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PROJECT

NUTRITION AND FOOD SECURITY IN BURKINA FASO

DIAGNOSTIC OVERVIEW

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Abstract

This analysis uses data from a nationally-representative household consumption and expenditure survey (HCES), linked with food composition databases, to identify areas of nutritional deficiencies, food insecurity, and child undernutrition in Burkina Faso. While HCES are not primarily designed to collect data for studying food and nutrition security, they often collect food consumption and agricultural production data that can be analyzed to shed light on the state of food and nutrition security. Results show that agricultural production focuses heavily on grain staples such as sorghum, maize, and millet whose production is far from sufficient to meet nutritional needs, consistently with Burkina Faso's status as a net food importer. The calorie consumption of about half of Burkinabe' households is likely to be insufficient to cover the energy requirements for a healthy and normally active life. Additionally, Calcium and vitamin A intake levels seem to be lower than the estimated average requirements for 90% and 56% of the households, respectively. Food and nutrient intake varies across regions and sociodemographic groups. Child undernutrition is widespread with a third of children under five being stunted, an indicator of long-term undernourishment. These results can be used to identify priority areas for policy-makers working to reduce extreme hunger and undernutrition in the country.

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Acronyms

AME	Adult Male Equivalent
ASF	Animal Source Foods
BMI	Body Mass Index
CIA	Central Intelligence Agency
CPI	Consumer Price Index
DHS	Demographic and Health Surveys
EAR	Estimated Average Requirement
EMC	Enquête Multisectorielle Continue
FAFH	Food Away From Home
FAO	Food and Agriculture Organization of the United Nations
FCT	Food Composition Table
FIES	Food Insecurity Experience Scale
HCES	Household Consumption and Expenditure Surveys
HDDS	Household Dietary Diversity Score
IFPRI	International Food Policy Research Institute
INDDEX	International Dietary Data Expansion Project
IOM	United States Institute of Medicine
IYCF	Infant and Young Child Feeding Practices
LSMS	Living Standards Measurement Survey
RE	Retinol Equivalents
RNI	Recommended Nutrient Intakes
TEE	Total Energy Expenditure
USDA	United States Department of Agriculture

1. Introduction

1.1 Study Objectives

The public health community needs more nuanced dietary data. Even in the world's poorest countries, obesity is rising even as undernutrition remains a considerable problem. While in the past, development practitioners considered economic welfare as a suitable proxy for nutrition, the double burden of malnutrition requires a more nuanced approach (Coates et al., 2016). This study therefore illustrates how Household Consumption and Expenditure Surveys (HCES) can be used for food security and nutrition analysis. We use available data in Burkina Faso to identify major sources of nutrients and calories from both production and consumption information.

We address the following questions:

- Are Burkinabe households net buyers or net sellers of food commodities?
- What are the regional patterns of food production and consumption?
- Is there heterogeneity in food consumption, nutrient intake, food security, and child nutritional status by region or socioeconomic characteristics?

1.2 Country Background

Burkina Faso is overwhelmingly poor, rural, with an agriculture-dominant economy. In 2012, average per capita income was \$460, and 44% of the population lived on under \$1.90 (in purchasing power parity) per day (Nguyen and Dizon, 2017). Although the country has witnessed an improvement from 82% poverty rate in 1998 (World Bank, 2018), considerable efforts need to be exerted to eradicate extreme poverty.

The agricultural sector accounts for 35% of value-added on GDP in 2014, higher than for countries such as the Gambia (20%) and Zimbabwe (12%), but less than Togo's 42%. This fraction has remained relatively stable since 1990. In absolute terms, agriculture's contribution to GDP has increased steadily from \$ 1 billion in 1990 to \$ 3.2 billion in 2014, in line with growth of the economy as whole (World Bank, 2018). The agricultural sector provides employment for over 80% of its population and job creation is one of the four pillars of the country's poverty

reduction strategy. Unemployment rate currently stands at about 6% with migration to neighboring countries for a period of up to two years being a common practice (CIA, 2017). Poverty tends to be geographically clustered, with nomadic people in the north generally much less poor, partly due to livestock presence (Nguyen and Dizon, 2017).

1.3 Agricultural Production

Burkina Faso is generally dry and more arid than neighboring Benin, Cote d'Ivoire, and Togo. While southern Burkina Faso is primarily covered by tropical savannahs, central Burkina Faso is warm and semi-arid, while the north is covered by warm deserts of the Sahelian region (Nguyen and Dizon, 2017). Eighty percent of the population is rural, with the rural sector employing 86% of the country's active workforce (FAO, 2015). Though rural population has decreased slightly from a high of 86% in 1990, the percentage is still higher than Zimbabwe (68%), Togo (61%), and the Gambia (41%) (World Bank, 2018). Key agricultural production includes cotton, peanuts, shea nuts, sesame, sorghum, millet, corn, rice, and livestock (CIA, 2017).

Agriculture is the primary activity for most Burkinabe households. Agricultural enterprises employ 80% of the working population, including 66% of all non-poor and 95% of poor individuals (Nguyen and Dizon, 2017). While agricultural output has increased in recent years, agricultural productivity remains low. The increase in output can be explained entirely by increases in crop area, while actual productivity has decreased. Average cereal yield in Burkina Faso is 1,226 kg/hectare, compared to a world average of 3,886 kg/hectare. Cash crop production, particularly cotton, is concentrated in the south. In this area, 73% of farmers sell some of their production, compared to just 30% in the north (World Bank, 2018). Though cereal food crop production has risen steadily from 1.5 million metric tons in 1990 to 4.5 million metric tons in 2014, production is still primarily for subsistence purposes (World Bank, 2018). Only 10% of sorghum growers in Burkina Faso sell this crop, despite sorghum being a major staple in the Burkinabe diet (Nguyen and Dizon, 2017).

Burkina Faso is particularly susceptible to chronic recurring droughts, which threaten agricultural output and increase food prices (CIA, 2017). Food price shocks most recently hit the country in 2008 and 2012 and led to violent protests in the capital city Ouagadougou, as people in urban settings were hit the hardest given their reliance on food purchases (FAO, 2012). Price shocks affected food items independently, with the highest increase for fish, millet, rice, maize flour, vegetable oil, and groundnut paste. The price of the median food basket increased by 32% following the 2008 price shock, while expenditures increased by only 18%, thus implying a reduction in average food intake or a shift to cheaper, possibly less nutritious diet (Martin-Prével et al., 2012).

1.4 Food and Nutrition Security

Chronic undernutrition is rampant in Burkina Faso among both reproductive-age women and young children. For example, based on food consumption data collected from reproductive-age women and 24-hour recalls, Becquey and Martin-Prével (2010) find adequate intake of Vitamin B-12, folate, riboflavin, and niacin among, respectively, 4%, 12%, 13%, and 20% of the sample. Given Burkina Faso's diverse range of agro-ecological zones, diet composition varies significantly across the country. While in the south area main staples include maize and rice, northern diets are much more reliant on sorghum and millet (Nguyen and Dizon, 2017). Cereals of any type, however, account for nearly 73% of all calories consumed (FAO, 2012).

Generally, diet is substantially different in urban areas, where purchased food accounts for 46% of available calories (Becquey and Martin-Prével, 2010). Population in the south enjoys a more diverse diet, along with higher agricultural productivity, as measured by a Hirschman food consumption index (Nguyen and Dizon, 2017). Processed food currently plays little role in the typical Burkinabe diet, though its importance might rapidly change as consumer demands shift along with increasing incomes (Staatz and Hollinger, 2016). However, all regions are exposed to seasonality both in agricultural production and the incidence of hunger. Harvest begins in October, with supplies typically lasting well into April and the lean season typically lasting between June and September (Frongillo and Nanama, 2006). This seasonality has direct

implications for household dietary diversity and nutritional outcomes as documented in Savy et al. (2006) and Some and Jones (2018) as well as adequate intake of crucial micronutrients (Arsenault et al., 2014). In the lean season, households are likely to diversify away from local staple crops to consume a higher variety of cereals, fewer nuts and seeds, and less meat and animal products, shifting away from less-essential foods, thereby decreasing dietary diversity (Martin-Prevel et al., 2012).

In line with the Millennium Development Goals (2000-2015), under-5 child mortality in Burkina Faso dropped from 199 deaths per 1000 live births in 1999 to 92.8 in 2010, though is still higher than Togo (80), the Gambia (69.9), and Zimbabwe (64) (World Bank, 2018). Under-5 child stunting rate, an indicator of long-term undernutrition, was 35.1% in 2010. Although the stunting rate decreased from 45.5% in 1999, it is still well above Togo's 30% or the Gambia's 23% (World Bank, 2018). Other anthropometric indicators fare slightly better, with wasting rate at 15.4% and underweight rate at 26% in 2010. Seasonality in food and nutrition security has previously been documented. For example, using an experience-based household food insecurity score, Frongillo and Nanama (2006) document a higher level of food insecurity during the hungry season in July than during the post-harvest season in January, although such seasonality was not observed when examining child nutritional outcomes based on anthropometric data.

According to the 2018 FAO report *The State of Food Security and Nutrition in the World* (FAO IFAD, UNICEF, WFP and WHO, 2018), Burkina Faso's nutritional conditions relative to other West African economies show a mixed picture. For example, 27% of under-five Burkina children were stunted in 2017, a rate that is lower than the average for sub-Saharan Africa (33%) and West Africa (30%). Similarly, child wasting rate stood at 7.6%, marginally lower than the rate for West Africa (8.1%). In terms of adult obesity rate in 2016, Burkina Faso had a relatively lower rate (4.5%) than that for West Africa (7.7%). Burkina Faso also performed well in exclusive breastfeeding, with half of infants below 5 months were exclusively breastfed in 2017, compared to the regional average of 31% (FAO, 2018). On the other hand, about 21% of the

Burkina population was reported to be undernourished during 2015-2017, 8 percentage points higher than the average for West Africa during (13%) (FAO IFAD, UNICEF, WFP and WHO, 2018).

2. Data

This Diagnostic Overview analyzes data from the 2014 Continuous Multisectoral Survey (*Enquête Multisectorielle Continue*) (EMC 2014), a nationally representative survey administered in Burkina Faso between January and December 2014 by the *Institut National de la Statistique et de la Démographie*, funded by Statistics Sweden.¹ Sampled households were interviewed in four separate visits that correspond to the agricultural production cycle. The visits were made in mid-January to mid-March (post-harvest season); end of April to end of June (beginning of lean season); mid-July to mid-August (end of the lean season); and finally, mid-September to mid-December (harvest season).

The survey covered all the 45 provinces, and two-stage stratified sampling is used to select survey households. In the first stage, enumeration areas were drawn with probability proportional to the number of households in the area. In the second stage, twelve households were randomly sampled from each enumeration area. The sample covered 10,860 households over 905 enumeration areas. Face-to-face interviews were conducted in French or local languages, as appropriate, covering modules on individual characteristics, agricultural production, consumption, employment, assets, health, education, food savings, coping strategies, savings, and child anthropometry. The EMC data have been used in previous studies across several research disciplines. For example, Nguyen and Dizon (2017) examine agricultural yield and productivity improvements, while Goundan and Magne Domgho (2016) study agricultural land area use. Other studies address poverty (based on food and non-food consumption expenditure) directly, as in Niankara (2017) and Bahan and Dramani (2015). Production data are reported using a production-season (annual) recall at a plot-crop level. Respondents report the area planted with each crop (in hectares) as well as the harvested

¹ The survey is part of the Living Standards Measurements Study-Integrated Surveys on Agriculture (LSMS-ISA), available at <http://microdata.worldbank.org/index.php/catalog/2538>.

amount (in kilograms). Food consumption inside the household is reported using a 7-day recall. Data on the value and quantity of food were collected for 56 food items, disaggregated by acquisition source: purchased items, produced items, or items received as a gift or in exchange for work.

The publicly available 2014 EMC dataset includes information on the quantities of foods consumed inside the household only in the first visit, while datasets from the other three visits encompass only information on the type and monetary value (*not quantity*) of food items consumed. The bulk of the dietary/nutrition analysis therefore uses food consumption data collected during the first visit, while data from the other visits are also analyzed to examine household-level dietary diversity and the consumption of food away from home (FAFH). Results from the analysis of nutrient intake presented here, therefore, may not reflect consumption patterns outside the post-harvest season (mid-January to mid-March).

Our approach links reported agricultural production and consumption data to food composition data to assess the nutritional status of households. The quality of HCES-based dietary analysis is largely a function of the completeness and accuracy of the food consumption data, used here as a proxy for the unobserved food intake, together with the food composition table (FCT) used. Globally, quality of food composition tables varies dramatically. In high-income countries, FCTs are typically comprehensive and local-specific. In poorer countries, they may lack key consumption items and fail to account for geographic differences in nutrients. Even within a country, nutrient profiles may vary substantially as a function of soil composition, agro-ecology, planting practices, or other environmental factors. As such, even accurate national-level FCTs may reveal sub-national differences (Coates et al., 2016).

We primarily use the West African FCT² (FAO 2012), which has been recognized as a reliable source for West African diets (see Vinceti et al., 2013; Abizari et al., 2012; Aworh, 2015). For any

² The INDDEx Project is currently investing in updating the West African Food Composition Table, expected in 2018. The updated table will include more foods, 100 additional recipes, and the addition of nutritional information on fermented foods (see Coates et al., 2016).

gaps between the EMC survey items and the reference data provided in the West African FCT, we use the USDA Food Composition Database (2016). The following nutrients are computed based on the edible portions of harvested crops– calorie (kilocalorie-kcal), zinc (milligram-mg), iron (mg), vitamin A measured in Retinol Equivalents (RE) (microgram-ug), and calcium (mg). Vitamin A contents of crops are computed based on retinol and beta-carotene equivalent values and the appropriate conversion factors from food composition tables.³

Data on Estimated Average Requirements (EAR) come from different sources. For vitamin A, EAR published by FAO/WHO are used (WHO and FAO, 2004) (Appendix A1). EMC’s food consumption module collected data on “patate” and “pomme de terre” that we translated as sweet potato and potato. Since sweet potato is not disaggregated by type, we applied a simple average of the nutrient contents of pale yellow, dark yellow, and yellow fleshed sweet potatoes to compute the nutrient contents of sweet potato, a crucial source of vitamin A. Similarly, since in the EMC survey data are broken down by different oil types, our nutrient conversion factor for EMC food item “oils” is based on a simple average of the following four types of oils from the West Africa FCT: palme, huile, rouge; Arachide, huile; Coton, huile; and Palme, huile, raffiné. EAR data for calcium are based on the U.S. Health and Medicine Division. These EARs were used by experts who defined the methodology for the Minimum Dietary Diversity for Women (HMD, 2016) (Appendix A2).

