Methodology for Developing Nutrition Smart Agriculture (NSmartAg) Country Profiles

May 2020

Financial support for this work was provided by the Government of Japan through the Japan Trust Fund for Scaling Up Nutrition

Table of contents

1 Introduction—Nutrition Smart Agriculture (NSmartAg) 4

2 Methodology 5

2.1 Step 1. Agriculture and Nutrition Context 5

2.2 Step 2. Nutrient Adequacy Analysis 6

2.2.1 Food Consumption Analysis 8

2.2.2 Desired Outputs 9

2.2.3 Data Flow 10

2.2.4 Food Production Analysis 12

2.2.5 Outliers Detection and Treatment in Terms of Production 12

2.2.6 Consumption and Production Per Adult Equivalent 13

2.3 Step 3. Identification of Food Groups 13

2.4 Step 4. Identification of NSmartAg Practices and Technologies 17

2.5 Public Policy and Programs 20

2.6 Food Environment 21

2.7 Outlook 22

2.8 Validation 22

3 Notes and Possible Improvements 23

3.1 Interpreting Double-Bell Intakes Distributions 23

3.2 Improving Food Chain Parametrization 24

3.2.1 Implement Food Products Geo-variability 24

3.2.2 Improve Cooking Habits Models (re-cooking oil and destruction model) 24

3.2.3 Improve Food Retention Factor (at the food product level) 24

3.2.4 Introduce Cultural Habits Into Food Distribution 26

3.2.5 Aggregate by Social Groups 26

4 Detailed Analytical Process 27

4.1 Step 1: Data Pre-processing and Common Tables 27
4.1.1 Food Composition Table (FCT) 27
4.1.2 DRC Food Products Composition Table 28
4.1.3 DRC Local Units 29
4.1.4 Density Computation 31
4.1.5 Nutrients Requirements Table 31
4.1.6 Retention Factors and Cooking Habits Tables 32
4.2 Step 2: Consumption Data Processing 34
4.3 Step 3: Grams-per-unit Bootstrapping and Calculations 34
4.4 Step 4: Outliers Detection 35
4.5 Step 5: Local Marketplace Reinforcement 35
4.6 Step 6: Outliers Treatment/Filtering 35
4.7 Step 7: Nutrient Intake Computation 36
4.8 Aggregate and Export 40
5 Gender and NSmartAg 40
6 Discussion 41
7 Appendices 42
7.1 Nutrition Smart Agriculture Post-harvest Interview Guide and Questionnaire 42
7.2 The EAT-Lancet Commission Food Groups and Targets 49
7.3 Development of Visualization Tools for an Interactive NSmartAg WebPage... 49
7.4 Survey Questions with a Gender Focus for Country Profiles.. 55
8 References 57

1 Introduction—Nutrition Smart Agriculture (NSmartAg)

The nutrition agenda within the agriculture sector has yet to make a convincing case for the alignment between food production and health and nutrition outcomes. Within the nutrition sensitive agenda, nutrition smart investments in agriculture are those that achieve the double objective of contributing to improving nutrition while increasing farm and/or agribusiness-level productivity or revenue—the drivers for agribusiness investment. Although there are existing agriculture technologies and practices, such as biofortification, that can be considered "nutrition smart" (meeting the double objective), this concept is new and thus not always explicitly supported by existing agriculture public policies and programs. Nutrition Smart Agriculture (NSmartAg) could be a strategic way to attract the attention of ministries in the agriculture sector towards the importance of the sector's contribution to the nutrition agenda.

These NSmartAg practices and technologies are no-regret type of interventions that agriculture ministries, agencies and stakeholders could already see a potential in and therefore readily promote. NSmartAg recommendations complement the broader nutrition sensitive agriculture agenda which is formulated under multisectoral nutrition plans/strategies and coordinated across sectors, such as health, social protection and others. In order to transform the notion in the agriculture sector that nutrition is an additional lens to regular agriculture investments to contribute to someone else's objective, NSmartAg specifically aims to propose readily available investment opportunities that would trigger interest in nutrition from within the agricultural sector.

One critical step to jump-starting "Nutrition Smart Agriculture" is to produce country profiles. These profiles could begin country-level policy dialogues to identify and introduce the agriculture policy reforms and sector investments needed to promote increased production and consumption of safe, nutritious, diverse and affordable diets. The goal of the NSmartAg country profile is therefore to identify governmental and/or business opportunities in agriculture that could improve the validated practices and technologies at the farm and agribusiness levels that have the double objective under the NSmartAg approach. The NSmartAg Country Profile "*look and feel*" takes after the Climate Smart Agriculture (CSA) Country Profiles. [1]

This document presents an overview of the methodology used to develop NSmartAg Country Profiles. The methodology presented here uses the case of the Democratic Republic of Congo (DRC) to illustrate the specific steps taken to build the country profile. The sections of this document reflect the structure of the country profile, and discuss the analysis and methods used for the different components. However, as more country profiles are prepared, this methodological guide should evolve to include additional options for the analysis based on data sources available in the various countries, as well as country-specific nutrition and agriculture considerations.

[1] CSA country profiles can be found here: https://ccafs.cgiar.org/publications/csa-country-profiles

2 Methodology

There are four main steps in the methodology for the development of the NSmartAg country profile. Figure 1 illustrates these four general steps: Step 1 involves the identification of the local malnutrition problems from existing sources; Step 2 includes an analysis to extract nutrient consumption levels for a set of nutrients associated with the identified malnutrition problems and posing considerable health burdens, as well as presentation of this information in bar graphs and pie charts (providing readers with a quick overview of nutritional facts for a given focus group, region and the entire country); Step 3 uses the data and analysis from Step 2 to identify food groups for further investigation; and Step 4 concludes with the identification of a sample menu of options of validated NSmartAg practices and technologies.

Figure 1. NSmartAg methodology steps

2.1 Step 1. Agriculture and Nutrition Context

The national context of agriculture and nutrition provides an overview of the importance of the agriculture sector in the country, the main trends in food trade, the minimum cost of a nutritious diet vs. a regular diet (if available), and the main malnutrition issues. The malnutrition problems to be addressed in the country profile are those that have been identified in the most recent national policy documents and strategies, country profiles and situation analysis reports related to nutrition and food security. Such documents could include the National Food Security and Nutrition Plan or Strategy, the National Multi-Sectoral Nutrition Plan or Strategy, the National Nutrition-Sensitive Agriculture Strategy, the National Agriculture Investment Plan, the National Food Fortification Plan, the Micronutrient Deficiency Control Strategy, the Stunting Reduction Strategy, etc.

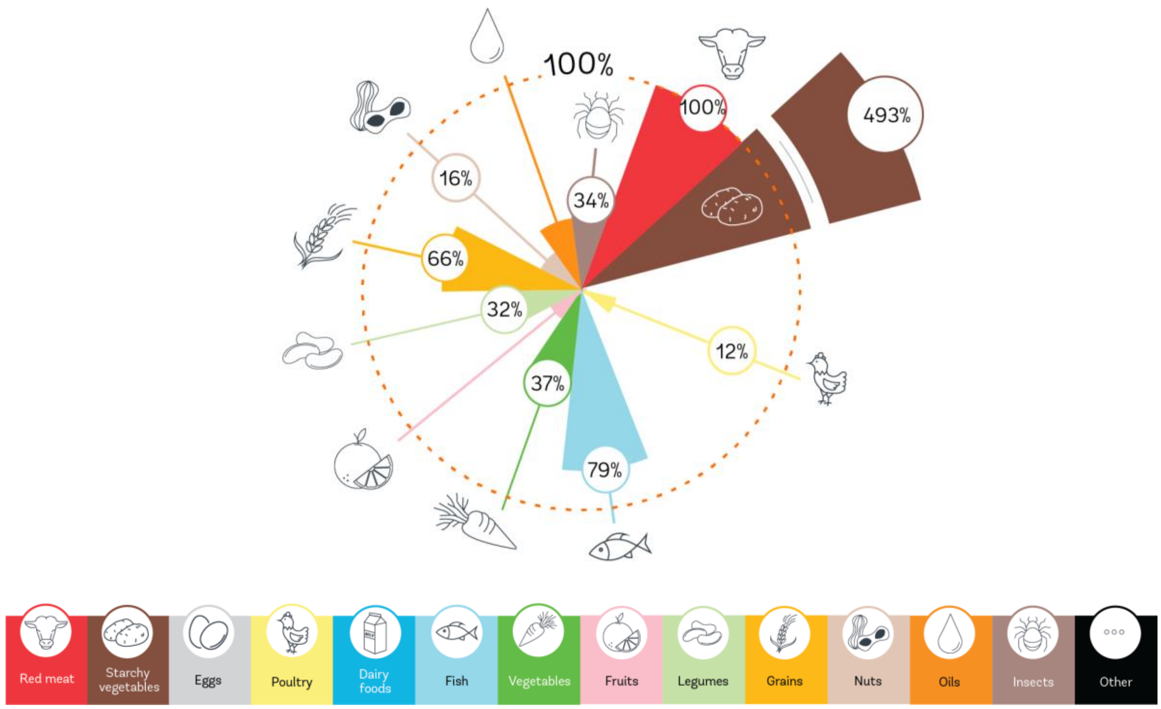
2.2 Step 2. Nutrient Adequacy Analysis

The key malnutrition problems identified in Step 1 are linked to key macro and micronutrients. Iron, iodine, folate, vitamin A, and zinc deficiencies are the most widespread micronutrient deficiencies and are common contributors to poor growth, intellectual impairments, perinatal complications, and increased risks of morbidity and mortality [1]. In the case of DRC, the review of national policies/strategies and other literature revealed that iron, vitamin A and zinc are commonly referred to as problem key micronutrients to be addressed as part of national efforts [2]. Protein, as one of the important macronutrients, was added in the case of DRC because deficiency in protein negatively affects the physiological utilization of other important nutrients, such as iron, and is associated with the compromised health and well-being of individuals, including growth failure and decreased immunity. Further, evidence suggests that protein intakes tend to fall significantly short of the recommended levels in many developing countries [3]. Other key nutrients should also be looked at, if possible, to demonstrate that other micronutrient deficiencies are prevalent and have negative consequences on population health and well-being nationally or sub-nationally (e.g. vitamin B_{12} deficiency in Guatemala). Overweight and obesity are an emerging nutritional problem in many low-income countries, yet evidence related to the impact of specific interventions in agriculture on overweight/obesity is still limited. Therefore, specific interventions that directly try to address overweight and obesity issues were not analyzed.

