0.001	-0.001	-0.005***	-0.005***
			0.002	*0.002*	*0.002*	*0.002*	*0.002*	*0.002*
Education level attained by household head†								
Primary (0=no, 1=yes)			0.125**	0.127**	0.068	0.069	0.009	0.010
			0.061	*0.061*	*0.060*	*0.060*	*0.059*	*0.059*
Secondary or higher (0=no, 1=yes)			0.446***	0.446***	0.346***	0.346***	0.243***	0.242***
			0.072	*0.072*	*0.070*	*0.070*	*0.069*	*0.069*
Non-agricultural employment (0=no, 1=yes)			0.475***	0.476***	0.401***	0.401***	0.338***	0.339***
			0.051	*0.051*	*0.050*	*0.050*	*0.049*	*0.050*
Farm size (sq.m.; log)			0.052**	0.059***	0.042**	0.047**	0.013	0.019
			0.021	*0.021*	*0.021*	*0.020*	*0.020*	*0.020*
Ruminant ownership (0=no, 1=yes)			0.030	0.029	0.002	0.001	0.011	0.010
			0.055	*0.055*	*0.053*	*0.053*	*0.051*	*0.051*
Poultry ownership (0=no, 1=yes)			0.185***	0.197***	0.202***	0.212***	0.197***	0.207***
			0.051	*0.051*	*0.050*	*0.050*	*0.048*	*0.048*
Constant	8.998***	9.141***	7.730***	7.746***	4.192***	4.186***	6.197***	6.216***
	0.264	*0.261*	*0.306*	*0.304*	*0.399*	*0.398*	*0.666*	*0.665*

Source: Own estimation, based on GHS-W1 and GHS-W3 data and NBS food price data. The sample includes 2,537 households, with each one observation in 2011 and 2016.
Note: See Table 5.3.
***, **, * Coefficient is statistically significant at the 1%, 5%, and 10% level, respectively. Standard errors (shown in italics) are clustered at the household level.
† The reference value indicates no formal education.

Table A.4. Estimates of farm household characteristics in the fixed-effects model for the household dietary diversity score

	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)	(4a)	(4b)
Household size (number of persons)			0.001	0.002	0.035	0.037	0.118***	0.119***
			0.021	*0.021*	*0.023*	*0.023*	*0.022*	*0.022*
Sex of household head (0=male, 1=female)			0.403**	0.411**	0.508***	0.518***	-0.059	-0.049
			0.174	*0.174*	*0.179*	*0.178*	*0.185*	*0.184*
Age of household head (years)			0.014***	0.014***	0.018***	0.018***	-0.000	-0.000
			0.005	*0.005*	*0.005*	*0.005*	*0.005*	*0.005*
Education level attained by household head†								
Primary (0=no, 1=yes)			0.046	0.045	0.038	0.036	-0.060	-0.062
			0.109	*0.109*	*0.109*	*0.109*	*0.103*	*0.103*
Secondary or higher (0=no, 1=yes)			0.352***	0.352***	0.384***	0.385***	0.257**	0.258**
			0.132	*0.133*	*0.132*	*0.133*	*0.127*	*0.128*
Non-agricultural employment (0=no, 1=yes)			0.348***	0.357***	0.354***	0.364***	0.323***	0.330***
			0.086	*0.086*	*0.085*	*0.085*	*0.083*	*0.083*
Farm size (sq.m.; log)			0.075**	0.073**	0.076**	0.072**	0.032	0.031
			0.030	*0.029*	*0.030*	*0.029*	*0.028*	*0.028*
Ruminant ownership (0=no, 1=yes)			0.000	0.003	-0.021	-0.020	-0.015	-0.013
			0.089	*0.088*	*0.089*	*0.089*	*0.083*	*0.083*
Poultry ownership (0=no, 1=yes)			0.318***	0.328***	0.326***	0.337***	0.289***	0.298***
			0.076	*0.076*	*0.076*	*0.076*	*0.071*	*0.071*
Constant	7.664***	7.672***	5.850***	5.845***	3.952***	3.871***	5.201***	5.149***
	0.083	*0.086*	*0.377*	*0.377*	*0.616*	*0.615*	*0.728*	*0.728*

Source: Own estimation, based on GHS-W1 and GHS-W3 data and NBS food price data. The sample includes 2,537 households, with each one observation in 2011 and 2016.
Note: See Table 5.4.
The model parameters are fixed at the household level.
***, **, * Coefficient is statistically significant at the 1%, 5%, and 10% level, respectively. Standard errors (shown in italics) are clustered at the household level.
† The reference value indicates no formal education.

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