For zinc, the source of EAR data is IZINCG group (IZINCG, 2004), where we assume Burkina diet to be a mixed and refined vegetarian diets (with phytate to zinc molar ratio 4-18) and an unrefined, cereal based diet (phytate: zinc molar ratio >18). According to Wessell and Brown (2012), the phytate to zinc ratio for Burkina is 35 and so the EAR for unrefined, cereal based diet is used (Appendix A3). For iron, we use EAR for Bangladesh, based on FAO-WHO recommended nutrient intakes (RNI) (FAO and WHO, 2004), since EAR data for Burkina Faso were not available. Iron is a complex nutrient in terms of both diet bioavailability and

³ The conversion factor is $\mu\text{g RE} = \mu\text{g Retinol} + \mu\text{g Beta-carotene equivalents}/6$ (Moltedo et al., 2017).

distribution of its requirements, with some groups (e.g., women in the reproductive age group) having highly skewed distribution. Its accurate estimation is therefore more challenging.

3. Methodology

3.1 Household Consumption and Expenditure Surveys for Dietary Analysis

In recent decades, there has been an increase in quality of household consumption and expenditure surveys (HCES) as well as analytical rigor in their use for nutritional analysis. Within the realm of household-level dietary data analysis, weighing of food items is considered the gold standard to obtain reasonably accurate estimates of food quantities consumed (and, in turn, the associated expenditures), with the 24-hour recall method preferable to longer recall periods in terms of reduced recall bias and measurement error to assess dietary quality. However, these approaches are viewed as costly, time-consuming, and hard to implement, especially in resource constrained contexts (Fiedler et al., 2012).

HCES are typically collected as part of the national data collection system, and often boast large sample sizes, which allow sub-national representativeness (Fiedler et al., 2012). HCES food consumption data collection based on 7-day recall often suffers from recall bias and, in turn, underreporting, especially among vulnerable groups including elderly, women, and low-educated respondents (Backiny-Yetna et al. 2017; Beegle et al 2012). Despite these shortcomings, studies have shown a considerable consistency between HCES and more intensive 24-hour food recall, both in the type and quantity of foods consumed (Lambe et al., 1998; Friel et al., 2001; Naska, Vasdekis, and Trichopoulou, 2001; Rambeloson Jariseta et al., 2012) and nutrient availability (Naska et al., 2007; Nelson, Dyson, and Paul, 1985).

3.2 Adult Male Equivalent Analysis

Because EMC food consumption data are reported at the household (and not individual) level, there are different methods on how to allocate overall consumption amongst household members. One common approach to take intra-household distribution into account is through adult male equivalent (AME) benchmark, in line with FAO (2003) guidelines. The AME

calculation considers each household member's age, sex, and physical activity level⁴ to determine nutrient needs relative to a fully-grown adult male. We assume that household consumption is distributed evenly across all consumption items according to everyone's share of the total household adult male equivalents in terms of calorie requirements. Therefore, household members with higher calorie needs will be allocated a bigger share of the total, even though the total might be inadequate to meet all household needs (Coates et al., 2017, Weisell and Dop, 2012). This approach implies that households in states of nutritional deficiency will ration according to need, rather than favor some household members over others, therefore preventing us from inferring intra-household dynamics and inequality. We follow a similar approach to determine estimated average requirements of vitamin A, iron, calcium, and zinc for the different life-stage groups (IOM, 2006; IZiNCG, 2004).

AME's calculation has been shown to perform better than simple per capita measures in capturing the average household consumption taking age and sex of household members into account (Fiedler et al., 2012). Coates et al. (2017) compare AME distributions to individual-level food consumption in Ethiopia and Bangladesh and find that predictions are generally accurate within 10 percentage points. However, the error is not fully random across households, with vulnerable groups such as women and children more prone to measurement error. This is indeed one of the fundamental flaws in the use of AME's benchmark as a better average measure of individual food consumption from household-level data- namely, that it is impossible to capture intra-household inequality under the assumption of equitable distribution of food consumption across household members according to calorie needs. Policies aimed at reducing undernutrition for vulnerable populations cannot rely solely on AME reference to identify groups at-risk; individual data must also be collected.

⁴ In line with Coates et al. (2017), we assume all household members to exert a moderate level of physical activity. Though errors may be reduced by further refining physical activity levels based on reported manual labor or other individual-level information, the correction is a potential additional source of unknown measurement error.

3.3 Non-Standard Units

The EMC survey's consumption module allows respondents to choose the units in which to report consumption quantities. Some of these units, such as grams and liters, are universal measures that can easily be matched to FCTs. Other non-standard units, such as heaps, loaves, and plates, must be converted to standard measurement units. These weights can vary tremendously between, as well as within, countries (Fiedler et al., 2012). To account for this heterogeneity, surveys often include a secondary community-level module to find the standard weights of non-standard units within a given village, region, or country (Fiedler et al., 2012).

This report uses non-standard unit conversions for the EMC collected by the World Bank's Living Standards Measurement Survey (LSMS). The conversion data includes food item-level information about the average and median conversion factor. Local unit conversion factors were provided in three sizes – small, medium, and large – and at three administrative units – strata, region, and national. In this study, the median conversion factor is used.⁵ In addition, since the size of the local units reported in the food consumption data is unknown, we use the medium size conversion factor when the information is available. When it is not available, we use the average of the small and large size conversion factors. For non-standard units without metric conversion factor through this process conversion was made based on data from the Burkina Faso Ministry of Agriculture photo guidelines and some assumptions. The Ministry of Agriculture provide standard weights for some non-standard units, including *yorubas* and *grosse boites*.

3.4 Foods Away from Home (FAFH)

Unlike food consumed inside the household, the ECM did not collect data on types and quantities of food consumed away from home (FAFH). What is available is instead data on household-level expenditure on two items that we consider as FAFH. The two items are “frais de cantines” (the amount spent for students/pupils' for their catering away from home) (FAFH-

⁵ Increasingly higher median conversion factors are used - strata level, then region level (if strata level conversion is missing), and finally national level (if both strata and region level conversion factors are missing).

1) and “frais de restauration dans les restaurants, cafés et établissements similaires.” (FAFH-2). While the reference period for FAFH-2 was the last three months during the first visit, it was changed to last seven days in the last three visits to minimize measurement errors due to potential memory loss. FAFH-2 from first visit has therefore been converted into seven days.

We follow Molledo et al. (2014) to estimate caloric availability from FAFH using the unit cost-per-calorie method. After computing the cost of calorie intake per AME per day for food consumed inside the household (based on the median cost of calorie by province), calorie intake from FAFH is imputed by dividing total expenditure on FAFH with the cost of calorie. While informative, this approach might be prone to measurement error, since data are missing on the actual food items consumed away from home. Therefore, the interpretation of caloric intake from FAFH should be made having this caveat in mind.

3.5 Crop Production

For the crop production analysis, we first use FCTs to determine the edible portion and nutrient composition of food crops harvested by survey households during the reference season. This information is then linked with self-reported data on the quantity of crops harvested by EMC households (kilograms). Several summary tables are provided showing the most commonly grown groups, total area and quantity of harvest, as well as their contributions to total available macro and micronutrients from crop production. It is worth noting that available nutrients will most likely be underestimated, since we are not accounting for household supply of nutrients from animal-sourced foods (ASF) due to missing data on livestock ownership/rearing and associated production of ASF by the household.

3.6 Nutritional Outcomes

For the nutrition analysis, we first convert the quantity of foods consumed reported in local/non-standard units into grams based on the metric conversion data from the World Bank. Since the nutrient content of the edible portion of food items from the food composition table (FCT) is expressed in unit of 100 grams, conversion factors to grams were scaled down by

dividing them by 100. For example, if a sachet of sorghum weighs 40g, the metric conversion factor applied is 0.4 (=40/100), so that for a household consuming one sachet of sorghum, we count only 40% of the nutrient contents of sorghum expressed per 100g.

3.6.1 Nutrient Intake and Inadequacy

Based on reported quantity of foods consumed and their nutrient contents, we estimate the apparent intake of different macro and micro nutrients per AME per day, as well as the share of energy consumption from protein, carbohydrates, and fat.⁶ These three macronutrients differ in how quickly they supply energy with carbohydrates and fats being the quickest and the slowest in doing so. To estimate the incidence of caloric inadequacy and deficiency nationally or for different sub-populations, following (FAO, 2004) we construct two indicators of energy requirement intended to reflect the range of energy requirements within each group of sex and age – the Minimum Dietary Energy Requirement (MDER) and the Average Dietary Energy Requirement (ADER). These indicators are constructed based on the predictive equations shown in Appendix B1 (for MDER) and B2 (for ADER).

Energy requirement is the “amount of food energy needed to balance energy expenditure to maintain body size, body composition and a level of necessary and desirable physical activity consistent with long-term good health.” It also includes “the energy needed for the optimal growth and development of children, for the deposition of tissues during pregnancy, and for the secretion of milk during lactation.” (FAO, 2004: page 4). The computation of energy requirements based on household survey data takes into account the individual characteristics in terms of age, sex, pregnancy status, and physical activity level as available from the survey.

As shown in Appendix B1 and B2, MDER and ADER are estimated based on the energy requirements of different groups with the same sex and comparable age, body size (Body Mass Index-BMI) and physical activity. As shown in Appendix B, the predictive equations for

⁶ Given that carbohydrate (*carb*) and protein (*prot*) provide 4 calories per gram each and fat (*fat*) provides 9 calories per gram, shares (*sh*) are computed as follows: $sh_{prot} = prot * 4 / tot$; $sh_{carb} = carb * 4 / tot$; and $sh_{fat} = fat * 9 / tot$, where *prot*, *carb*, and *fat* are intakes per AME/day and $tot = carb * 4 + prot * 4 + fat * 9$.

estimating caloric requirements of children younger than two years old depend on whether under-five mortality rate (U5MR) is above or below 10 per 1000 live births. Given that the U5MR for Burkina Faso is estimated at 59.9 per 1000 live births⁷, we scale the contribution of weight gain per age to the predicted total energy expenditure (TEE) by a factor of 2. For infants younger than two years old, the predictive equations are also multiplied by 0.93 to compensate for the fact that the TEE was about 7% higher than the actual TEE measurements (FAO, 2004).

Finally, in the estimation of the MDER, the equations for children 10-18 years are multiplied by 0.85 to adjust for the reduced energy requirement of the group (by 15 percent) due to the group being less active (FAO, 2004). The classification of lifestyles in relation to the intensity of habitual physical activity (PAL) is based on FAO (2004, page 38), where a PAL of 1.45 is used for the lower limit (MDER), 1.85 for the middle range (ADER), and 2.2 for the upper limit (XDER). BMI measures individual's weight for the attained height. To adjust the dietary energy requirement for the different BMI values, we follow FAO Statistics Division and use national median heights derived from secondary sources (FAO, 2014). BMI values in adults are age-independent and the same for both sexes so that values <18.5, 18.5-24.99, and ≥25 would classify underweight, normal/healthy, and overweight individual (WHO, 2018). As human energy requirement for basic metabolic rates are expressed per unit of body mass (expressed in kg), the range of energy requirements to be considered for an individual in a given sex and age group must also consider the range of healthy body masses indexes (for example, from 18.5 to 24.9 for adults). Hence, the MDER is estimated assuming a BMI = 18.5.

According to FAO/WHO/UNU, Human Energy Requirements, the extra energy needed by pregnant women is 360 kcal/day in the second trimester and 475 kcal/day in the third one. FAO also notes that in the absence of data about pregnancy status, the birth ratio can be used to adjust the predictive equation for TEE by adding an extra energy defined as birth ratio times 210 Kcal/day for females in the reproductive age group (14-49 years old). The likelihood of an adult woman being pregnant is computed based on the ratio between the crude birth ratio

⁷ <http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators>

(assumed 0.03)⁸ and the share of adult female population. We are not accounting for the extra energy needed for lactating women to avoid double counting of requirements, since information about lactating status is indirectly captured by the energy requirements of infants (FAO, 2004).

The age- and sex-specific MDER is computed based on the total energy expenditure corresponding to the minimum acceptable limit of the range of body-weight for attained-height and physical activity norm (FAO, 2008, page 10). Similarly, the age- and sex-specific ADER is determined based on the average age- and sex-specific recommended energy requirements of a specific population. Each household's specific MDER is then computed as the average of the MDERs of the sex and age types that compose the household.

The percentage of households with inadequate dietary energy consumption is then estimated by counting the proportion of households where the estimated average daily dietary energy intake is lower than the household's specific MDER. In doing this, measurement errors in the dietary intake proxy may lead to overestimating the proportion of households with inadequate consumption. To mitigate the impact of possible measurement error in estimating household calorie intake (e.g., due to survey design, timing of data collection, and reporting quantities of food consumed), we follow FAO's practice to fit a linear model of household dietary energy consumption per AME/day ($Pcal_{ame}$) as a function of log of total household consumption expenditure ($lnexp$); $lnexp^2$; fixed effects for region, area of residence (urban versus rural), and indicators for the 64 population groups defined based on age and sex (as shown in Appendix B1 and B2); and interaction terms between region and urban, $lnexp$ and urban, and $lnexp^2$ and urban. Two indicators of calorie inadequacy are then defined based on the amount of model-predicted dietary energy intake relative to ADER and MDER as shown below:

1. If $\widehat{Pcal_{ame}_h} < ADER_{ame_h}$, i.e., if the average dietary energy intake is lower than the average dietary energy requirement, the amount of food consumed by the household

⁸ <http://esa.un.org/unpd/wpp/Download/Standard/Interpolated/>.

is deemed inadequate. Otherwise ($Pcal_ame_h \geq ADER_ame_h$), it is considered adequate. Population weighted average of this indicator will measure the extent to which food consumption covers dietary energy requirements in the population.