Once the key nutrients are identified, nutrient consumption levels are estimated from household surveys [4] to assess the level of consumption of such nutrients. It is generally expected that the availability of up-to-date quantitative dietary intake survey data is limited in many countries, as was in the case of DRC. Using other data sources and statistical computation, this analysis produces two outputs.

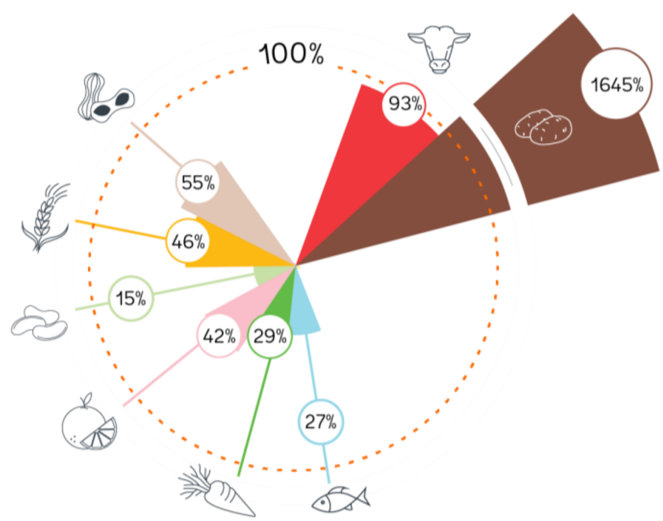
The first output is a set of pie charts to visualize the balance of the diet across major food groups. Food-based dietary guidelines (FBDGs) or recommendations developed for the country of interest should ideally be used if available. In the case of DRC where such guidelines or recommendations are not available, the EAT-Lancet Commission's planetary health plate [5] was applied where a boundary marked by 100% representing the healthy eating plate is established, and the different food groups are mapped in terms of distance to the line (Figure 2). As the EAT-Lancet's boundary is not an endorsed tool to be used as a dietary reference/benchmark for any particular population group, it is used only for an illustrative purpose, rather than to quantify deficiencies/excess against the 100% line.

Figure 2. Example of consumption pie chart for DRC



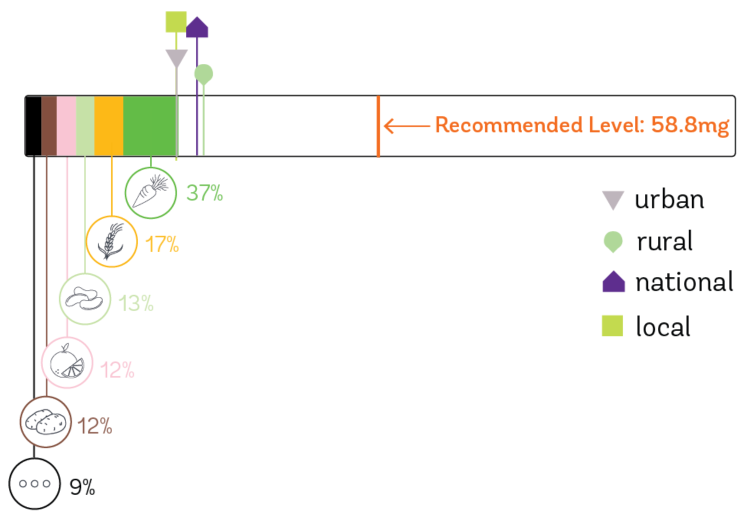
With respect to food production, the household survey also contains agriculture modules for certain farming households, which provide insight on the production side of specific nutrients of interest. In this case, the pie chart (Figure 3) represents the production level of the entire country or province if all that is produced by the households was consumed locally (no exports or imports). This gives an idea of how far off the production of some key food products is from the "self-sufficiency" link representing the average healthy eating plate of that given population. This does not mean that self-sufficiency is being promoted, but it is an indication of an opportunity to increase production of certain foods that clearly show a deficit in terms of the nutrient deficiencies of the local population.

Figure 3. Example of production pie chart for DRC



The second output are bar graphs, following the visual representation in the 2018 Global Nutrition Report (GNR), that show indicative levels of inadequacy in specific key nutrients in relation to various benchmarks (Figure 4). Both outputs rest on the estimated nutrient consumption levels for each household (ideally for each member of the household), so statistical analysis can be run over the entire population (at the national and provincial level). Below is an example of such an output for DRC (consumption side).

Figure 4. Example of bar graph for DRC

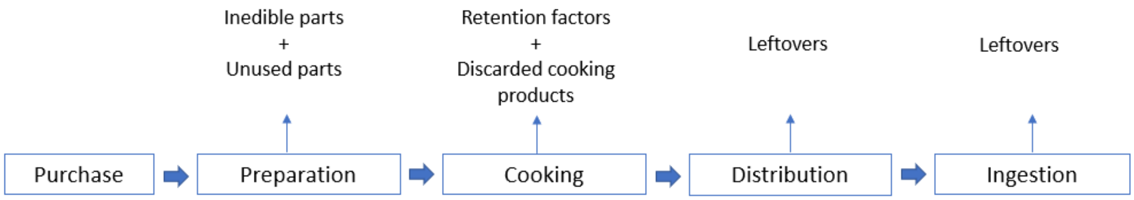


2.2.1 Food Consumption Analysis

The process of estimating the nutrients that are presumably consumed starts with the purchase at the market and ends with the individual consuming the product in a transformed/cooked form. In the case of DRC, all products considered were bought raw because the product list presented in the consumption tables was indicative of that. This may change from country to country, as larger proportions of the commonly consumed foods may be purchased in prepared/processed forms, including ready-to-eat/packaged foods at the market [6].

Figure 5 shows the key factors that should be accounted for in the analysis to estimate nutrient consumption levels from household consumption data. Among those is the nutrient loss that may take place at different stages between food acquisition (likely raw for most products) and actual intake (in raw, prepared/processed or cooked forms). At every stage, some form of nutrient loss may likely happen, for example, removal of non-edible portion of the food product; removal of bad/rotten or unnecessary portions of the product during the preparation; loss of nutrients during preparation and cooking (use of retention factors); further removal of some portion during cooking (such as burnt portions, etc. though rare), and/or reduced intake because of non-ingested leftovers.

Figure 5. Steps from food acquisition to intake and its associated nutrient loss factors



There are also some products that are subject to specific refuse factors. For example, edible oils are often used during cooking but not eaten with other ingredients of the dish. The analysis requires certain assumptions regarding how much of the concerned nutrients in such a food item, for example, vitamin A in palm oil, could be transferred to the food that is actually eaten. Different methods used in preparing and cooking food items can also induce a high variation in the final nutrient consumption estimates. There are several prohibiting and enhancing factors for each nutrient, including water solubility, heat resistance at different temperatures for different cooking times, interactions with other nutrients, and so on. A goal of this methodology is to try to model and estimate those factors as much as possible from literature reviews and expert consultations, to minimize the uncertainty of the results. That said, uncertainty remains inevitable and part of this methodology should be to try to quantify it.

2.2.2 Desired Outputs

The analysis performed is articulated around the concept of food groups (or categories). These food groups follow the ones presented in the EAT-Lancet Commission report and will remain an important part of the methodology: part of the study will be performed around food groups, more than specific products. Indicative EAT-Lancet Commission food groups include: "Dairy food", "Red meat", "Starchy vegetables" etc. The importance of using this classification is to single out such food groups as "Sugar" and the food items under those categories that should not be promoted in the context of rising overweight/obesity problem even in low- and middle-income countries. A complete list of the food groups (and targets) is available in Appendix 7.2.