2. If $Pcal_ame_h < MDER_ame_h$, i.e., if the average dietary energy intake is lower than the minimum dietary energy requirement, the household is labeled calorie deficient.

Population weighted average of this indicator measures the percentage of individuals whose dietary intake levels are likely to be insufficient to cover normal energy requirement for healthy and active life.

3. For micronutrients, as micronutrient requirements are independent from body mass and physical activity level, there is no need to establish a range of requirements, and a household is considered deficient in the intake of micronutrient x if

$Actual\ intake_ame_h^x < EAR_ame_h^x$, where *Actual intake_ame* and *EAR_ame* express the actual intake and the estimated average requirement of x , respectively.

Population weighted averages of the nutrient inadequacy indicators measure the percentage of individuals in households whose intake of the respective nutrient is lower than the EAR.

3.6.2 Household Food Insecurity and Seasonality

We complement the nutrient-based analyses with analysis of two household-level indicators—household dietary diversity score (HDDS) and food insecurity severity measurements using the food insecurity experience scale (FIES) tool. The HDDS is calculated by grouping all foods items consumed in the household during the reference period into one of the 16 nutritionally significant food groups (Kennedy et al., 2011). The food groups are cereals; white roots and tubers; vitamin A rich vegetables and tubers; dark green leafy vegetables; other vegetables; vitamin A rich fruits; other fruits; organ meat; flesh; eggs; fish and other sea food; legumes and nuts; milk and milk products; oil and fats; sweets; and other foods and drinks (spices, condiments and beverages). While food items can be grouped into fewer classes –e.g., the 12

food groups in Swindale et al. (2006)⁹ –, the 16-food groups we present provide richer information about dietary diversity. Ruel (2003) notes that while there are several food-group based indicators of dietary diversity, and despite the conceptual differences among them, they tend to be positively correlated with each other and with food and nutrition security, since more diverse diets are more likely to include a higher number of nutrients.

The second indicator is obtained by analyzing data collected with the FIES, a tool that can be used to compute internationally comparable indicators of the prevalence of food insecurity at different levels of severity, when applied according to the standard protocol. The FIES relies on self-reported data about access to adequate food, and it is based on the following eight yes/no questions and has been shown to be an internationally comparable measure of food insecurity (Ballard et al., 2013):

1. Have you been worried about not having enough food for lack of money or other resources?
2. Could you not eat healthy and nutritious food for lack of money or other resources?
3. Did you eat a little varied food for lack of money or other resources?
4. Did you have to skip a meal because you did not have enough money or other resources to get you food?
5. Did you eat less than you thought you should have eaten because of a lack of money or others?
6. Did your household no longer have food because there was not enough money or other resources?
7. Were you hungry but you did not eat because there was not enough money or other resources to get you to eat?
8. Did you spend a whole day without eating for lack of money or other resources?

⁹ These food groups are cereals; root and tubers; vegetables; fruits; meat and poultry; eggs; fish; legumes and nuts; milk and milk products; oil and fats; sugar; and other foods and drinks (Swindale et al. 2006)

The total number of affirmative responses can be used as an ordinal measure of food insecurity with the higher the score, the more severe the food insecurity (see Cafiero et al. 2018).

Households with affirmative response to 3 or fewer questions are identified as food secure or mildly food insecure; those with affirmative response to 4, 5, or 6 questions are moderate food insecure; and households with an affirmative response to 7 or 8 questions are considered severely food insecure. Although almost all questions include perception-related elements, the FIES analytic protocol is designed to factor out the perception-based elements, and to preserve in the measure only the information that refers to the objective severity of the constraints that prevents full access to food.

3.6.3 Child Undernutrition

Household-level nutritional analysis is complemented with child-level information using child anthropometry data collected in the 2014 EMC survey during the fourth visit. The WHO (2006) child growth standards are used to compute the incidence of stunting and underweight among children younger than 5 years old. A child is said to be stunted if she is too short for her age, that is, her height-for-age (HAZ) z-score falls below -2 standard deviations (SD) from the median HAZ of the WHO child growth standards.¹⁰ Stunting may result from poor nutrition in-utero and early childhood.

Stunted children may not only never fully attain their possible potential in height but may have impaired cognitive development with long-term implications on their educational attainment and earning potential. An underweight child is one who is too thin for her age as measured by a weight-for-age (WAZ) z-score falling below -2 SD from that of the reference population.

Underweight could result from inadequate consumption of macronutrients, absorption of inadequate nutrients due to a medical problem, or other developmental limitations.

All summaries presented are weighted by sampling weights to guarantee statistical representativeness to the underlying population.

¹⁰ Z-score is computed as the deviation of a child's score from that of the median for the reference population, divided by the standard deviation (SD) of the score for the same population.

When reporting household-level indicators defined in AME terms, individual sampling weights are used, defined as a product of the household survey weights and the number of individuals in the household. Haughton and Khandker (2009) note that when analyzing individual-level measures based on data from surveys that sample households (versus individuals) – e.g. nutrient intake per AME in our case – using household weights would assign little weight to individuals in large households. They therefore argue that individual weights should be used in such cases. When reporting child-level outcomes, household survey weights are used instead. As necessary, summaries are disaggregated by region, and selected socio-economic variables including area of residence (urban or rural), sex of the household head, household head's level of educational attainment, household expenditure quintile (as a proxy for wealth), and household's land ownership quintile.

4. Results

4.1 Nutrient Availability from Crop Production

The diet of the Burkinabe population is cereal-based, and household food security depends on the level of cereal production. Table 1 shows the most commonly grown food crops, along with harvested area (millions of hectares) and total production (millions of kilograms). Non-food cash crops, such as cotton, which account for about 10% of cultivated land, are not reported. Nearly 60% of harvested area is devoted to sorghum, maize, and millet. Crops like cowpea, peanut, and sesame are also among the next most commonly grown crops accounting for 24% of the harvested area. Vegetables such as sorrel, yam or peas are relatively rare, produced by less than 1% of households.

Table 2 summarizes macro and micro nutrient availability from harvested crops per household per day (absolute value and percent). Only crops that contribute to more than 1% of the total calorie supply are shown. In a fully autarkic subsistence society, these food crops would represent the total plant-based food items available for consumption, although the autarky assumption is unrealistic. Sorghum, peanut, millet, and cowpea, and maize jointly account for more than 90% of total crop-based calorie availability. In terms of micronutrient, Sesame is a

relatively large contributor of calcium; maize, cowpea, and sweet potato contribute the most to vitamin A availability; while millet, sorghum, and cowpea are the main contributors of iron supply.

It is worth noting that data on nutrient availability does not include animal-source foods, which would add a lot to iron and calcium, since the EMC does not have data on the production of livestock and livestock products. Also, nutrient supply data does not include supply from imported food items as well as possible destocking. While households can fill individual nutrient deficiencies through inter-household trade or market purchases, national level deficits must be topped up through international trade, as is the case with Burkina Faso which is a net food importer in 2016 (CIA, 2017).

Table 1 Crop production

Crop	Households (thousands)		Harvested area (millions of hectares)		Total edible production (millions of kilograms)
	Number	Percent	Hectares	Percent	
Sorghum	1,272.1	21.52%	225.6	25.32%	196.2
Maize	897.0	15.18%	175.0	19.64%	115.2
Millet	854.9	14.46%	129.3	14.52%	102.9
Cowpea	791.0	13.38%	59.7	6.70%	63.2
Peanut	783.3	13.25%	85.2	9.56%	65.1
Sesame	445.8	7.54%	72.1	8.09%	32.4
Rice	226.5	3.83%	22.4	2.52%	24.8
Boro (Ground-Pea)	146.3	2.48%	12.5	1.40%	5.5
Okra	122.0	2.06%	8.3	0.93%	2.5
Sorrel	23.9	0.40%	1.0	0.11%	0.8
Yam	10.6	0.18%	0.8	0.09%	1.2
Fonio	10.3	0.17%	1.1	0.13%	1.0
Peas	9.1	0.15%	0.4	0.05%	0.7
Sweet Potato	8.4	0.14%	2.0	0.22%	4.3
Ginger	3.3	0.06%	0.1	0.01%	0.3
Watermelon	3.1	0.05%	0.1	0.02%	2.1
Chilli Pepper	2.9	0.05%	0.2	0.02%	0.1
Cassava	2.0	0.03%	0.3	0.03%	0.2
Eggplant	2.0	0.03%	0.3	0.04%	0.1
Melon	1.9	0.03%	0.2	0.03%	0.4
Tomato	1.7	0.03%	0.0	0.01%	0.0
Green Bean	1.5	0.03%	0.1	0.01%	0.1
Turnip	1.3	0.02%	0.2	0.02%	0.3
Taro	1.1	0.02%	0.1	0.01%	1.2
Corn	1.0	0.02%	0.0	0.00%	0.0
Mint	0.8	0.01%	0.1	0.01%	0.1
Clove	0.7	0.01%	0.1	0.01%	0.0
Amaranth	0.7	0.01%	0.1	0.01%	0.0
Calabash	0.6	0.01%	0.0	0.00%	0.0
Celery	0.5	0.01%	0.0	0.00%	0.1
Onion	0.5	0.01%	0.0	0.01%	0.0
Spinach	0.4	0.01%	0.0	0.00%	0.0
Pepper	0.4	0.01%	0.0	0.00%	0.0
Potato	0.3	0.01%	0.0	0.00%	0.0
Parsley	0.2	0.00%	0.0	0.00%	0.0
Total			890.9		801.5

Source: Burkina Faso - Enquête Multisectorielle Continue 2014

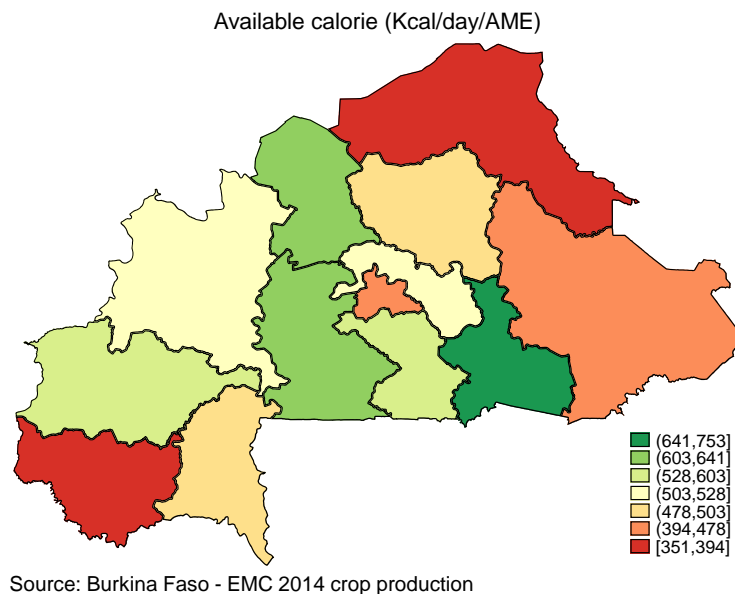
Table 2 Crop production and nutrient supply by EMC households (per household/day)

Crop	Crop-based nutrient availability (hh/day)								Share of crops to total nutrient availability							
	Energy Kcal	Protein g	Fat g	Carbs g	Calcium mg	Iron mg	Zinc mg	Vitamin A RE ug	Energy	Protein	Fat	Carbs	Calc.	Iron	Zinc	Vitamin A
Sorghum	312.8	9.55	3.03	57.38	21.92	3.36	1.63	1.29	36.1%	30.8%	14.9%	44.7%	16.3%	27.2%	32.8%	2.5%
Peanut	174.5	6.76	13.85	4.40	14.09	1.18	0.76	-	20.2%	21.8%	68.2%	3.4%	10.4%	9.5%	15.4%	0.0%
Millet	166.0	5.20	1.94	29.86	16.55	4.53	0.70	-	19.2%	16.8%	9.6%	23.3%	12.3%	36.6%	14.2%	0.0%
Cowpea	90.9	5.90	0.45	13.49	20.21	2.06	1.24	13.98	10.5%	19.0%	2.2%	10.5%	15.0%	16.7%	25.1%	27.0%
Maize	57.7	1.51	0.68	10.56	3.10	0.51	0.26	26.56	6.7%	4.9%	3.3%	8.2%	2.3%	4.1%	5.2%	51.3%
Rice	40.2	0.79	0.07	9.01	1.38	0.16	0.13	-	4.6%	2.5%	0.3%	7.0%	1.0%	1.3%	2.7%	0.0%
Boro (Ground-Pea)	9.5	0.51	0.15	1.49	1.65	0.08	0.09	1.21	1.1%	1.6%	0.7%	1.2%	1.2%	0.7%	1.7%	2.3%
Sesame	8.2	0.63	0.09	1.09	53.03	0.38	0.11	0.60	0.9%	2.0%	0.5%	0.9%	39.3%	3.1%	2.3%	1.2%
Sweet Potato	1.9	0.03	0.00	0.42	0.59	0.02	0.01	5.93	0.2%	0.1%	0.0%	0.3%	0.4%	0.1%	0.1%	11.5%
Fonio	1.6	0.04	0.01	0.32	0.21	0.04	0.01	0.00	0.2%	0.1%	0.1%	0.2%	0.2%	0.3%	0.2%	0.0%
Totals	865	31	20	128	135	12	5	52	100%	100%	100%	100%	100%	100%	100%	100%

Source: Burkina Faso - Enquête Multisectorielle Continue 2014 and West African Food Composition Table 2012

While crop production seems to be inadequate to meet nutritional needs at the national level, there is considerable spatial heterogeneity in caloric availability, as shown in Figure 1. Sahel, Cascades, Centre, and Est regions report below-average calorie production, while Centre-Est, Nord, and Centre-Ouest show above-average calorie production.

Figure 1 Spatial variation in calorie availability from crop production



Heterogeneity in plant-based caloric availability is also observed along several characteristics including area of residence, gender of the household head, and land size, the latter used as a proxy for household wealth, as summarized in Table 3. For example, availability of calories among households in rural areas (versus urban), female-headed (versus male headed), and land abundant (versus land scarce) is above the national average, while the relationship between caloric availability and education is non-linear.

Table 3 Nutrient availability from crop production per AME per day

		Energy Kcal	Protein g	Fat g	Carbo- hydrates g	Calcium mg	Iron mg	Zinc mg	Vitamin A RE ug
Overall	Burkina Faso	545	19.6	12.8	80.8	85.5	7.8	3.1	32.1
Domain	Rural	554	20	13	82	88	8	3	32
	Urban	419	15	13	56	55	5	2	30
Head Gender	Male	539	19	12	80	86	8	3	33
	Female	630	22	18	87	75	8	3	26
Head's Education	None	537	19	13	80	84	8	3	31
	Preschool	819	29	19	121	108	12	5	40
	Primary	604	22	15	88	100	9	3	41
	2ndary 1	543	20	14	77	94	8	3	34
	2ndary 2: general	290	11	7	41	98	4	2	31
	2ndary 2: tech/prof	238	9	8	30	52	4	1	13
	More	637	21	22	83	125	6	3	45
Land size	Quintile 1	291	9	3	53	22	4	1	24
	Quintile 2	306	10	7	47	32	4	2	16
	Quintile 3	497	17	11	75	63	7	3	23
	Quintile 4	612	22	14	92	87	9	4	32
	Quintile 5	589	22	15	85	110	8	3	41

Source: Burkina Faso - Enquête Multisectorielle Continue 2014 and West African Food Composition Table 2012

4.2 Household Food Consumption

Table 4 shows food items consumed by at least 15% of the households during the reference period. As expected, the consumption of seasonings, dried fish, oils, salt and sugars were quite common, consumed by more than 65% of the sampled households. Rice (the 7th most commonly grown), maize (the 2nd most commonly grown), and sorghum (the 1st most commonly grown) are also among the most commonly consumed staple crops, while okra is the most commonly consumed vegetable. Except for dried fish, the consumption of ASF is not as common, with sheep/goat, fresh fish, beef and milk each consumed by only about a fifth of the households.

Table 4 Most commonly consumed food items

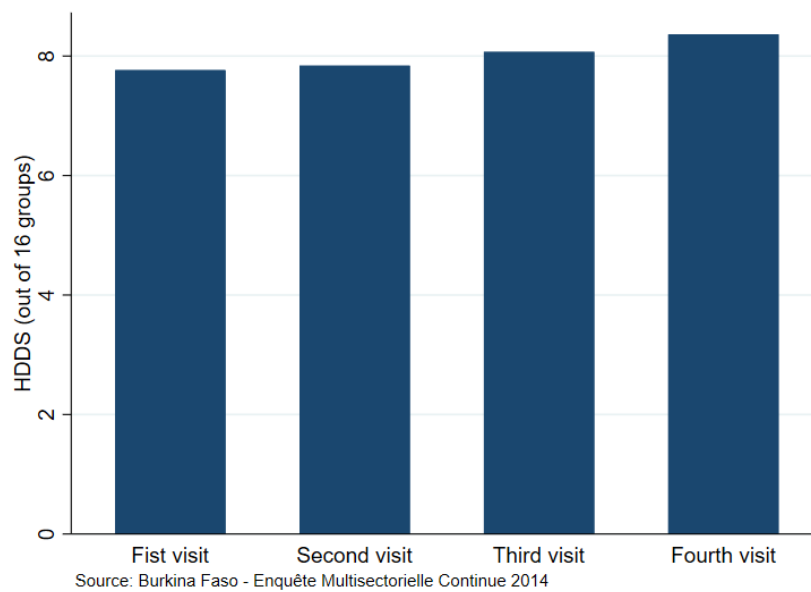
Food item	Households consuming	
	Number	Percent
salt	2,315,404	95.7%
seasoning cubes	2,229,742	92.2%
okra	1,971,541	81.5%
sumbala seasoning	1,907,476	78.9%
greens	1,883,600	77.9%
onions	1,821,887	75.3%
oils	1,695,517	70.1%
dried fish	1,683,613	69.6%
tomatoes	1,677,248	69.3%
granulated sugar	1,621,150	67.0%
rice	1,519,564	62.8%
maize	1,193,026	49.3%
kapok (voaga)	1,103,631	45.6%
beans	1,053,235	43.5%
tea	900,952	37.2%
bread	880,308	36.4%
peanut paste	863,361	35.7%
sorghum	835,614	34.5%
shea butter	748,674	31.0%
coca nuts	737,294	30.5%
coffee	735,553	30.4%
millet	716,477	29.6%
traditional beer	645,396	26.7%
tomato paste	584,668	24.2%
pasta	529,621	21.9%
sheep/goat	492,031	20.3%
fresh fish	440,070	18.2%
beef	430,200	17.8%
milk	406,569	16.8%
other	368,401	15.2%

Source: Burkina Faso - Enquête Multisectorielle Continue 2014

As noted in Section 2, EMC survey data on the consumption of sweet potato do not specify the type of sweet potato, so we use a simple average of the nutrient contents of pale yellow, dark yellow and yellow fleshed sweet potatoes to compute the nutrient content of the sweet potato consumed by sampled households. Similarly, a simple average of the nutrient content of four types of oil is used to compute the nutrient content of oil (of unspecified type) consumed by surveyed households. To the extent the actual consumption of the two food items is systematically skewed (nationally, regionally, or by socioeconomic groups) towards the consumption of one type of sweet potato or oil, our estimates of nutrient intake and subsequently nutrient inadequacy will be biased either upwards or downwards.

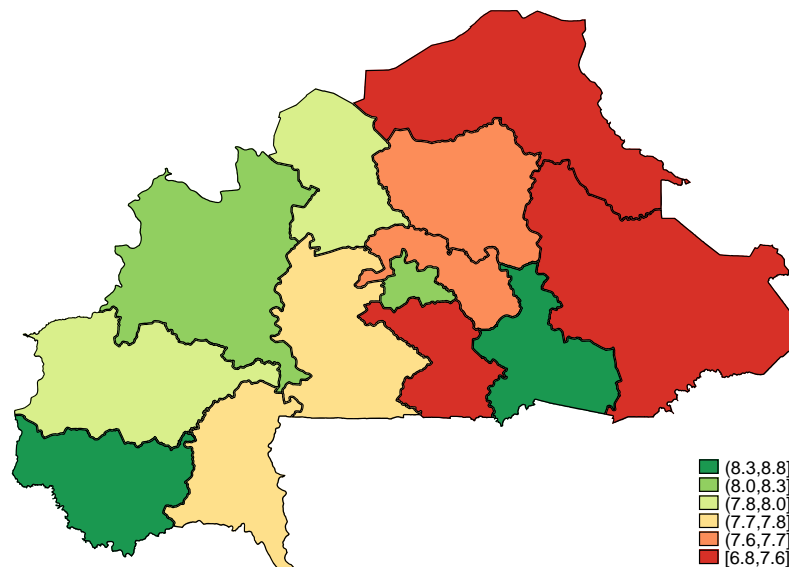
The average number of food groups consumed is around 8 (out of the 16 food groups), with no temporal variation (Figure 2). As noted before, the four visits to EMC households correspond to the post-harvest (visit 1), beginning of lean season (visit 2), end of the lean season (visit 3), and harvest season (visit 4). While the supply of own produced food may vary across visits especially in areas with some access to irrigation, we are unable to examine temporal trends in production due to lack of production data for all visits except the first.

Figure 2 Household dietary diversity score by survey visit



Focusing on just visit 1, HDDS average is relatively low in Sahel, Est, and Center-Sud regions and relatively high in Cascades, Center-Est, Boucle de Mouhoun, and Centre regions (Figure 3). In contrast to the West region, associated to favorable agricultural conditions and generally a cereal-surplus area, the East and North regions are less suitable for agricultural development due to poor quality soils (East) and low rainfall pattern (North).

Figure 3 Household dietary diversity score by region (visit 1)



Source: Burkina Faso - Enquête Multisectorielle Continue 2014

4.3 The Contribution of Crops to Total Nutrient Intake

Instead of counting food items or groups consumed, one could also examine the contribution of different food items to nutrient availability. Table 5 to Table 12 show the contribution of the top ten food items to the total availability of the respective nutrients and the associated share of households consuming them. More than 84% of the caloric intake comes from just seven foods: sorghum, maize, millet, rice, oils, seasoning and peanut paste (Table 5). The four staple crops – sorghum, maize, rice, and millet –are also among the top contributors of the other nutrients. Vitamin A is a special case, towards which oils, maize, tomato, seasoning, beans, sweet potato and dried fish are the main contributors (Table 12). As expected, oils are the top contributors of fat (Table 7).

Table 5 Top ten contributors to caloric intake

Ranking	Food name	Energy (AME/day)			% of HHs consuming
		Kcal (millions)	Percent	Cum %	
1	Sorghum	12,758	28%	28%	35%
2	Millet	8,312	18%	46%	30%
3	Maize	7,896	17%	63%	49%
4	Rice	4,820	11%	74%	63%
5	Oils	1,815	4%	78%	70%
6	Sumbala Seasoning	1,751	4%	81%	36%
7	Peanut Paste	1,360	3%	84%	79%
8	Beef	1,170	3%	87%	36%
9	Dried fish	1,133	2%	89%	67%
10	Beef	610	1%	91%	18%

Table 6 Top ten contributors to protein intake

Ranking	Food name	Protein (AME/day)			% of HHs consuming
		Grams (millions)	Percent	Cum %	
1	Sorghum	370	27%	27%	35%
2	Millet	260	19%	45%	30%
3	Maize	205	15%	60%	49%
4	Dried Fish	114	8%	68%	70%
5	Rice	94	7%	75%	63%
6	Peanut Paste	74	5%	80%	36%
7	Beef	65	5%	85%	18%
8	Bread	40	3%	88%	36%
9	Beans	20	1%	89%	44%
10	Sumbala Seasoning	19	1%	91%	79%

Table 7 Top ten contributors to fat intake

Ranking	Food name	Fat (AME/day)			% of HHs consuming
		Grams (million)	Percent	Cum %	
1	Oils	202	25%	25%	70%
2	Peanut Paste	139	18%	43%	36%
3	Sorghum	131	17%	60%	35%
4	Millet	97	12%	72%	30%
5	Maize	96	12%	84%	49%
6	Beef	37	5%	89%	18%
7	Rice	16	2%	91%	63%
8	Bread	11	1%	92%	36%
9	Sheep/Goat	10	1%	93%	20%
10	Other Oils/Greases	6	1%	94%	2%

Table 8 Top ten contributors to carbohydrates intake

Ranking	Food name	Carbohydrates (AME/day)			% of HHs consuming
		Grams (million)	Percent	Cum %	
1	Sorghum	2,344	30%	30%	35%
2	Millet	1,494	19%	50%	30%
3	Maize	1,443	19%	68%	49%
4	Rice	1,067	14%	82%	63%
5	Granulated Sugar	283	4%	86%	67%
6	Sumbala Seasoning	282	4%	89%	79%
7	Bread	218	3%	92%	36%
8	Maize Flour	113	1%	94%	10%
9	Sugar Cubes	69	1%	94%	9%
10	Pasta	66	1%	95%	22%

Table 9 Top ten contributors to calcium intake

Ranking	Food name	Calcium (AME/day)			% of HHs consuming
		Mg (million)	Percent	Cum %	
1	Salt	7,211	59%	59%	96%
2	Sorghum	880	7%	67%	35%
3	Millet	828	7%	73%	30%
4	Sumbala Seasoning	660	5%	79%	79%
5	Maize	350	3%	82%	49%
6	Beans	310	3%	84%	44%
7	Dried Fish	291	2%	87%	70%
8	Milk	286	2%	89%	17%
9	Rice	285	2%	91%	63%
10	Peanut Paste	180	1%	93%	36%

Table 10 Top ten contributors to iron intake

Ranking	Food name	Iron (AME/day)			% of HHs consuming
		Mg (million)	Percent	Cum %	
1	Millet	227	39%	39%	30%
2	Sorghum	134	23%	62%	35%
3	Maize	74	13%	75%	49%
4	Salt	42	7%	82%	96%
5	Rice	23	4%	86%	63%
6	Sumbala Seasoning	16	3%	89%	79%
7	Peanut Paste	12	2%	91%	36%
8	Beans	7	1%	93%	44%
9	Beef	6	1%	94%	18%
10	Bread	6	1%	95%	36%

Table 11 Top ten contributors to zinc intake

Ranking	Food name	Zinc (AME/day)			% of HHs consuming
		Mg (million)	Percent	Cum %	
1	Sorghum	71	33%	33%	35%
2	Maize	37	17%	50%	49%
3	Millet	35	16%	67%	30%
4	Rice	19	9%	76%	63%
5	Beef	12	5%	81%	18%
6	Peanut Paste	6	3%	84%	36%
7	Sumbala Seasoning	4	2%	86%	79%
8	Bread	4	2%	88%	36%
9	Salt	3	2%	89%	96%
10	Dried Fish	3	1%	91%	70%

Table 12 Top ten contributors to vitamin A intake

Ranking	Food name	Vitamin A RE (AME/day)			% of HHs consuming
		ug (million)	Percent	Cum %	
1	Oils	5,771	67%	67%	70%
2	Maize	1,120	13%	80%	49%
3	Tomatoes	369	4%	84%	69%
4	Sumbala Seasoning	363	4%	88%	79%
5	Beans	313	4%	92%	44%
6	Sweet Potato	231	3%	95%	5%
7	Tomato Paste	81	1%	96%	24%
8	Dried Fish	76	1%	96%	70%
9	Sorghum	52	1%	97%	35%
10	Okra	44	1%	98%	82%

4.4 Nutrient Intake and Inadequacy

Table 13 summarizes the average nutrient intake and the share of energy consumption from protein, carbohydrates, and fat, as estimated from household food consumption data. The contribution of FAFH to household total calorie intake is relatively low, accounting for less than 1%. Mirroring the trends in plant-based caloric supply, the average calorie intake of rural, agriculture-dominant households, and female-headed households is above the national average of 2,526 Kcal per AME per day. Apparent caloric intake of the wealthiest households (in the top quintile of total household consumption expenditure) is more than 50% higher than that of the poorest households in the bottom quintile of expenditure. Nutrient intake is correlated to caloric intake, and does not show much variability across the characteristics considered, except for vitamin A. While rural households show higher calorie intake than their urban counterparts, the opposite holds when looking at the implied vitamin A intake which also appears to decrease with land size.