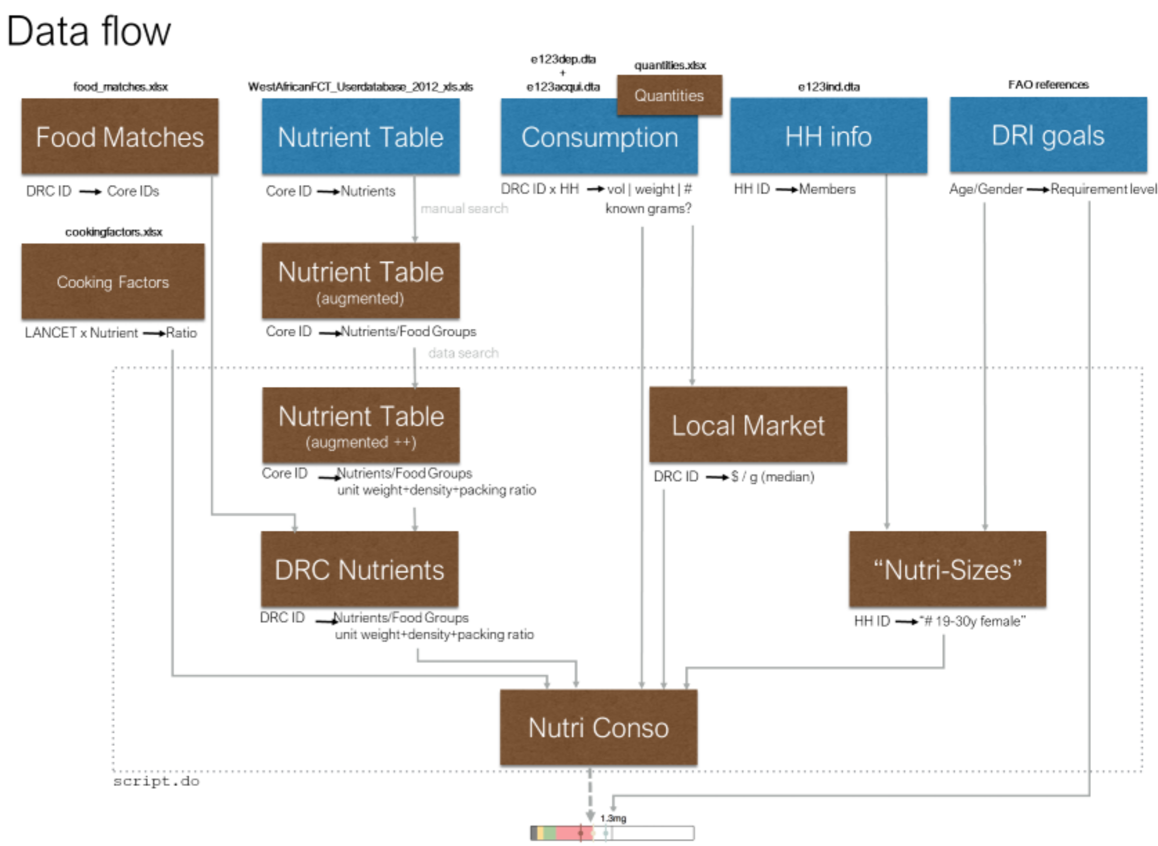
Centered around the concept of food groups, are the two final outputs produced by this methodology:

- Pie charts with major food groups: a "consumption" pie chart illustrating the daily quantity consumption per capita for each food group, using EAT-Lancet Commission's "planetary health diet" food groups and the boundary. This chart allows for a quick glance at where the imbalances are among the major food groups contained in an average diet of the population, for an illustrative purpose.
- Bar graphs for each selected key nutrient: a "consumption" bar graph illustrating the estimated consumption level of a given nutrient, for a given social group, region or for the entire country. The bar graphs also show a share of each food group in the estimated total nutrition consumption level, accompanied by a list of products that contribute most. The reference threshold is placed at the center of each bar graph to depict the distance of the average nutrient consumption from its recommended level.

2.2.3 Data Flow

The analysis follows the data flow skeleton shown in Figure 6. The detailed description of the analysis is based on the use of household expenditure and consumption surveys, since many countries do not have quantitative dietary intake data for different population groups and thus require conversion of household-level food acquisitions to individual nutrient consumption levels.

Figure 6. Data flow in NSmartAg nutrient consumption analysis



In principle, the following sets of information are combined to compute "*Nutri Conso*", an estimated nutrient consumption level of an adult female equivalent for each of the selected nutrients (a dotted arrow in Figure 6):

- ***DRC Nutrients***: these are adopted nutrient densities (quantity per 100 g) to be used for converting "food" consumption levels into "nutrient" consumption levels; the densities are computed by matching food items in the consumption data with corresponding ones in reference food composition tables.
- ***Consumption***: these are the raw consumption levels of identified food items per household, converted into grams.
- ***Nutri-Sizes***: these are the sum of the RNI ratios of the members of an average DRC household for a given nutrient; applied to derive nutrient consumption levels per adult female from nutrient consumption levels per household.

The detailed data processes are as follows:

1) Pre-process data and common resources
    - compute densities based on nutrients
    - compute local products nutrients
    - compute household "*Nutri-Sizes*" (household nutrient sizes in terms of adult female equivalent) and "nutri-coefs" (specific household coefficient compounding the food distribution model with adult female normalization, for each nutrient)
    - pre-process and clean consumption data.
2) Compute quantities
    - bootstrap grams-per-unit with "density x scientific conversion" rule + "special" rules
    - overwrite grams-per-unit based on known number of units and known grams (when available) for all local non-standard units
    - compute grams = grams-per-unit x number of units
    - overwrite grams with known purchased grams (when available).
3) Detect outliers
    - flag outliers with Tukey k=1.5
    - detect both price and quantity outliers.
4) Analyze local marketplace/use price information
    - perform regression log (q) = f (log [price]) on all, except outliers
    - compute quantities for entries flagged as "by price"
    - overwrite quantities for problematic units with quantities out of the regression prediction.
5) Filter
    - process outlier by Windsorization or replacing outliers with prediction.
6) Compute nutrients
    - compute food-consumption-per-day (in grams) for a household (i.e. "*Consumption*") based on food consumption entry info
    - compute nutrient-consumption-per-day for a household by applying "*DRC Nutrients*" densities
    - apply retention factors and cooking rules (i.e. "*Cooking Factors*")
    - apply "*Nutri-Sizes*" to compute nutrient-consumption-per-day for an "adult female" (i.e. "*Nutri Conso*").
7) Aggregate and export
    - aggregate nutrient consumption levels for each food group per adult female (marked by different colors in each bar chart)
    - generate the graphics.

The process above makes use of nutrient requirements reference values that are specific to each country studied. We used the FAO/WHO recommended reference, called the Recommended Nutrient Intake (RNI), based on the "Vitamin and mineral requirements in human nutrition, Second Edition" (2004) from FAO as well as "Protein and amino acid requirements in human nutrition" (2007) from WHO/FAO/UNU. Table 1 shows the values used for DRC, based on the FAO/WHO RNI thresholds using the lowest bioavailability categories for iron and zinc.

Table 1. RNI table used in the case of DRC for the nutrients of interest

age_min	age_max	gender	pregnancy_stage	Proteing_d	Femg_d	Znmg_d	VitARAEmcg_
0	0.5	0		10.2	1	6.6	375
0.5	1	0		11.6	18.6	8.4	400
1	3	0		12	11.6	8.3	400
4	6	0		16.65	12.6	9.6	450
7	9	0		26.05	17.8	11.2	500
10	14	m		40.5	29.2	17.1	600
15	18	m		51	37.6	17.1	600
19	51	m		51	27.4	14	600
51	65	m		51	27.4	14	600
65	199	m		47	27.4	14	600
10	14	f	0	41	46.7	14.4	600
15	18	f	0	47.4	62	14.4	600
19	51	f	0	51	58.8	9.8	500
51	65	f	0	48	22.6	9.8	500
65	199	f	0	47	22.6	9.8	600
13	199	f	1	65	90	15	800
13	199	f	2	67	30	17.0	850

From this table, we create an alternate reference ratio table that will be used throughout the process. We divide each requirement value by the threshold value of the appropriate gender category of the reference (19–51 years old "female" in our case). These ratios are applied to normalize the consumption levels of the individuals as well as to estimate the average consumption values for the household. The sum of the RNI ratios of the members of a household is called the "*Nutri-Size*" of the household, for a given nutrient.

2.2.4 Food Production Analysis

The methodology for the production analysis follows roughly the same schema as for the food consumption analysis. A couple of points to note:

- The production section uses the common tables such as Food Composition Table (FCT), Nutritional Risk Index (NRI), Dietary Reference Intake (DRI) ratios, as described in the consumption section.
- The detection and processing of outliers are slightly different (see below).
- The production items are always raw and whole, while the consumption items are often processed or a fragment of the whole product. As a result, the edible factors sometimes differ.
- For micronutrients, the production data does not consider bioavailability and losses due to cooking.

2.2.5 Outliers Detection and Treatment in Terms of Production

One main difference between the production and consumption analyses is that in the production analysis the detection of outliers and the regression have been performed simultaneously using a robust regression. In standard regression fitting OLS, it is well known that outliers can have a dramatic impact on coefficients. The robust regression reduces how much outliers can skew the regressors by assigning a weight proportional to their distance to the expected value. Observations with a weight smaller than half the normal weight were considered outliers and were replaced by the prediction. The selection of the threshold beyond which an observation is deemed an outlier is basically a rule of thumb. Based on observations of the weight assigned to each observation and common sense, we decided that the threshold of 50% weight would be retained. The implication is that roughly 10 percent of the observations were considered outliers and replaced with the predictor. As a reminder, data quality is relatively low, and the above assumption is within expectation.

The robust OLS regression of the quantity is performed on the following parameters: household size (polynomial); land surface (polynomial); province fixed effect. While this method can also be applied to the consumption analysis, performance constraints forced us to separate the methods in order to use a faster regression algorithm (the consumption data was very large in the case of DRC). Nevertheless, both methods were compared, and similar results were found.

2.2.6 Consumption and Production Per Adult Equivalent

In order to produce the EAT-Lancet Commission pie charts and bar graphs, we computed the per adult equivalent consumption and production at the household level by dividing the total consumption/production by the number of adults equivalent. We can then compute the mean consumption/production (by adjusting each household's sampling weight by its adult equivalent size) to obtain aggregate consumption/production figures.

The detailed analytical process is provided in Chapter 4.

2.3 Step 3. Identification of Food Groups

The food groups identified in the section above as showing "deficit" in relation to the healthy eating plate line are cross-checked against agricultural production data to determine if they are being produced. If they are being produced, and especially in quantities lower than the required consumption level, these are automatically included in the food groups of interest under the NSmartAg concept at the primary production level. Under each food group, food items are also identified in terms of their relative importance as sources of the key nutrients examined in the country profile.