There is a growing body of evidence that a major imbalance in the relative proportions of macronutrients can increase the risk of chronic disease and may adversely impact micronutrient intake. Carbohydrates are the primary sources of calories in many cases, while protein is important both as a source of calorie and for a health immune function, growth, and birth weight. While there is no single optimal macronutrient distribution, high energy density diets that are rich in (saturated) fats and added sugars and low in complex carbohydrates, dietary fibers, fruits and vegetables are not recommended, especially for those with whose lifestyle does not involve adequate physical activity. For Burkina Faso, on average more than two-third of the caloric intake comes from carbohydrates (which is at the higher end of the recommended range (45%-65%) while the share of protein is about 13%, falling at the lower end of the recommend range (10%-35%). The contribution of fat is higher among urban residents (versus rural) and those with higher education.

Intake of calcium is rather low, ranging mostly between 300-700 mg/AME/day. Calcium deficit has been found to be widespread in many places in Africa and South America (Balk et al. 2017).

Given the importance of calcium intake for bone health in adults, such low intake calls for appropriate policy interventions to enhance the intake of calcium-rich food items or supplements.

Table 13 Average nutrient intake (AME/day) by selected socioeconomic variables

		Energy	Energy	Protein	Fat	Carbo.	Calci.	Iron	Zinc	Vit.A	Sources of calorie			
		Kcal	Kcal-FAFH	g	g	g	mg	mg	mg	ug	Protein Fat Carbo.			
		(%)												
Overall	Burkina Faso	2526		5	76	43	428	676	31	12	487	13	16	71
Domain	Rural	2737		3	82	43	468	801	37	13	434	13	15	72
	Urban	2000		13	61	48	312	249	14	8	663	13	22	66
Head Gender	Male	2523		5	76	43	427	671	32	12	464	13	17	71
	Female	3168		7	95	62	519	783	36	14	711	13	18	69
Head Education	None	2646		4	80	43	451	724	35	12	437	13	16	72
	Preschool	2298		8	69	44	378	575	25	11	511	13	18	69
	Primary	2316		8	69	46	379	557	24	10	573	13	19	69
	2ndary 1	2207		19	68	51	345	439	19	10	701	13	22	66
	2ndary 2: general	2261		22	69	60	340	386	15	9	907	12	24	64
	2ndary 2: tech/prof	2075		20	74	67	278	319	14	10	801	14	28	58
	More	2459		23	76	70	360	387	16	10	1049	12	26	61
Expenditure	Quintile 1	1981		1	60	27	347	562	28	10	243	13	14	74
	Quintile 2	2324		1	69	34	404	650	32	11	327	13	15	73
	Quintile 3	2620		3	80	42	447	722	35	12	442	13	16	72
	Quintile 4	2861		4	86	50	481	773	35	13	554	13	18	70
	Quintile 5	3094		17	94	69	492	694	32	14	854	13	22	66
Land size	Quintile 1	2122		15	65	50	332	382	17	9	691	13	22	65
	Quintile 2	3274		3	99	51	563	954	48	15	490	13	15	72
	Quintile 3	3238		3	97	51	556	870	45	16	490	13	15	72
	Quintile 4	2811		3	84	45	479	778	38	13	449	13	15	72
	Quintile 5	2209		2	67	35	378	645	29	10	365	13	15	72

Source: Burkina Faso - Enquête Multisectorielle Continue 2014 and West African Food Composition Table 2012

In terms of the regional distribution of nutrient intake (Figure 4-Figure 7, left panel), a number of trends emerge. Unexpectedly, calorie intake in Sahel (4,368 Kcal/AME/day), Est (3,530 Kcal/AME/day), Centre-Nord (2,872 Kcal/AME/day), and Cascades (2,671 Kcal/AME/day) regions is above the national average while that of the other regions is below, with the Center region -that includes the capital city Ouagadougou- reporting the lowest calorie consumption

(1,897 Kcal/AME/day). To better understand the drivers of these unusual patterns in calorie intake, we examine the most commonly consumed combinations of staple crops; animal source foods; and processed foods in Sahel and Center regions (Appendix C). Compared to households in Center region, those in the Sahel are more likely to consume milk, poultry, and beef (Appendix C1); millet and sorghum (Appendix C2), and granulated sugar (Appendix C3). Again, contrary to expectations, the Sahel also ranks among the top in terms of intake of zinc and iron, while the Center region reports the lowest intake of iron, zinc, and calcium. National averages may hide substantial inequality, with relatively large number of individuals consuming below the required level and a relatively small fraction of population consuming significantly higher than the requirement amount.

Therefore, Table 14 summarizes the percentage of individuals in households with inadequate calorie consumption and intake of the four micronutrients. The proportion of individuals in households whose calorie intake is lower than the minimum daily energy requirement is 48%, while the percentage increases to 69% when comparing calorie consumption with the average daily energy requirement. As expected, the share of individuals with inadequate caloric consumption is much higher in urban areas than in rural areas, and among households in the bottom quintile rather than in the top quintile of total household per-capita consumption expenditure.

Table 14 Nutrient inadequacy by selected socioeconomic variables

		Energy<MDER	Energy<ADER	Calcium	Iron	Zinc	Vitamin A
Overall	Burkina Faso	48%	69%	90%	64%	60%	56%
Domain	Rural	43%	65%	87%	56%	54%	61%
	Urban	64%	83%	100%	93%	81%	40%
Head Gender	Male	48%	69%	90%	64%	61%	57%
	Female	46%	66%	89%	63%	50%	48%
Head's Education	None	47%	68%	89%	59%	57%	60%
	Preschool	62%	75%	95%	84%	58%	55%
	Primary	56%	75%	93%	76%	70%	48%
	Secondary cycle 1	54%	73%	96%	87%	75%	37%
	Secondary cycle 2: general	38%	65%	97%	93%	77%	24%
	Secondary cycle 2: tech/prof	47%	79%	100%	99%	76%	19%
	More	32%	60%	99%	89%	75%	27%
Expenditure	Quintile 1	68%	87%	97%	65%	68%	82%
	Quintile 2	55%	76%	92%	61%	61%	71%
	Quintile 3	42%	65%	89%	59%	56%	56%
	Quintile 4	39%	59%	83%	62%	56%	45%
	Quintile 5	34%	56%	86%	72%	60%	27%
Land size	Quintile 1	58%	76%	96%	90%	79%	40%
	Quintile 2	40%	57%	79%	47%	45%	56%
	Quintile 3	35%	57%	83%	44%	43%	54%
	Quintile 4	42%	65%	88%	51%	49%	57%
	Quintile 5	52%	76%	93%	68%	66%	68%

Source: Burkina Faso - Enquête Multisectorielle Continue 2014 and West African Food Composition Table 2012

Figure 4 Average caloric intake and inadequacy by region

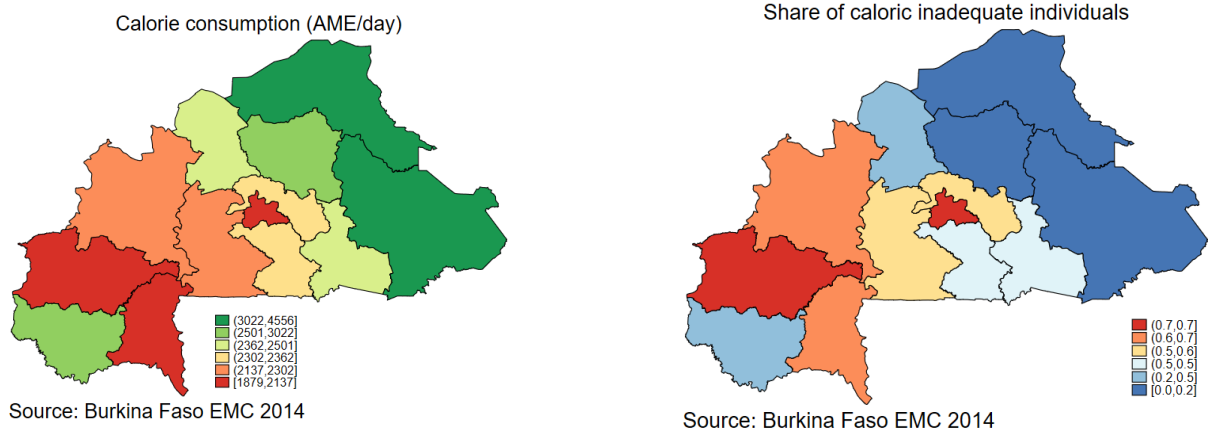


Figure 5 Average zinc intake and inadequacy (intake<EAR) by region

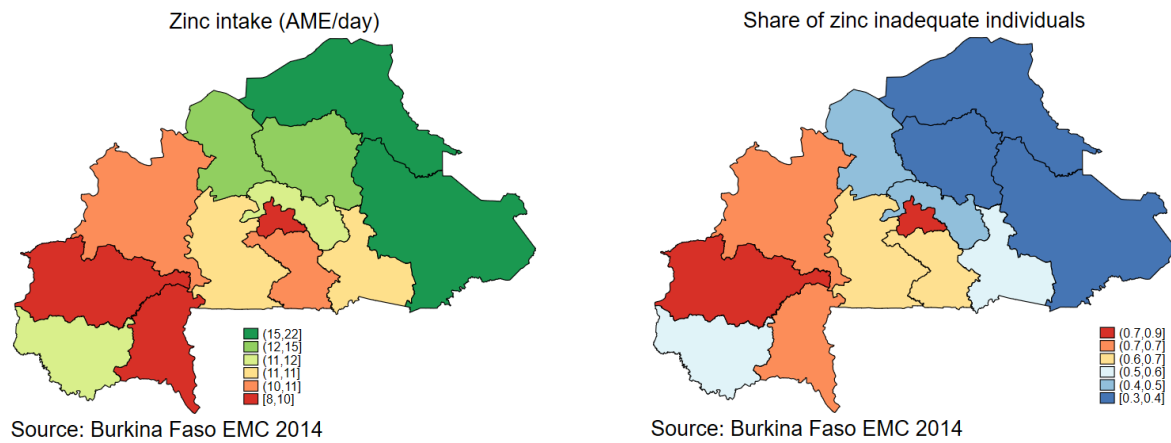


Figure 6 Average vit. A intake and inadequacy (intake<EAR) by region

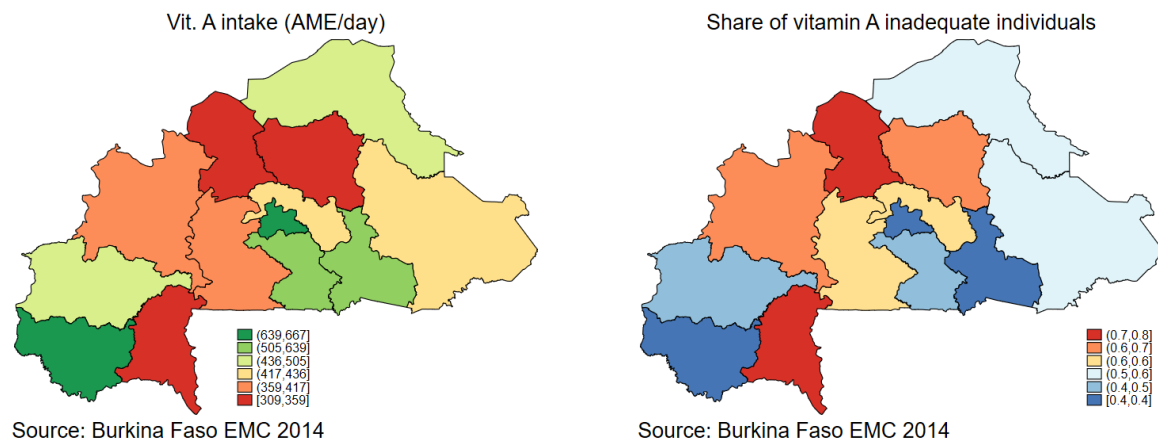
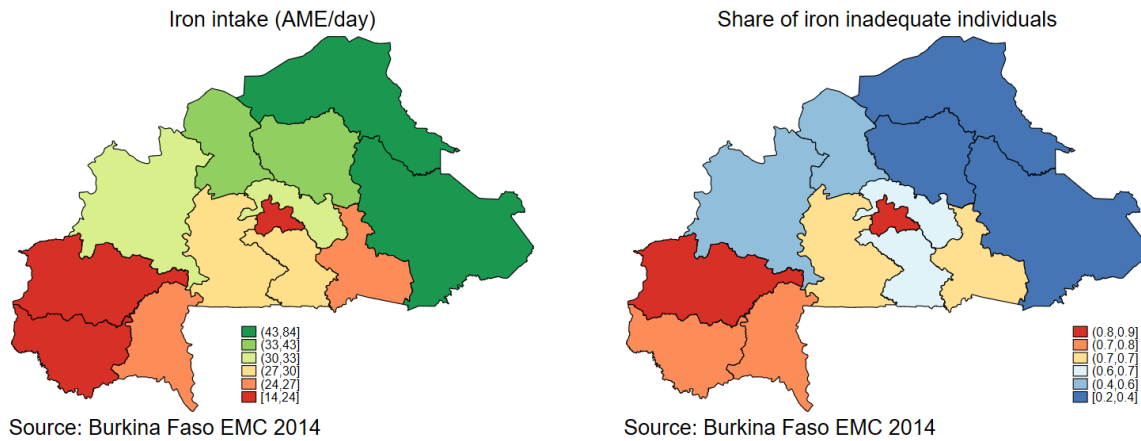


Figure 7 Average Iron intake and inadequacy (intake<RNI) by region

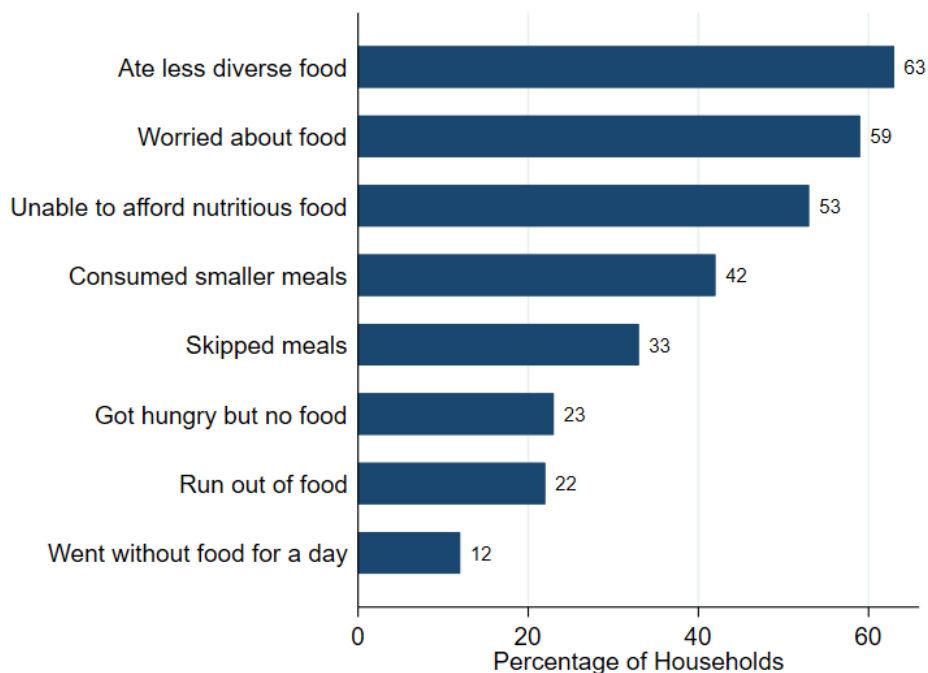


4.5 Food Insecurity Experience

Individuals with constrained access to food are likely to end up consuming inadequate quantity and insufficient quality of food, and therefore are likely to be deficient in macro and micronutrients that are crucial for normal metabolism, growth, and physical well-being. FAO's food insecurity experience scale (FIES) is meant to assess the severity of the food insecurity condition based on the responses given to eight questions reflecting conditions and behaviors that are typically associated with food insecurity. We generally expect a household to respond affirmatively to all questions that refer to experiences that are less severe than the respondent's condition, and negatively to those that are indicative of a more severe situation.

Figure 8 shows the share of affirmative response given to each of the eight FIES question, information used to determine the level of severity of food insecurity associated to each question. For example, 59% of the respondents were worried about not having enough food while 53% and 63% could not eat, respectively, nutritious and diverse food due to resource constraints. These three questions are thus the ones that reflect the least severe end of the scale. On the more severe end, we find "being hungry" and "going without a meal for a day", reported by 23% and 12% households respectively.

Figure 8 Percentage of households reporting each item of the FIES scale



We also summarize the prevalence of different levels of severity – food secure or mild food insecurity, moderate food insecurity, and severe food insecurity – nationally and by different socioeconomic groups (Table 15). About 62% were food “secure or mildly food insecure” as they answered “Yes” to at most 3 questions. The incidence of moderate food insecurity is 22%, defined by the share of households with affirmative response to 4, 5 or 6 questions. Finally, 16% were severely food insecure having responded affirmatively to 7 or 8 questions; these respondents are likely to have been feeling hungry but unable to eat or having skipped meals for a whole day, due to lack of money or other resources. Food insecurity seems to vary by the other dimensions we considered with a relatively higher incidence of severe food insecurity observed among rural households (versus urban); female-headed households (versus male-headed); less educated households, poorer households (as measured by lower consumption expenditure) and smaller land holding.

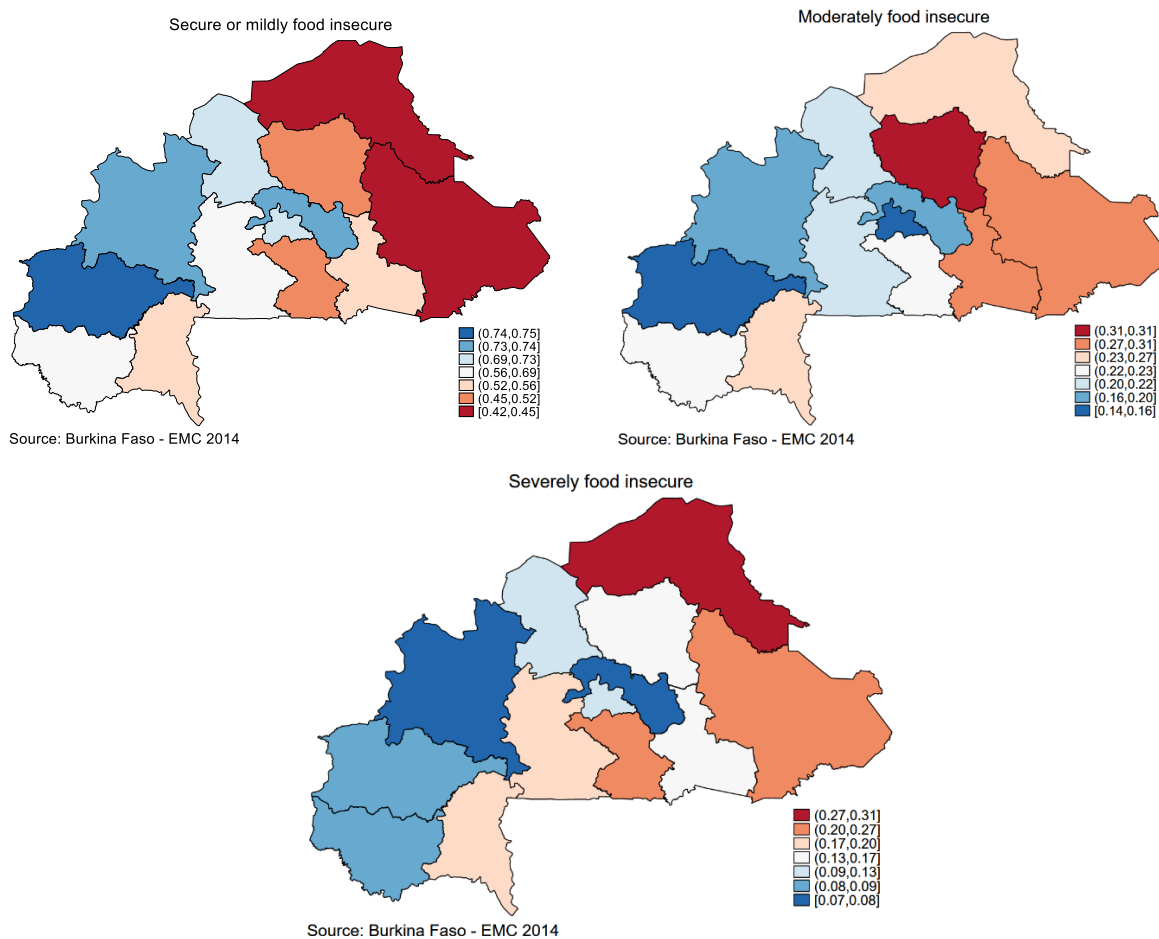
Table 15 Food Insecurity Experience

		Secure/mildly insecure	Moderately insecure	Severely insecure
Overall	Burkina Faso	0.62	0.22	0.16
Domain	Rural	0.57	0.26	0.17
	Urban	0.75	0.13	0.12
Head Gender	Male	0.63	0.22	0.15
	Female	0.54	0.26	0.20
Head Education	None	0.57	0.25	0.18
	Preschool	0.74	0.13	0.13
	Primary	0.72	0.18	0.10
	2ndary 1	0.76	0.12	0.11
	2ndary 2: general	0.89	0.07	0.05
	2ndary 2: tech/prof	0.89	0.11	0.00
	More	0.97	0.02	0.02
Expenditure	Quintile 1	0.53	0.26	0.21
	Quintile 2	0.59	0.25	0.16
	Quintile 3	0.57	0.26	0.17
	Quintile 4	0.56	0.25	0.19
	Quintile 5	0.75	0.15	0.10
Land size	Quintile 1	0.75	0.13	0.12
	Quintile 2	0.47	0.26	0.27
	Quintile 3	0.49	0.30	0.21
	Quintile 4	0.58	0.26	0.16
	Quintile 5	0.67	0.22	0.11

Source: Burkina Faso - Enquête Multisectorielle Continue 2014 and West African Food Composition Table 2012

As the other nutrition indicators summarized earlier, the level of food insecurity also varies by region: households residing in Est, Centre-Sud and Sahel being the most food insecure, while those in Cascades, Boucle du Mouhoun, Plateau-Central, Haut-Bassins, and Nord being relatively less food insecure (Figure 9). As summarized earlier, crop-based calorie supply is among the lowest for Sahel and Est, with the two regions also associated with the least diverse diets and the highest incidence of child undernutrition (shown below), especially for Sahel.

Figure 9 Level of food insecurity by region



4.6 Child Undernutrition

Child malnutrition not only has short-term adverse effects (e.g., through ill health and mortality) but also long-term effects through impaired cognitive development, educational

achievement and overall economic productivity (Grantham-McGregor et al., 2007). Average undernutrition rates among children under 5 years are summarized in Table 16.

Table 16 Incidence of undernutrition

		Stunting	Underweight	Wasting
Overall	Burkina Faso	34.2%	19.4%	11.7%
Child sex	Girl	31.0%	16.6%	10.3%
	Boy	37.1%	22.0%	13.0%
Domain	Rural	35.7%	20.8%	12.3%
	Urban	26.1%	12.0%	8.3%
Head Gender	Male	34.1%	19.4%	11.7%
	Female	34.3%	18.8%	11.8%
Head's Education	None	35.0%	20.6%	11.9%
	Preschool	54.5%	15.2%	19.4%
	Primary	30.5%	15.1%	11.1%
	2ndary 1	27.4%	9.9%	8.1%
	2ndary 2: general	29.8%	9.2%	7.5%
	2ndary 2: tech/prof	16.3%	14.5%	14.5%
	More	15.9%	2.5%	5.7%
Expenditure	Quintile 1	39.5%	22.4%	12.3%
	Quintile 2	36.0%	20.6%	11.8%
	Quintile 3	34.0%	19.1%	13.1%
	Quintile 4	32.7%	18.6%	11.4%
	Quintile 5	27.0%	15.2%	9.6%

National-level stunting, underweight, and wasting rates are around 34%, 19%, and 12%, respectively. These averages are comparable with those from the 2010 Demographic and Health Survey (DHS) for Burkina Faso, where average stunting, underweight, and wasting rates were estimated at 34.6% 24.6%, 15%, respectively. As expected boys are more likely to be undernourished than girls, and the incidence of undernutrition is inversely correlated with both education level of the household head and household total consumption expenditure.

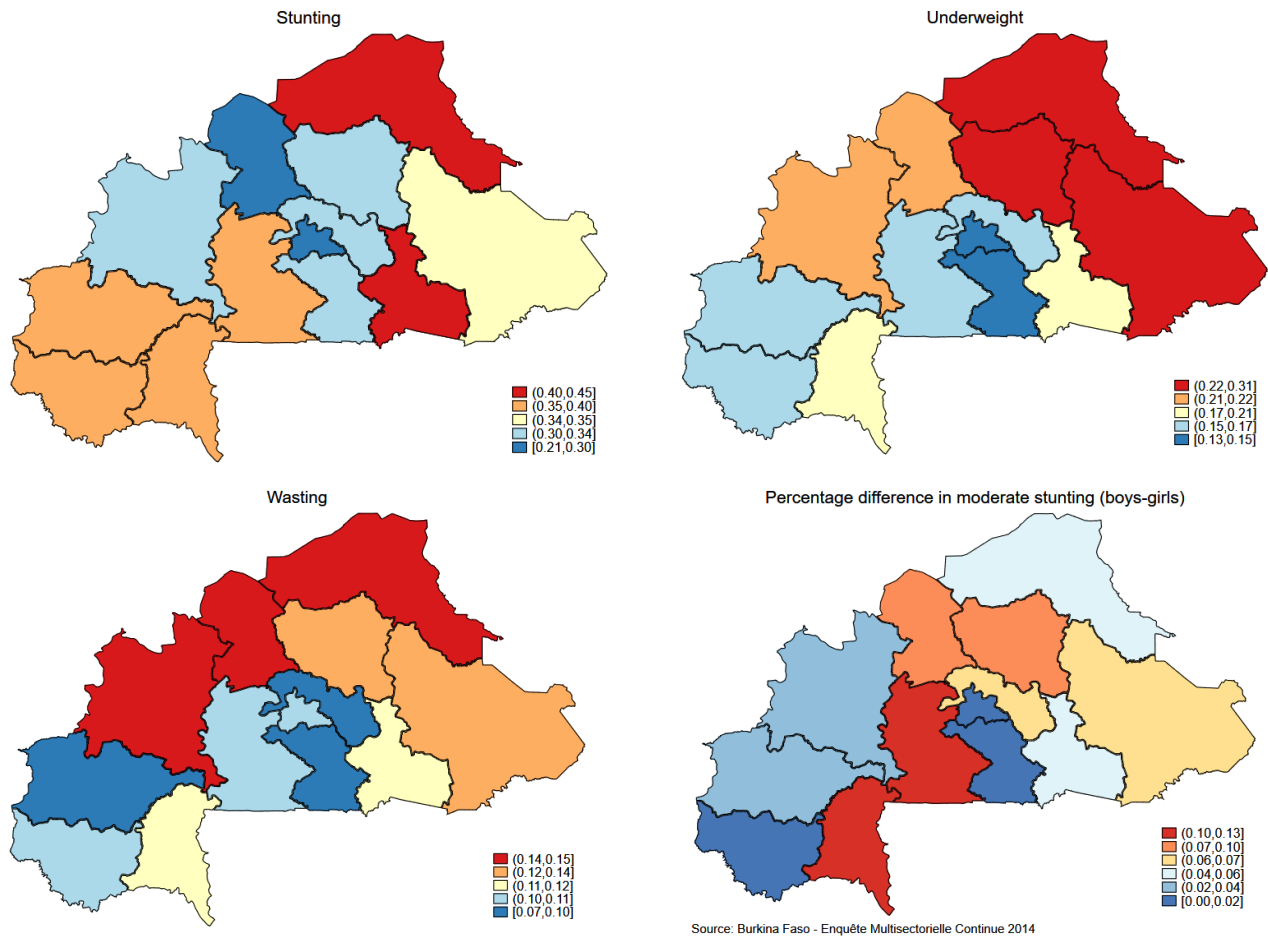
Undernutrition is marginally higher among rural children relative to urban children, and boys compared to girls.