Once the food groups are identified, a list of food items of interest can be curated by looking at the top nutrient-dense products listed under the bar graphs, for both consumption and production. For each list and nutrient, we may filter out the products with a known low content for that nutrient. Their contribution is likely caused by over-consumption (or over-production), which is not something we are looking to accentuate. Once filtered, the food products matching some of the following criteria may be selected:

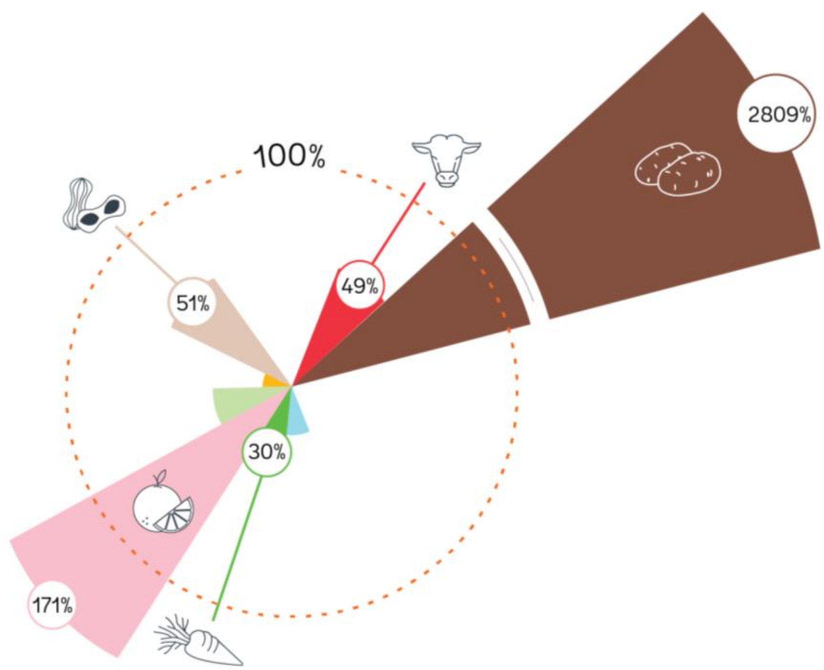
1) A product with a high contribution on the production side, but low (or inexistent) contribution to the consumption: promotion for this product could contribute to the improvement of a deficiency, as the production is showing an existing untapped "capacity". An increase of the production could be an option, yet the question of whether there are particular and robust reasons for low consumption in the locality (e.g., unaffordability, limited transportation means outside urban markets, etc.) should be carefully assessed.
2) A product with a low (or inexistent) representation on the production side, but with a high contribution to the consumption: this product could be considered as an accepted source for the nutrient, but the production could be increased or initiated (if feasible). However, consumption may already be saturated for the product.

3) A product with low contribution to the production and low contribution to the consumption: especially for high-nutrient-content products, this could prove to be a good product to promote and/or increase production of.

For the post-harvest food transformation/processing and handling, the identified food groups are used to undertake further research during the field visits, as established in the sections below. Given the relative paucity of activities expected to be found at post-harvest stage, we use food groups to guide this portion of the field work. For example, taking the food production and food consumption graphs of the Kongo Central Province in the Eastern part of DRC, the following food groups (Figure 7) were identified as potentially NSmartAg product categories under primary production. For further research under post-harvest processing, food items were not filtered according to the three aforementioned criteria prior to the field survey. The latter was instead guided by food groups in order to allow for a wider catch of potential activities than the preselected food items. The filtering, however, is an option that the team can make available as an interactive web tool for users that wish to apply certain criteria to the selection of food items for further investigation (Appendix 7.3).

Figure 7. List of food groups for further research: fish, vegetables, legumes, nuts

Kongo Central **PRODUCTION**



Kongo Central **CONSUMPTION**

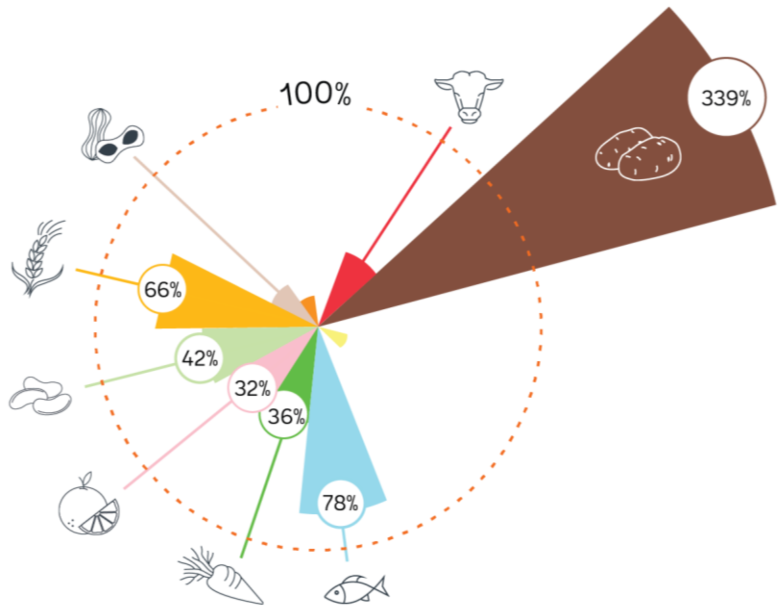
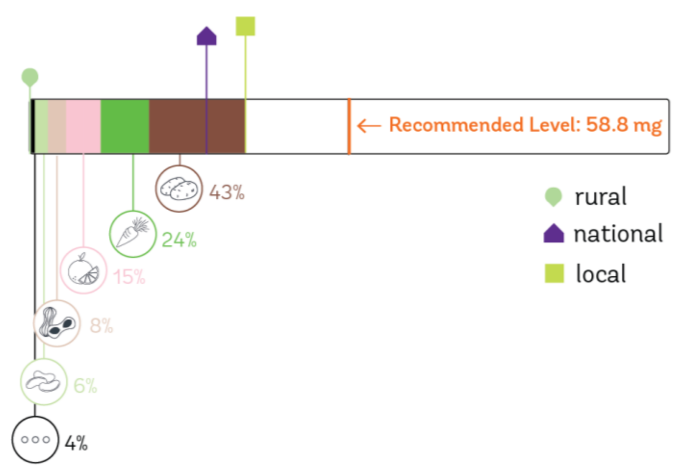


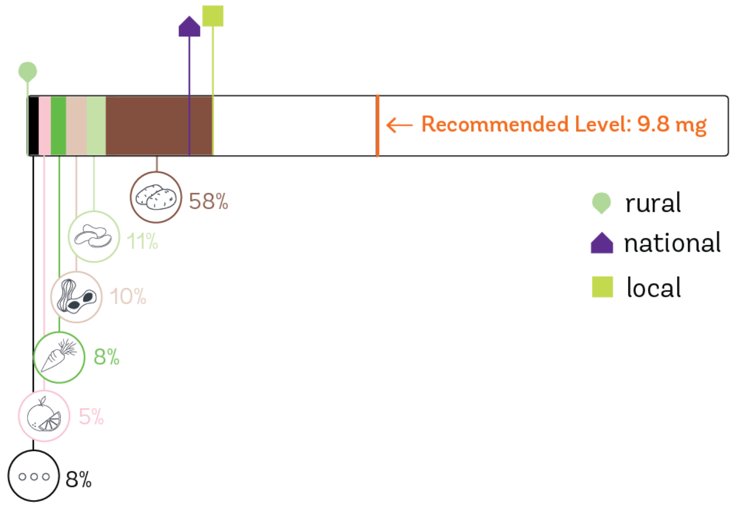
Figure 8. List of food items for further research

Kongo Central **PRODUCTION**

Iron

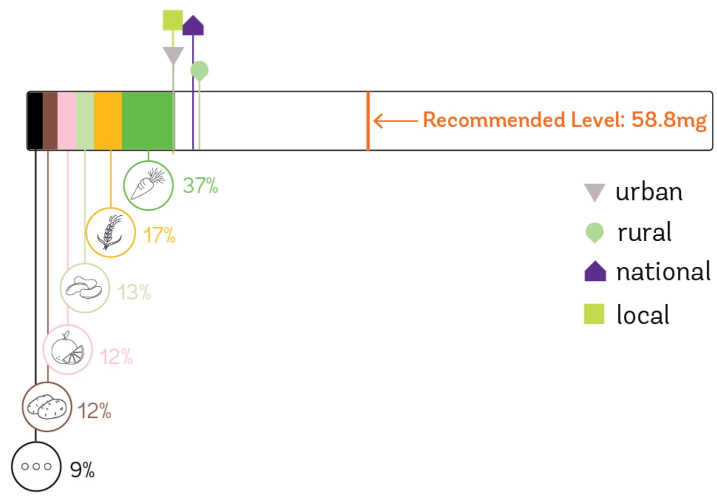


Zinc



Kongo-Central **CONSUMPTION**

Iron



Zinc

2.4 Step 4. Identification of NSmartAg Practices and Technologies

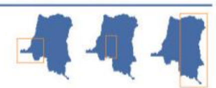
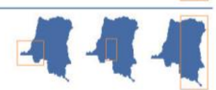
Based on the list of food groups and food items identified in the section above, two approaches were used to identify NSmartAg practices and technologies (the menu of options, according to the characteristics of the country, could be defined by agroecological area, subnational administrative regions, and/or socio-economic differences, such as indigenous vs. non-indigenous communities, that evidently affect food environment and consumption):

- **Primary production**: To identify NSmartAg practices and technologies for on-farm food production, data from household surveys and agriculture census were used to take the food groups and their top 10 food items identified in the section above and examined, to determine to what extent they were being produced in that particular location. Once specific food products are identified as being produced locally, general trends are analyzed from the data to assess whether the productivity and overall production trends have been positive (in other words, to check if the product is not disappearing from the local production systems). If trends are positive, then the food product can be added into the NSmartAg menu of options.
- **Post-harvest food transformation/processing and handling**: Given the lack of existing data on post-harvest food production, field visits are undertaken to search for agro-entrepreneurs that handle the food products under the identified food groups, in order to assess whether they are considered NSmartAg practices and/or technologies. The survey intends to assess both the degree to which the activity increases productivity or revenue and the extent to which the key nutrients are maintained/preserved, without adding unhealthy ingredients (sugars, trans fat, etc.) -or at least in acceptable quantities. Key criteria to select NSmartAg practices and/or technologies from this survey include: (i) preservation of key nutrients; (ii) avoidance of unhealthy foods and beverages known as risk factors to overweight/obesity and diet-related diseases, including ultra-processed foods and products with high sugar, sodium and saturated fat contents; (iii) whether the activity is being done for profit by cooperatives and/or micro, small and medium enterprises (MSMEs) (NGOs excluded); and (iv) whether the technology/practice has

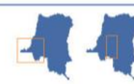
allowed the enterprise to increase revenue and/or reduce costs and/or improve productivity.

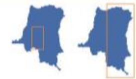
The full survey guide is in Appendix 7.1. The NSmartAg production and post-harvest practices and technologies are then summarized and presented in a table highlighting examples of validated practices and technologies. An indicative example is presented here for the West and East regions of DRC and the Kasais (Table 2).

Table 2. An indicative example of NSmartAg production and post-harvest activities

		NSmartAg		
Value Chain Segment	**Practices and Technologies**	**Contribution to nutrition**	**Market potential**	**Where**
PRODUCTION	Adoption of biofortified cassava (vitamin A)	Addresses micronutrient deficiencies (mainly vitamin A)	Small market size; expectation for market growth (Kasais: Kasai Oriental, Kasai)	
	Adoption of biofortified beans (iron)	Addresses micronutrient deficiencies (mainly iron) and may contribute increased protein intake if consumed more.	Small market size; expectation for market growth (West: Kongo Central, Kinshasa; Kasais: Kasai Oriental, Kasai)	
	Adoption of biofortified maize (vitamin A)	Addresses micronutrient deficiencies (vitamin A)	Small market size; expectation for market growth	
	Adoption of Quality Protein Maize (QPM)	Provides an additional source of protein consumption; increase intakes of high-quality protein that contribute to child growth	Positive outlook for commercial viability of the product; existing demand; small market size; expectation for market growth	
	Adoption of Orange Fleshed Sweet Potato (OFSP) (vitamin A)	Addresses micronutrient deficiencies (mainly vitamin A)	Small market size; expectation for market growth	
	Fish	Addresses micronutrient deficiencies (iron, zinc and vitamin A), and provides an additional source of protein consumption	Large market size; expectation for market growth [East (Ituri, South Kivu)] Positive market outlook; existing demand; Large market size; expectation for market growth (Kasais)	
	Production of fruits	Addresses micronutrient deficiencies (mainly vitamin A)	Large market size; expectation for market growth [Kasais; East; West (Kongo Central[16], Kwilu)]	
	Production of vegetables	Addresses micronutrient deficiencies (mainly iron and vitamin A in selected vegetables)	Large market size; expectation for market growth [Kasais (Kasai Oriental, Kasai)]	
	Production of nuts (peanuts)	Addresses micronutrient deficiencies (mainly iron and zinc); provides additional source of protein consumption	Large market size; expectation for market growth	
	Production of poultry	Addresses micronutrient deficiencies (iron, zinc and vitamin A), and provides an additional source of protein consumption	Large market size; expectation for market growth; limited competition	
	Production of pulses	Addresses micronutrient deficiencies (mainly iron) and may contribute increased protein intake if consumed more.	Small market size; expectation for market growth	

16 Increase in fruit production is identified for Kongo Central because the current "excess" production in this food group is mainly due to palm nuts.

		NSmartAg		
Value Chain Segment	**Practices and Technologies**	**Contribution to nutrition**	**Market potential**	**Where**
POST-HARVEST/ PROCESSING	Production of Sakasaka, or pondu (cassava leaves milled and cooked with added water)	Addresses micronutrient deficiencies (mainly iron, zinc and vitamin A)	Positive outlook for commercial viability of the product; existing demand; large market size; expectation for market growth	
	Processing of fish (light treatment of fish for final consumption, kept fresh or conserved with salt, smoked fish)	Addresses micronutrient deficiencies (iron, zinc and vitamin A), and provides an additional source of protein consumption	Positive outlook for commercial viability of the product; large market size; expectation for market growth (West for salted fish) & stable market growth (East for salted fish) Positive outlook for commercial viability of the product; existing demand; large market size; expectation for market growth (Kasais for salted fish) Positive outlook for commercial viability of the product; existing demand; large market size; stable/ growing market growth (Kasais for smoked fish)	
	Production of fruit juices (no sugar added)	Addresses micronutrient deficiencies (mainly vitamin A)	Small market size; expectation for market growth (West) Positive outlook for commercial viability of the product; existing demand; large market size; expectation for market growth (East) Positive outlook for commercial viability of the product; existing demand; Small market size; expectation for market growth (Kasais)	
	Fruit and vegetable drying (no sugar added)	Addresses micronutrient deficiencies (mainly vitamin A and iron in some selected vegetables)	Small market size; expectation for market growth (West) Positive outlook for commercial viability of the product; existing demand; large market size; expectation for market growth (Kasais)	
	Production of peanut butter (peanut paste)	Addresses micronutrient deficiencies (mainly iron and zinc); provides an additional source of protein consumption	Small market size; expectation for market growth; limited competition (West) Positive outlook for commercial viability of the product; expectation for market growth (East) Positive outlook for commercial viability of the product; existing demand; large market size; expectation for market growth (Kasais)	
	Production of peanut milk	Addresses micronutrient deficiencies (mainly iron and zinc); provides an additional source of protein consumption	Positive outlook for commercial viability of the product; existing demand; large market size; expectation for market growth (Kasais)	
	Production of soy milk	Addresses micronutrient deficiencies (mainly iron and zinc); provides an additional source of protein consumption	Positive outlook for commercial viability of the product; existing demand; large market size; expectation for market growth	
	Transport of fish	Addresses micronutrient deficiencies (mainly iron and some zinc), and provides an additional source of protein consumption	Positive outlook for commercial viability of the service; existing demand; large market size; stable market growth	

Value Chain Segment	Practices and Technologies	Contribution to nutrition (NSmartAg)	Market potential (NSmartAg)	Where
POST-HARVEST/ PROCESSING	Storage of fish	Addresses micronutrient deficiencies (mainly iron and some zinc), and provides an additional source of protein consumption	Positive outlook for commercial viability of the service; existing demand; large market size; expectation for market growth (East and Kasais)	
	Storage of chicken meat	Addresses micronutrient deficiencies, (iron, zinc and vitamin A) and provides an additional source of protein consumption	Positive outlook for commercial viability of the service; existing demand; large market size; expectation for market growth (Kasais: Kasai Oriental)	
	Processing of chicken meat (smoked)	Addresses micronutrient deficiencies, (iron, zinc and vitamin A) and provides an additional source of protein consumption	Positive outlook for commercial viability of the product; existing demand; small market size; expectation for market growth	
	Mix of minimally processed ingredients as basis for complementary food (e.g. corn, rice, and roasted soybeans, wheat, sorghum, sesame, and peanuts)	When micronutrient/ protein rich products, such as soybeans, sesame and peanuts, are included in sizable proportions, it addresses micronutrient deficiencies (iron, zinc and/or vitamin A, depending on the ingredients) and provides an additional source of protein consumption	Positive outlook for commercial viability of the product; existing demand; small market size; expectation for market growth	
	Production of soy – sorghum flour	Addresses micronutrient deficiencies (iron and zinc); provides an additional source of protein consumption	Positive outlook for commercial viability of the product; existing demand; large market size; expectation for market growth	
	Providing service of milling of soy – sorghum flour	Addresses micronutrient deficiencies (iron and zinc); provides an additional source of protein consumption	Positive outlook for commercial viability of the service; existing demand; large market size; expectation for market growth	
	Production of flour from dried plantain	Addresses micronutrient deficiencies (mainly vitamin A, iron and zinc); provides an additional source of some protein consumption	Positive outlook for commercial viability of the product; existing demand; small market size; expectation for market growth	
	Production of soybean flour mixed with peanut flour	Addresses micronutrient deficiencies (mainly iron and zinc); provides an additional source of protein consumption	Positive outlook for commercial viability of the product; existing demand; large market size; expectation for market growth	

2.5 Public Policy and Programs

Based on literature review, stakeholder and expert consultations, relevant public policies and programs are listed to provide the framework in which the NSmartAg interventions are being developed and to identify the constraints and opportunities this agenda may encounter in the future. This section is not intended as a policy analysis; rather it is meant to highlight the overall policy environment in which NSmartAg programs can be developed, complementing any efforts towards policy reform under the broader nutrition sensitive agriculture agenda. Table 3 lists key indicative actions led by the government in DRC recognizing the role of agriculture sector interventions in addressing malnutrition and calling for such investments.

Table 3. Key indicative actions led by the government in DRC recognizing the role of agriculture sector interventions in addressing malnutrition

2013 National Agricultural Investment Program (*Programme National d'Investissement Agricole, PNIA*)	• Rests on a pillar intending to manage food and nutrition security, and strategic food reserves. • Calls for actions that contribute to improved nutrition.
National Multisectoral Strategic Nutrition Plan (*Plan National Stratégique Multisectoriel de Nutrition, PNSMN*) 2016-2025	• Calls for the agriculture sector to respond to malnutrition with increasing availability and access to diversified foods, including bio-fortified crops and fortified foods; and • Calls for the strengthening of governance and multisectoral coordination for nutrition
National Policy on Food and Nutritional Security (*Politique Nationale de Sécurité Alimentaire et Nutritionnelle, PNSAN*) 2018-2030	• Calls for increasing local agricultural productivity; improving physical and economic access to food; and • Aims to develop sustainable value chains in family farms and small and medium-sized agro-enterprises.
National Plan for Fortification (*Plan national pour la fortification, PNF*)	• Aims to promote the addition of vitamins and minerals, iron, iodine in locally processed food products.