The Sahel region scores the highest incidence of undernutrition (stunting, underweight, as well as wasting) (Figure 10 Figure 10 Undernutrition and gender gap by region) with Est and Centre-Nord joining Sahel region in terms of having a relatively high underweight. To recall, Sahel was also associated with the least diversified diet and the highest calorie intake. This may suggest that more diverse diets reduce the burden of stunting and chronic child undernutrition (Sien et al., 2018), while caloric availability may not translate into better child nutritional outcomes. Depending on the indicator, other regions also rank at the top in terms of the incidence of undernutrition. These include Centre-Est (stunting), Est and Centre-Nord (underweight), and Nord and Boucle de Mouhoun (wasting).

Such regional patterns reflect the complex interactions between child and household level socioeconomic factors, as well as environmental-level factors that determine nutritional outcomes (Haddad et al., 1997). For example, Nord, Boucle du Mouhoun, Centre Quest, and Est regions show the highest poverty rate in the country (World Bank, 2016) which may also correlate with child morbidity (diarrhea, malaria) and insufficient health coverage that in turn may affect food and nutrient intake. Poor infant and young child feeding (IYCF) practices are widespread in Burkina Faso, contributing to the high stunting and wasting. According to (MOH, 2017)¹¹, just 56% of infants are breastfed within one hour of birth, and only 48% are exclusively breastfed in the six months following birth. Complementary feeding is also highly inadequate with only 14% children 6–23 months receiving a minimally acceptable diet (MOH, 2017). Relative to the other regions, the gender gap in stunting rate (boys-girls) is the highest in Centre-Ouest and Sud-Ouest regions by about 10 percentage points, which merits further investigation.

¹¹ <https://www.usaid.gov/sites/default/files/documents/1864/Burkina-Faso-Nutrition-Profile-Mar2018-508.pdf>.

Figure 10 Undernutrition and gender gap by region



5. Conclusion

Developments in data collection and processing over the past 15 years have rendered nutrition analysis easier than ever before. Our analysis relies on the use of household consumption expenditure surveys (HCES) and nutritional information to assess dietary quality across Burkina Faso. While, among the food consumption data collection approaches, 24-hour food recall methods are among the most rigorous, analysis based on HCES and anthropometric data allow us to paint a broad picture of the nutritional status of a country, minimizing the trade-off between accuracy and resources needed. As part of the INDDEx24 initiative, a mobile app is under development that will allow enumerators to administer dietary recall modules with automatic match with cloud-based dietary databases, to evaluate individual and household nutritional status quicker and easier than previously possible (Coates et al., 2016).

Despite some shortcomings of HCES-based dietary data, the resulting information can be used to create targeted nutrition programs in developing countries, as the present work proposes. Our results for Burkina Faso point to vast inequality in food consumption, nutrient intake and nutritional outcomes across regions and by socioeconomic groups. While in regions such as Centre-Nord, individuals on average consume enough to meet their caloric needs, the caloric intake of individuals in other regions (e.g., Sud-Ouest, Haut-Bassins) seem to fall below the required level. Regional averages also hide substantial inequality, and food consumption of about half of individuals nationwide do not seem to satisfy the minimum caloric requirements. Despite these grim numbers, households do not seem to suffer from widespread and deep food insecurity, measured by the FIES. Undernourishment is coupled with poor child growth, with one third of children suffering from stunting, indicating chronic undernutrition.

The personal and societal costs of micronutrient deficiencies are quite high (World Bank, 2011). One policy option to tackle this problem is the diversification of production and diets (away from grain staples and towards more nutritionally dense meats, nuts, and vegetables. Currently, both production and consumption are heavily dependent on cereals whose production is insufficient to meet domestic caloric needs. While the nutritional composition of these grains may vary depending on the variety, they generally lack crucial micronutrients such as vitamins A, C and B12, and bioavailability may be limited for some of the B-vitamins they contain (e.g., B6). Food items such as tomatoes, leafy greens and animal source foods can help address both caloric and micronutrient deficiencies, as would biofortification of cereals. While the summaries we report are informative of the state of food and nutrition security in Burkina Faso, our results could potentially suffer from some of the well-known shortcomings of using HCES data for food and nutrition analysis. Below, we highlight some of these limitations by way of identifying possible areas of improvement for future HCES.

First, our analysis assumes that foods purchased within the 7-day recall period were consumed. This assumption may have implications that might systematically bias our results. It implies that households purchase food as needed rather than stocking it up, the latter practice more

common in urban areas where a substantial share of households monthly purchase in bulk key staple foods, as well as oil and sugar in some cases, and slowly deplete stocks over time (Fiedler et al., 2012). Thus, this assumption likely overestimates consumption for households that have just made a purchase and underestimates it for those that are depleting stocks purchased 7 days or earlier. This collection method should leave average consumption unaffected over large sample sizes but may incorrectly overestimate variation in consumption. Future HCES should therefore differentiate between food consumed from held-over holdings and new purchases (Fiedler et al., 2012). Additionally, attempt should be made to capture possible food waste within the household as well as possible “unusual” events that may significantly affect reported food consumptions (e.g., food consumed by visitors or family guests).

Second, since the EMC does not include information about livestock production, nutrient availability from crop production will likely underestimate the total supply of (own-produced) nutrients from ASF. *Third*, food items and local measurement units reported using “other” are excluded from this analysis, resulting in underestimation of food and caloric intake and over estimation of nutrient inadequacy. To the extent possible, HCES should expand the list of items, strive to avoid collecting data using unspecified food items and units (in the form of “other”) or using local units that may not be associated to an accurate metric conversion (e.g., pile or bunch).

Fourth, the unit cost-per -calorie method employed to compute calorie intake from FAFH will most likely be biased, since data are missing actual food items eaten or their amount. Estimates of micronutrient inadequacy as well as household dietary diversity are likely to be underestimated, especially in urban and semi-urban areas where consumption of processed street food is quite common. Especially with the rising middle-income group, HCES should attempt to capture FAFH specifically in urban areas. It is true that data on FAFH can be subject to underreporting due to respondents’ inability to accurately recall the quantity of and expenditure on FAFH, especially since the respondent may not be aware of FAFH by all household members (Fiedler and Yadav, 2017). Incorporating a separate “meals away from home” module into HCES (as has been done in the 2011 India’s National Survey Sample

Organization; and the Tanzania National Panel Survey) would allow us to have a more complete picture of the state of food and nutrition security in the household, especially in urban areas where street vendors and restaurants are more common. Alternatively, one can include commonly consumed FAFH in the standard food consumption module, although care must be exerted in selecting the respondent(s) to ensure that FAFH data collected is representative of not just the respondent but also other household members. In our case, the EMC food module mostly includes staple foods, with limited information on processed foods or meals consumed in restaurants and canteens.

Fifth, to the extent possible, HCES should collect disaggregated data for some crucial food items for a more accurate estimation of micronutrient availability. In our case, since the EMC did not collect data broken down by type of sweet potato (yellow or orange flesh) and oil (red or white palm oil), we used a simple average of nutrient conversion factors for different types of these two items from the West Africa food composition table. Nonetheless, and depending on the spatial distribution of food consumption, our estimates of vitamin A intake may be biased. For example, if most households in a given region consume orange fleshed sweet potatoes that are relatively highly rich in beta-carotene, our estimates of vitamin A intake (inadequacy) for the region will be underestimated (overestimated). Similarly, if households in a given region consume mostly white palm oil (that is relatively low in vitamin A) and no red palm oil (that is relatively high in vitamin A), our estimates of vitamin A intake from oil for the region would be overestimated.

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Appendix A: Nutrient requirements

Appendix A1: Estimated Average Requirements (EAR) for Vitamin A

Sex	Life stage group	mcg RE/d
Male	0 to 6 months	180
Male	7 to 12 months	190
Male	1-3 y	200
Male	4-6 y	200
Male	7-9 y	250
Male	10-18 y	330-400
Male	19-50 y	300
Male	50-65 y	300
Male	≥ 65 y	300
Female	0 to 6 months	180
Female	7 to 12 months	190
Female	1-3 y	200
Female	4-6 y	200
Female	7-9 y	250
Female	10-18 y	330-400
Female	19-50 y	270
Female	50-65 y	270
Female	≥ 65 y	300

Source: WHO and FAO (2004)

Appendix A2: Estimated Average Requirements (EAR) for Calcium

Age	mg/day	
	Males	Females
<1	230 ^a	230 ^a
1-3	500	500
4-8	800	800
9-13	1 100	1 100
14-18	1 100	1 100
19-50	800	800
51-70	800	1 000
≥ 71	1 000	1 000

^a Source: HMD (2016).

^b EAR values calculated as the average of the Adequate Intakes (AI) of infants 0-6 and 6-12 months old.

Appendix A3: Estimated Average Requirements (EAR) for Zinc

Sex	Life stage group	(mg/day)	
		Mixed or refined vegetarian diets (Phytate: Zinc molar ratio 4-18)	Unrefined, cereal based diet (Phytate: Zinc molar ratio >18)
Male	0 to 6 months		
Male	7 to 12 months	3	4
Male	1-3 y	2	2
Male	4-8 y	3	4
Male	9-13 y	5	7
Male	14-18 y	8	11
Male	≥ 19 y	10	15
Female	0 to 6 months		
Female	7 to 12 months	3	4
Female	1-3 y	2	2
Female	4-8 y	3	4
Female	9-13 y	5	7
Female	14-18 y	7	9
Female	≥ 19 y	6	7
Pregnant women	14-18 y	9	12
Pregnant women	≥ 19 y	8	9
Lactating women	14-18 y	8	10
Lactating women	≥ 19 y	7	8

Source: Wessells and Brown (2012).

Appendix A4: Estimated Average Requirements (EAR) for Iron

Age	mg/day	
	Males	Females
<1	14.4	14.4
1-3	9.2	9.2
4-6	10	10
7-10	14.2	14.2
11-14	23.4	24
15-17	30	32.4
18-50	21	29.2
≥51	21	17.4

FAO and WHO (2004) estimates for Bangladesh

Appendix B

Appendix B1. Predictive Equations for Estimating *Minimum Dietary Energy Requirement (MDER)* (kcal/day)

Energy Requirements (kcal/day) ⁽¹⁾			
Age: Less than 1 year / Class group: 1			Parametric assumptions
Male and Female	if U5MR > 10 %	TEE = (-99.4 + 88.6*RBM) +2* WG * ERWG	5 th percentile for BMI and WG
	if U5MR <= 10 %	TEE = (-99.4 + 88.6*RBM) + WG * ERWG	
Age: From 1 to 1.9 year / Class group: 2			
Male	if U5MR > 10 %	TEE = 0.93 ⁽²⁾ * (310.2 + 63.3*RBM - 0.263*RBM^2) + 2 * WG * ERWG	5 th percentile for BMI and WG
Female	if U5MR > 10 %	TEE = 0.93 ⁽²⁾ * (263.4 + 65.3*RBM - 0.454*RBM^2) + 2 * WG * ERWG	
Male	if U5MR <= 10 %	TEE = 0.93 ⁽²⁾ * (310.2 + 63.3*RBM - 0.263*RBM^2) + WG * ERWG	
Female	if U5MR <= 10 %	TEE = 0.93 ⁽²⁾ * (263.4 + 65.3*RBM - 0.454*RBM^2) + WG * ERWG	
Age: From 2 to 9.9 years / Class group: From 3 to 10			
Male	TEE = (310.2 + 63.3*RBM - 0.263*RBM^2) + WG * ERWG)		5 th percentile for BMI and WG
Female	TEE = (263.4 + 65.3*RBM - 0.454*RBM^2) + WG * ERWG		
Age: From 10 to 17.9 years / Class group: From 11 to 18			
Male	TEE = MC1018 ⁽³⁾ * (310.2 + 63.3RBM - 0.263RBM^2) + WG * ERWG		5 th percentile for BMI and WG, and MC1018=0.85
Female	TEE = MC1018 ⁽³⁾ * (263.4 + 65.3RBM - 0.454RBM^2) + WG * ERWG		
Age: From 18 to 19 years / Class group: From 19 to 20			
Male	TEE = PAL * (692.2 + 15.057RBM)		5 th percentile for BMI and PAL=1.45
Female	TEE = PAL * (486.6 + 14.818RBM)		
Age: From 20 to 29.9 years / Class group: From 21 to 22			
Male	TEE = PAL * (692.2 + 15.057RBM)		5 th percentile for BMI and PAL=1.45
Female	TEE = PAL * (486.6 + 14.818RBM)		
Age: From 30 to 59.9 years / Class group: From 23 to 28			
Male	TEE = PAL * (873.1 + 11.472RBM)		5 th percentile for BMI and PAL=1.45
Female	TEE = PAL * (845.6 + 8.126RBM)		
Age: More than 59.9 years / Class group: From 29 to 31			
Male	TEE = PAL * (587.7 + 11.711RBM)		5 th percentile for BMI and PAL=1.45
Female	TEE = PAL * (658.5 + 9.082RBM)		

Note: TEE=Total Energy Expenditure (kcal); U5MR=Under 5 Mortality Rate; RBM = Reference Body Mass (Weight for attained height (kg)) defined as BMI*(height/100)^2, where BMI=Body Mass Index (kg/m^2); WG = Weight Gain per age; ERWG = energy required per gram of weight gain (kcal)⁽⁴⁾; MC1018= Multiplication Coefficient for children between 10 and 18 years; PAL=Physical Activity Level.