Ongoing and planned interventions in agriculture and nutrition are presented in a succinct fashion (Table 4) aiming to quickly convey what NSmartAg practices and technologies are supported, where and by whom, so that synergies, opportunities and gaps can be easily identified.

Table 4. Indicative ongoing and planned interventions in agriculture and nutrition

NSmartAg activity	Program name (duration)	Development partner	Target areas	Brief description as related to NSmartAg
Biofortification	Multisectoral child nutrition and health project (2019-2025)	World Bank	Kwilu, Kasai, South Kivu	Roll out of biofortification (maize, beans, cassava, orange fleshed sweet potato)
NSmartAg menu of options	National Agriculture Development Program (under preparation)	World Bank	Kwilu, Kasai, Kasai Central, North Kivu, Kongo Central	Direct farmer support to agricultural productivity
Primary production; post-harvest	Programme de Développement Agricole au Kwilu et Kwango (PRODAKK)	Enabel – Belgian Development Agency	Kwilu, Kwango	Value chain development including for bananas and pisciculture
Primary production; post-harvest	Agricultural value chain strengthening project (2017 – 2022)	USAID	South Kivu	Value chain development for soybeans and beans
Primary production; post-harvest	Integrated Rural Economic Development Support Project (PROADER) (2020 –2025)	African Development Bank (AfDB)	Kongo Central, Kwilu, Kasai, Kasai Central and Kasai Oriental	Value chain development (various agro-products)
Primary production; post-harvest	Project for Youth Entrepreneurship in Agriculture and Agro-Business (PEJAB) (2017-2023)	African Development Bank (AfDB)	Kinshasa, Ituri, South Kivu, Kasai, Kasai Central, and Kasai Oriental	Value chain development (various agro-products)

2.6 Food Environment

Based on the different geographic segmentation of the country profile (Provincial, Agroecological Zone, etc.), a brief description of the food environment will be provided to highlight the main issues to be aware of when intervening from the food production side. Although the NSmartAg practices and interventions cannot guarantee an eventual impact on nutrition outcomes, this section intends to point out important issues to consider, such as where food is mainly consumed, the proportion of food that is bought, the level of food preparation at home or in post-harvest processes, the role of different family members in food production and consumption decisions, etc. Information for this section originates from existing literature.

2.7 Outlook

This section intends to take the information provided in the previous sections of the country profile to guide the reader into considerations for further integration of NSmartAg practices and technologies into agriculture investments, in particular public sector programs. The outlook will consider issues related to the policy and program framework, the food environment and the list of NSmartAg practices and technologies identified to draw on guidance for policy-makers and public sector officials in charge of program design on how best to integrate such opportunities in projects and farmer/agribusiness incentives for technology adoption.

2.8 Validation

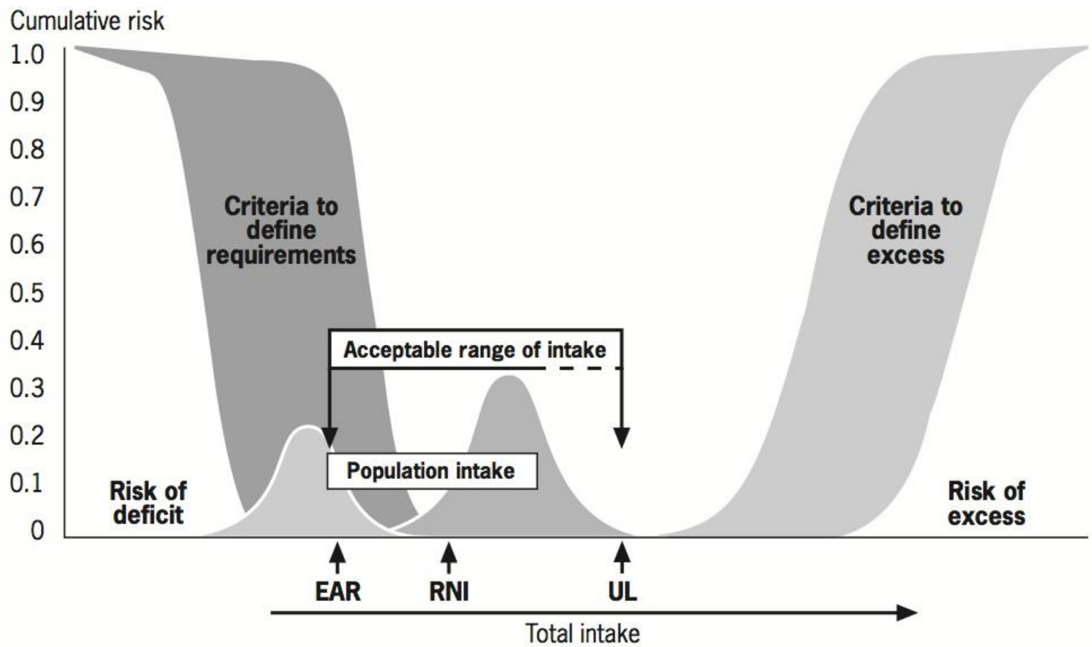
All findings from the methodology are validated through in-country national-level workshops with regional representation, and subnational workshops, if needed.

3 Notes and Possible Improvements

3.1 Interpreting Double-Bell Intakes Distributions

One important point needs to be made regarding the validity of the deficiency analysis when solely based on the bar graphs. Indeed, as pointed out in the FAO document ("Vitamin and mineral requirements in human nutrition—Second edition" 2004), deficiency analysis can be invalid when the intakes distribution contains multiple groups (i.e., when the distribution basically contains multiple "bell curves"). Figure 9 below illustrates the situation:

Figure 9. Double-bell intakes distribution



In this case, the average intake may be in a "safe zone", pulled up by the healthier "higher" group, but the count of deficient households remains high. A complementary statistical analysis should be performed on the deficiency count to improve the methodology. In the case of DRC, the actual values are so low that very little doubt is cast on the fact there are deficiencies—solely based on the bar graphs—but the opposite is not always true: if the aggregated intake (i.e. "nutrient consumption level" in our analysis) seems somewhat acceptable, it is recommended to complement the analysis with a more detailed deficiency analysis [7]. Such complementary analysis could include a deficiency count, which would provide a percentage of the households exhibiting an adult female consumption level below the EAR (Estimated Average Requirement) level. It is important to remember, however, that one of the goals of the analysis was to provide simple graphical outputs in order to offer a quick glance at large enough gaps in production and consumption of key nutrients that could potentially be narrowed through readily available agribusiness models. The bar graphs provide a limited insight into the exact deficiency status of the population, but they provide nonetheless an indication (especially regarding the contribution of the food groups and food products to their average consumption levels of the key nutrients) of where the gaps/imbalances are.

3.2 Improving Food Chain Parametrization

3.2.1 Implement Food Products Geo-variability

The fact that cassava leaves are subject to geo-variability when it comes to their nutritional content [8] can be addressed by developing a region-dependent FCT. A “region” entry could be added in the many-to-many relation table linking the local products to the generic FCT products: when a region is specified, the entry could be looked up against a specific FCT table made for the country and region dependent. As a result, the right product for each consumption entry could be selected based on the region/location of the household.

3.2.2 Improve Cooking Habits Models (re-cooking oil and destruction model)

By looking at the cooking habits table, the retention factors table and the chosen trashing ratios, it is clear that a lot more work has to be done to improve the modeling of the food chain for these stages. Further work would require an accurate quantification of the transfer of nutrients from oil to aliments (when cooking) and would involve looking at a lot more literature to gather retention factor values.

3.2.3 Improve Food Retention Factor (at the food product level)

Modeling retention factors based on food products—and not EAT-Lancet categories—is also something that seems like a natural improvement. Such retention factors could be found in the “USDA Table of Nutrient Retention Factors” from 2007, for example. An extract of this table is shown below (Table 5).

Improved retention ratios together with better insights on cooking practices (occurrences of fried vs. boiled vs. steamed vs. raw) could lead to a better statistical average in terms of nutrient destruction through the cooking process.