Sources: ^{(1), (2), (3)} FAO (2004); ⁽⁴⁾ WHO (1983); Parametric assumptions about age- and sex-specific BMI and WG are based on the distribution of the indicators from secondary sources.

Appendix B2. Predictive Equations for *Estimating Average Dietary Energy Requirement* (ADER)

(kcal/day)

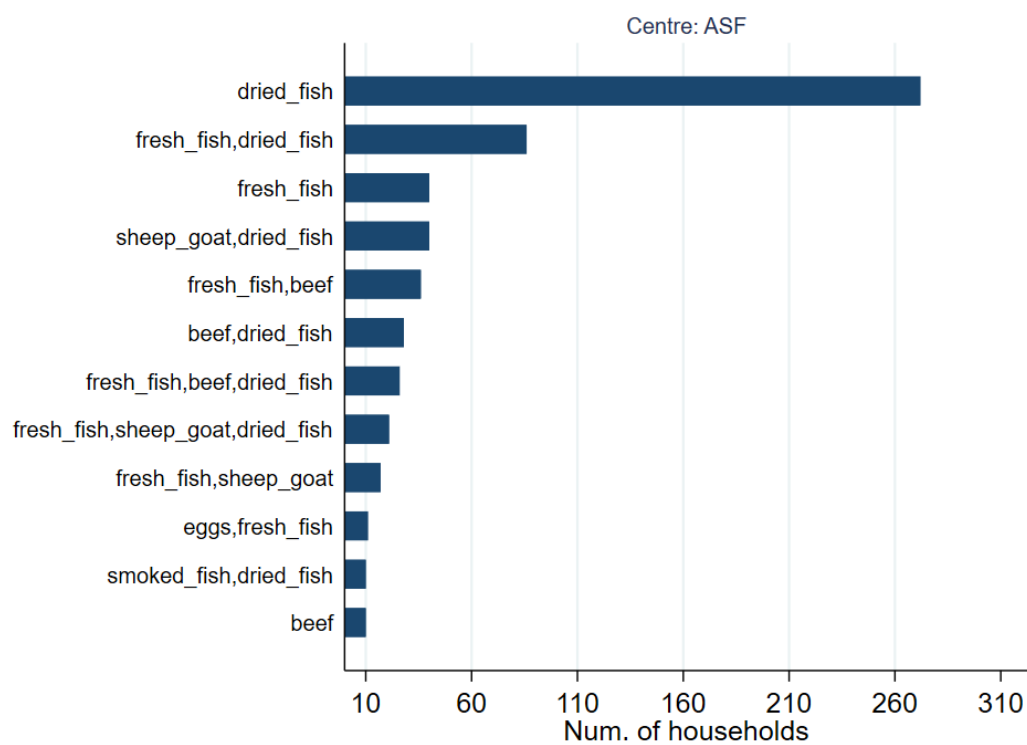
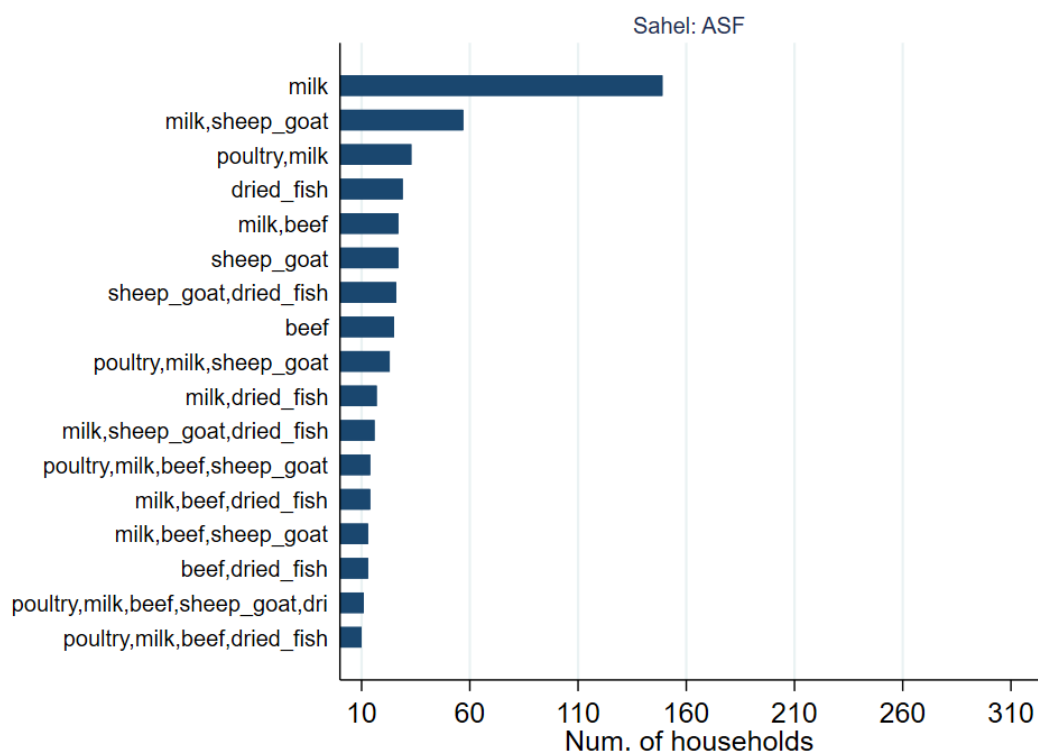
Energy Requirements (kcal/day) ⁽¹⁾			
Age: Less than 1 year / Class group: 1			Parametric assumptions
Male and Female	if U5MR > 10 %	TEE = (-99.4 + 88.6*RBM) + 2* WG * ERWG	50 th percentile for BMI and WG
	if U5MR <= 10 %	TEE = (-99.4 + 88.6*RBM) + WG * ERWG	
Age: From 1 to 1.9 year / Class group: 2			
Male	if U5MR > 10 %	TEE = 0.93 ⁽²⁾ * (310.2 + 63.3*RBM - 0.263*RBM^2) + 2 * WG * ERWG	50 th percentile for BMI and WG
Female	if U5MR > 10 %	TEE = 0.93 ⁽²⁾ * (263.4 + 65.3*RBM - 0.454*RBM^2) + 2 * WG * ERWG	
Male	if U5MR <= 10 %	TEE = 0.93 ⁽²⁾ * (310.2 + 63.3*RBM - 0.263*RBM^2) + WG * ERWG	
Female	if U5MR <= 10 %	TEE = 0.93 ⁽²⁾ * (263.4 + 65.3*RBM - 0.454*RBM^2) + WG * ERWG	
Age: From 2 to 9.9 years / Class group: From 3 to 10			
Male		TEE = (310.2 + 63.3*RBM - 0.263*RBM^2) + WG * ERWG	50 th percentile for BMI and WG
Female		TEE = (263.4 + 65.3*RBM - 0.454*RBM^2) + WG * ERWG	
Age: From 10 to 17.9 years / Class group: From 11 to 18			
Male		TEE = MC1018 ⁽³⁾ * (310.2 + 63.3RBM - 0.263RBM^2) + WG * ERWG	50 th percentile for BMI and WG, and MC1018=1.15
Female		TEE = MC1018 ⁽³⁾ * (263.4 + 65.3RBM - 0.454RBM^2) + WG * ERWG	
Age: From 18 to 19 years / Class group: From 19 to 20			
Male		TEE = PAL * (692.2 + 15.057RBM)	50 th percentile for BMI and PAL=1.8
Female		TEE = PAL * (486.6 + 14.818RBM)	
Age: From 20 to 29.9 years / Class group: From 21 to 22			
Male		TEE = PAL * (692.2 + 15.057RBM)	50 th percentile for BMI and PAL=1.8
Female		TEE = PAL * (486.6 + 14.818RBM)	
Age: From 30 to 59.9 years / Class group: From 23 to 28			
Male		TEE = PAL * (873.1 + 11.472RBM)	50 th percentile for BMI and PAL=1.8
Female		TEE = PAL * (845.6 + 8.126RBM)	
Age: More than 59.9 years / Class group: From 29 to 31			
Male		TEE = PAL * (587.7 + 11.711RBM)	50 th percentile for BMI and PAL=1.8
Female		TEE = PAL * (658.5 + 9.082RBM)	

Note: TEE=Total Energy Expenditure (kcal); U5MR=Under 5 Mortality Rate; RBM = Reference Body Mass (Weight for attained height (kg)) defined as BMI*(height/100)^2, where BMI=Body Mass Index (kg/m^2); WG = Weight Gain per kg; ERWG = energy required per gram of weight gain (kcal); MC1018= Multiplication Coefficient for children between 10 and 18 years; PAL=Physical Activity Level.

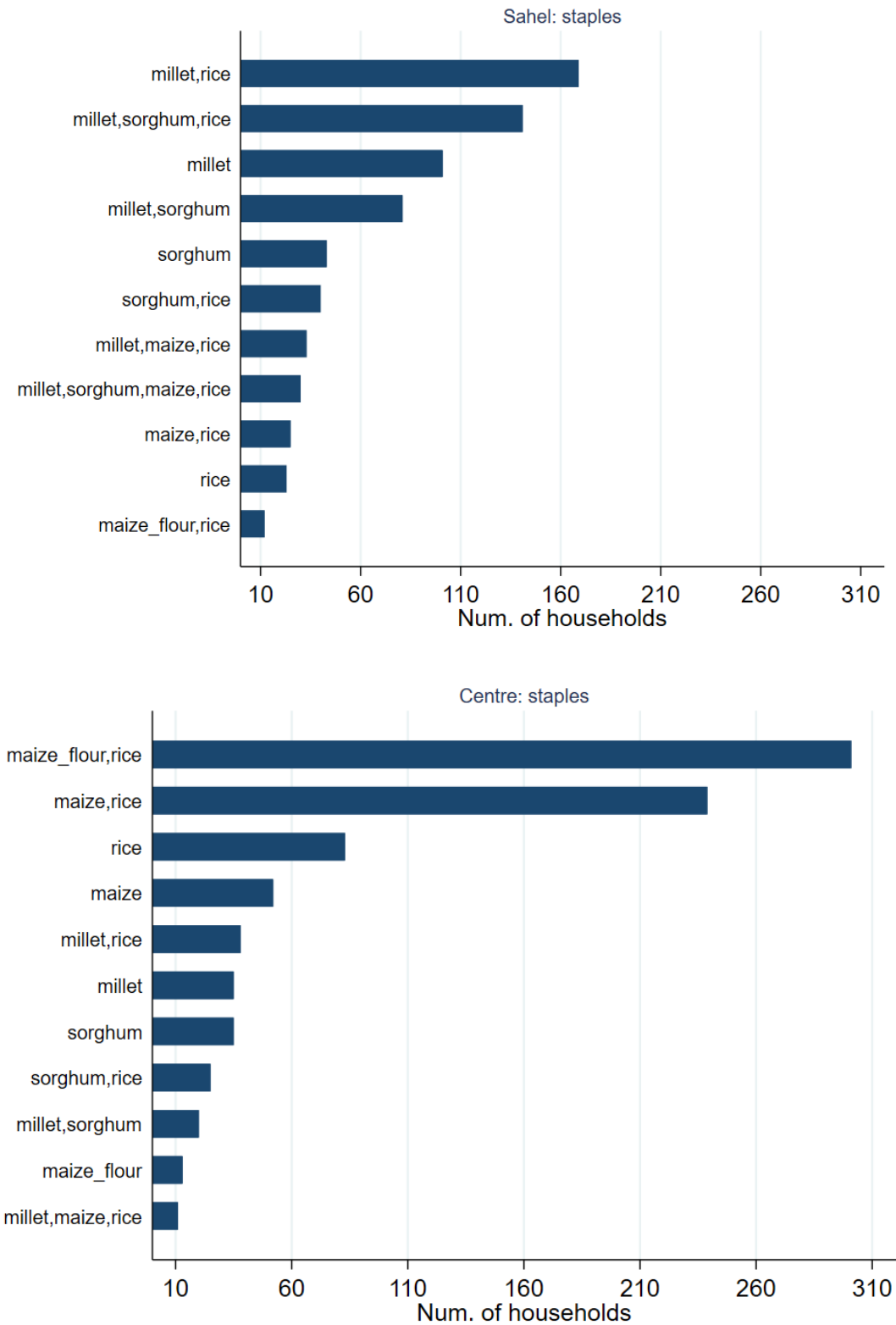
Source: ⁽¹⁾, ⁽²⁾, ⁽³⁾ FAO (2004); ⁽⁴⁾ WHO (1983); Parametric assumptions about age- and sex-specific BMI and WG are based on the distribution of the indicators from secondary sources.

Appendix C

Appendix C1. Consumption of animal source foods (ASF) in Sahel versus Center regions



Appendix C2. Consumption of cereals/staples in Sahel versus Center consumption regions



Appendix C3. Consumption of processed foods in Sahel versus Center regions