Table 5. Product-based retention factors (USDA—2007)

Retention Code	Food Group Code	Retention Description	Calcium, Ca	Iron, Fe	Magnesium, Mg	Phosphorus, P	Potassium, K	Sodium, Na	Zinc, Zn	Copper, Cu	Vitamin C, total ascorbic acid	Thiamin	Riboflavin	Niacin	Vitamin B-6	Folate, food	Folic acid	Folate, total	Choline, total	Vitamin B-12	Vitamin A, IU	Vitamin A, RE	Alcohol, ethyl	Carotene, beta	Carotene, alpha	Cryptoxanthin, beta	Lycopene	Lutein + zeaxanthin
0001	01	CHEESE,BAKED	100	100	100	100	100	100	100	100	65	75	100	100	75	80	80	80	75	55	100	100	100	100	100	100	100	100
0003	01	CHEESE,BROILED	100	100	100	100	100	100	100	100	65	75	100	100	75	80	80	80	75	55	100	100	100	100	100	100	100	100
0005	01	CHEESE,COOKED W/LIQUID	100	100	100	100	100	100	100	100	65	75	100	100	75	80	80	80	75	55	100	100	100	100	100	100	100	100
0007	01	CHEESE,REHEATED	100	100	100	100	100	100	100	100	95	95	100	100	95	95	95	95	95	95	100	100	100	100	100	100	100	100
0101	01	EGGS,BAKED	100	100	100	100	100	100	100	100	80	80	95	90	95	75	75	75	80	80	100	100	100	100	100	100	100	100
0103	01	EGGS,FRIED,SCRAMBLED	100	100	100	100	100	100	100	100	80	85	95	95	95	75	75	75	85	85	100	100	100	100	100	100	100	100
0105	01	EGGS,HARD COOKED	100	100	100	100	100	100	100	100	80	85	95	95	95	75	75	75	80	85	100	100	100	100	100	100	100	100
0107	01	EGGS,POACHED	100	100	100	100	100	100	100	100	80	80	85	85	85	75	75	75	80	80	100	100	100	100	100	100	100	100
0109	01	EGGS,REHEATED	100	100	100	100	100	100	100	100	95	95	100	100	95	95	95	95	85	95	100	100	100	100	100	100	100	100
2151	01	MILK,HEATED APPROX 10MIN	100	100	100	100	100	100	100	100	85	90	100	100	90	85	85	85	90	80	100	100	100	100	100	100	100	100
2152	01	MILK,HEATED APPROX 30MIN	100	100	100	100	100	100	100	100	65	75	100	100	75	80	80	80	75	55	100	100	100	100	100	100	100	100
2153	01	MILK,HEATED APPROX 1 HOUR	100	100	100	100	100	100	100	100	45	60	100	100	55	70	70	70	60	30	100	100	100	100	100	100	100	100
2154	01	MILK,REHEATED	100	100	100	100	100	100	100	100	95	95	100	100	95	95	95	95	95	95	100	100	100	100	100	100	100	100
0801	05	CHICKEN,BROILED	95	90	75	80	80	80	100	95	80	70	90	80	80	60	60	60	70	65	75	75	100	75	75	75	75	75
0803	05	CHICKEN,FRIED,WO/COATING	95	90	75	80	80	80	100	95	80	70	90	80	80	60	60	60	70	65	75	75	100	75	75	75	75	75
0804	05	CHICKEN,FRIED,W/COATING	95	90	75	80	80	80	100	95	80	70	90	80	80	60	60	60	70	65	75	75	100	75	75	75	75	75
0805	05	CHICKEN,ROASTED	95	90	75	80	80	80	100	95	80	70	90	80	80	60	60	60	70	65	75	75	100	75	75	75	75	75
0851	05	CHICKEN,BROWN,SIMMER,WO/DRIPPINGS	80	90	65	70	60	70	100	90	80	55	95	60	50	60	60	60	70	50	75	75	100	75	75	75	75	75
0852	05	CHICKEN,BROWN,SIMMER,W/DRIPPINGS	100	100	100	100	100	100	100	100	85	75	100	95	65	70	70	70	70	65	80	80	100	80	80	80	80	80
0855	05	CHICKEN,SIMMERED,WO/DRIPPINGS	80	90	65	70	60	70	100	90	80	55	95	60	50	60	60	60	70	50	75	75	100	75	75	75	75	75
0856	05	CHICKEN,SIMMERED,W/DRIPPINGS	100	100	100	100	100	100	100	100	85	75	100	95	65	70	70	70	70	65	80	80	100	80	80	80	80	80
0864	05	CHICKEN,REHEATED	100	100	100	100	100	100	100	100	95	95	100	100	95	95	95	95	70	95	100	100	100	100	100	100	100	100
1805	05	TURKEY,ROASTED	100	95	80	80	75	75	100	70	80	65	85	90	70	60	60	60	70	65	75	75	100	75	75	75	75	75

3.2.4 Introduce Cultural Habits Into Food Distribution

Currently the food distribution model solely considers the theoretical caloric requirements of each household member category. But the reality in many low-income countries is that the actual allocation of foods and nutrients intakes does not follow theoretical requirements. For example, women may have access to less food than the male members within the household, or be subject of food taboos under certain cultural/social practices. Infants' complementary foods are often monotonous, dominated by carbohydrates and excessively diluted with water (e.g., porridge), due to lack of knowledge about their ability to eat and digest more diverse, nutrient-rich foods. This situation could be significantly improved if actual quantitative dietary intake data or at least intra-household food allocation patterns that reflect particular social and cultural habits become available.

3.2.5 Aggregate by Social Groups

More types of aggregations could be performed according to more criteria, such as female-headed households; social filters; and/or education filters.

4 Detailed Analytical Process

The analytical part of the methodology can be divided in 7 main steps/blocks.

1) Gathering local specific data (local FCT, adapted EARs/RNIs, etc.)
   Adapting local data to a more standardized format (local quantities, for example)
   Augmenting the FCT to include all local products
   Pre-processing the raw survey tables and standardizing them
2) Computing a first pass of consumed quantities associated with each purchase
3) Detecting outliers
4) Performing price regression and "reinforcing" the data based on it
5) Filtering outliers
6) Computing nutrients intakes
7) Aggregating data for visual representations

4.1 Step 1: Data Pre-processing and Common Tables

4.1.1 Food Composition Table (FCT)

For DRC, the Food Composition Table is based on the West African Food Composition Table for 2012 from FAO (http://www.fao.org/3/a-i2698b.pdf). A partial example of FCT for DRC is shown in Table 6 below.

Table 6. Partial example of FCT for DRC

Code	LANCET	FoodnameinEnglish	unit_weight_net_g	Edibl	Energy_kcal	Waterg	Proteir	Fatg	Fibreg	Ashg	Camg	Femg	Mgmg
00_000	none	nothing	0	0	0	0	0	0	0	0	0	0	0
01_001	Grains	fonio, white, whole grain, raw		1	348	11.10	7.03	3.10	7.40	2.10	40.00	8.50	430.00
01_002	Grains	fonio, black, whole grain, raw		1	353	10.30	8.90	3.00	6.20	2.20	51.00	10.00	433.87
01_003	Grains	fonio, white, whole grain, boiled* (without salt)		1	145	62.96	2.93	1.30	3.10	0.90	16.67	3.50	179.17
01_004	Grains	maize, white, whole kernel, dried, raw		1	349	11.38	9.15	4.11	9.70	1.77	18.73	3.06	81.85
01_005	Grains	maize, white, whole kernel, boiled* (without salt)		1	134	65.92	3.52	1.58	3.73	0.68	7.20	1.20	31.48
01_006	Grains	maize, yellow, whole kernel, dried, raw		1	353	11.26	9.04	4.45	9.71	1.28	12.37	3.54	120.50
01_007	Grains	maize, yellow, whole kernel, boiled* (without salt)		1	136	65.87	3.48	1.71	3.73	0.49	4.76	1.30	46.35
01_008	Grains	maize, gougba variety, whole kernel, dried, raw (benin) n=1		1	344	13.05	8.74	4.00	9.70	1.03	18.38	3.00	80.30
01_009	Grains	maize, gbaévè variety, whole kernel, dried, raw (benin) n=1		1	344	13.02	8.10	4.00	9.70	1.18	18.39	3.00	80.33
01_010	Grains	maize, dmr-esr-w variety, whole kernel, dried, raw (benin) n=1		1	343	13.22	8.75	4.00	9.70	1.07	18.34	2.99	80.15
01_011	Grains	maize, poza rica 7843 sr variety, whole kernel, dried, raw (ben		1	343	13.39	8.96	4.00	9.70	1.03	18.31	2.99	79.99
01_012	Grains	maize, tzpb-sr variety, whole kernel, dried, raw (benin) n=1		1	340	14.02	8.80	4.00	9.70	1.08	18.17	2.97	79.41
01_013	Grains	maize, gnonli variety, whole kernel, dried, raw (benin) n=1		1	341	13.61	7.55	4.00	9.70	1.18	18.26	2.98	79.79
01_014	Grains	maize, combined varieties, whole kernel, dried, raw (benin)		1	343	13.39	8.48	4.00	9.70	1.10	18.31	2.99	79.99
01_015	Grains	millet, whole grain, raw		1	348	11.60	10.90	4.07	8.80	2.00	34.70	9.50	272.75
01_016	Grains	millet, whole grain, boiled*(without salt)		1	145	63.17	3.86	1.70	3.67	0.83	14.46	3.90	113.65
01_017	Grains	pearl millet, whole grain, raw (with bran)		1	364	10.14	8.80	5.80	9.00	1.50	13.57	7.60	97.37
01_018	Grains	pearl millet, variety kmv 8201, whole grain, raw (burkina faso) n		1	381	7.48	10.30	7.40	9.46	1.67	14.05	7.80	100.77
01_019	Grains	pearl millet, variety kmp 1, whole grain, raw (burkina faso) n=1		1	372	10.08	9.50	6.90	8.06	1.62	13.65	7.60	97.94
01_020	Grains	pearl millet, variety kmp 2, whole grain, raw (burkina faso) n=1		1	373	9.39	9.00	7.10	9.12	1.64	13.76	7.70	98.69
01_021	Grains	pearl millet, variety kmp 3, whole grain, raw (burkina faso) n=1		1	389	6.65	14.50	9.00	11.25	1.69	14.17	7.90	101.67
01_022	Grains	pearl millet, variety kmp 4, whole grain, raw (burkina faso) n=1		1	383	9.05	13.40	9.00	9.69	1.64	13.81	7.70	99.06
01_023	Grains	pearl millet, variety kmp 5, whole grain, raw (burkina faso) n=1		1	396	5.97	14.20	10.20	12.40	1.70	14.28	7.90	102.42
01_024	Grains	pearl millet, variety kmp 6, whole grain, raw (burkina faso) n=1		1	376	8.82	16.00	6.90	8.35	1.65	13.84	7.70	99.31
01_025	Grains	pearl millet, variety kmp 7, whole grain, raw (burkina faso) n=1		1	383	6.43	11.70	6.80	9.16	1.69	14.21	7.90	101.91
01_026	Grains	pearl millet, variety kmp 8, whole grain, raw (burkina faso) n=1		1	387	6.04	8.40	7.20	8.78	1.70	14.26	7.90	102.34
01_027	Grains	pearl millet, variety kmp 9, whole grain, raw (burkina faso) n=1		1	389	6.52	10.60	8.40	10.13	1.69	14.19	7.90	101.82
01_028	Grains	pearl millet, variety kmp 10, whole grain, raw (burkina faso) n=1		1	372	10.47	8.70	7.80	9.62	1.62	13.59	7.60	97.51
01_029	Grains	pearl millet, variety kmp 11, whole grain, raw (burkina faso) n=1		1	375	9.15	8.10	7.70	10.13	1.64	13.79	7.70	98.95
01_030	Grains	pearl millet, variety kmp 12, whole grain, raw (burkina faso) n=1		1	385	6.59	10.40	7.40	9.61	1.69	14.18	7.90	101.74
01_031	Grains	pearl millet, variety kmp 13, whole grain, raw (burkina faso) n=1		1	386	6.63	10.20	7.60	9.14	1.69	14.17	7.90	101.70
01_032	Grains	pearl millet, combined varieties, whole grain, raw (burkina faso)		1	382	7.80	11.10	7.80	9.64	1.66	14.00	7.80	100.42
01_033	Grains	pearl millet, whole grain, boiled* (without salt)		1	152	62.75	3.70	2.42	3.80	0.63	5.65	3.10	40.57
01_034	Grains	rice, brown, raw		1	352	11.90	7.80	2.20	3.00	1.30	21.50	1.85	143.00
01_035	Grains	rice, brown, boiled* (without salt)		1	352	64.76	3.12	0.88	1.20	0.52	8.60	0.74	57.20
01_036	Grains	rice, white, polished, raw		1	353	11.00	6.14	0.46	1.08	0.70	10.84	0.73	35.00
01_037	Grains	rice, white, raw		1	349	12.13	6.85	0.60	1.40	0.70	12.00	1.40	35.00
01_038	Grains	rice, white, boiled* (without salt)		1	134	66.21	2.64	0.23	0.54	0.30	5.00	0.54	13.46
01_039	Grains	sorghum, whole grain, raw		1	344	10.87	10.50	3.33	9.90	2.40	24.11	3.70	310.59
01_040	Grains	sorghum, whole grain, white, raw		1	354	9.41	9.30	3.90	9.90	2.00	24.00	3.90	311.00
01_041	Grains	sorghum, whole grain, red, raw		1	348	10.10	10.50	3.50	9.90	2.40	24.00	3.40	311.00
01_042	Grains	sorghum, whole grain, boiled* (without salt)		1	143	62.90	4.40	1.39	4.10	1.00	10.04	1.50	129.41
01_043	Grains	wheat flour, white		1	351	11.85	10.36	1.45	3.17	0.63	18.65	2.02	60.00
01_044	Grains	bread, maize flour, yellow, with milk and eg	250	1	247	50.40	7.60	11.30	1.20	1.30	70.00	0.70	35.00
01_045	Grains	bread/rolls, white	80	1	264	34.30	9.10	2.70	2.70	1.70	26.00	1.20	23.00
01_046	Grains	bread, wheat, white	250	1	249	36.50	8.40	1.80	3.10	1.90	28.00	1.20	23.00
01_047	Grains	bread, wheat, white for toasting	200	1	253	37.10	8.00	2.70	3.30	1.50	44.00	0.94	18.00
01_048	Grains	bread, wheat, wholemeal	250	1	234	39.10	8.90	2.30	6.20	2.10	49.00	2.00	53.00
01_049	Grains	fonio, black, whole grain, boiled* (without salt)		1	147	62.63	3.74	1.30	2.60	0.92	21.25	4.10	180.78
01_050	Grains	fonio, husked grains, raw (bran removed)		1	347	12.38	6.94	1.21	2.24	1.21	27.68	1.75	121.10
01_051	Grains	fonio, husked grains, boiled* (without salt)		1	145	63.49	2.89	0.51	0.93	0.51	11.53	0.73	50.46
01_052	Grains	macaroni, dried		1	359	9.45	12.47	1.51	3.70	0.88	23.00	1.15	53.26
01_053	Grains	macaroni, boiled* (without salt)		1	156	60.60	5.40	0.70	1.60	0.40	10.00	0.50	23.00
01_054	Grains	maize, yellow, flour of whole-grain		1	353	11.25	9.33	4.40	9.42	1.30	18.00	3.00	123.00
01_055	Grains	maize, yellow, grit, degermed		1	350	11.00	7.61	0.73	3.40	0.70	8.23	0.30	27.00
01_056	Grains	maize, yellow, soft porridge* (without salt)		1	48	87.80	1.00	0.10	0.50	0.10	1.00	0.04	4.00
01_057	Grains	maize, white, flour of whole grain		1	351	11.50	9.67	4.00	9.00	1.35	17.50	3.75	93.00
01_058	Grains	maize, white, flour refined		1	354	11.60	7.60	2.90	5.50	0.80	6.00	1.20	83.00
01_059	Grains	maize, white, flour degermed		1	361	10.00	7.10	1.50	2.20	0.50	4.00	1.00	32.00
01_060	Grains	maize, white, grit, degermed		1	356	9.50	8.78	0.60	3.40	0.70	4.00	0.30	27.00
01_061	Grains	maize, white, soft porridge* (without salt)		1	49	87.60	1.20	0.10	0.50	0.10	0.70	0.04	4.00
01_062	Grains	maize, combined varieties, whole kernel, boiled* (without salt)		1	132	66.69	3.26	1.50	3.70	0.42	7.04	1.15	30.77
01_063	Grains	pearl millet, flour (without bran)		1	355	12.00	7.40	3.16	4.60	0.79	13.45	5.80	0.00
01_064	Grains	pearl millet, combined varieties, whole grain, boiled* (without sa		1	159	61.59	4.60	3.30	4.01	0.69	5.83	3.20	41.84
01_065	Grains	rice, red native, hulled, raw		1	359	11.30	7.40	2.20	0.40	1.40	38.00	2.80	0.00

4.1.2 DRC Food Products Composition Table

The products listed in the consumption tables need to be matched against the FCT. When no FCT entry is found, the FCT needs to be augmented using the USDA database. If a product is not found in the USDA, an approximation can be made with the closest similar food product found either in the FCT or the USDA database. If no approximation can be made, the product will be ignored. However, if the product is vastly represented in the consumption data, a similar product must be found, or it is advised to ask local experts for its composition.

Technically, the matching of DRC food products with the products present in the West African FCT is done through a one-to-many relation table, where we associate each DRC food products to one or more food products in the generic FCT. For example, it is possible to associate the DRC "oil" product to different types of oils. It is also possible to give a percentage of representation (occurrence probability) for each of those associations. In the case of oil, the recommendation was that 95% of consumed “oil” is red palm oil and 5% is “generic” oil (according to FAO Kinshasa, DRC). Based on these percentages and the actual nutrient composition of the FCT food products, we can compute a hybrid composition for each country’s food product, by averaging the FCT nutrient levels weighted by the occurrences’ probabilities. Table 7 illustrates the data used to match food products.

Table 7. Products matching table

origCode	englishName	edible_special	unit_weight_special	code1	code2	code3	code4	code5	code6	code7
11323	fretins (ndakala)			09_506						
11324	bitoyo salty fish			09_507						
11325	cod salted fish			09_507						
11326	congo ya sika salted			09_002	09_005	09_006	09_007	09_015	09_018	09_021
11327	herring (mpiodi) smoked			09_509	09_510					
11328	sardine oil, pilchards			09_037						
11329	other dried or smoked fish, preserved p			09_511	09_512	09_513	09_514	09_515	09_516	09_517
11411	sweetened condensed milk			10_015						
11412	fresh milk			10_001	10_013	10_014				
11413	non-concentrated milk			10_001						
11414	milk powder nido			10_002						
11415	cowbell milk powder			10_011						
11416	kerrygold milk powder			10_002						
11417	milk for baby			10_011	10_012					
11418	other milk n.e.			10_003						
11422	cheese			10_006	10_007	10_008	10_020			
11424	yogurt			10_005	10_021					
11425	soy milk			10_500	10_501	10_502	10_503			
11426	other dairy products n.e.			10_505	10_506	10_507	10_508			
11431	Local eggs			08_001						
11432	other eggs n.e.			08_001						
11511	fresh butter			11_001						
11512	margarine pot			11_503	11_504					
11513	margarine sachet			11_500	11_501					
11521	imported vegetable oil			11_010						
11522	Palm oil			11_004@0.95	11_007					
11523	local vegetable oil			11_010						
11524	animal fat (lard, etc.)			11_502						
11525	other oils and fats n.e.			11_002	11_003	11_005	11_009			
11531	peanut pie			06_026						
11533	other fat n.e.			10_009	10_010					
11611	pineapple			05_018						
11612	lawyers			05_002						
11613	sweet bananas			05_028						
11614	lemons			05_014						
11615	mangos			05_015	05_036	05_037				

4.1.3 DRC Local Units

A scientific conversion of the local units has been established, in order to help bootstrap the quantities computation and maximize information availability. The following Table 8 presents the one developed for DRC.

Table 8. DRC non-standard units conversion

code	description	factor	oUnit	unsafe	code	description	factor	oUnit	unsafe
0	sans unité	1	byprice	0	44	quartier	0.8	unit	1
1	pièce, feuille, unité, tarif, nomb	1	unit	1	45	Demi-quartier	0.4	unit	1
2	paquet, boîte, sachet manufac	1	unit	1	46	cuisse		special	1
3	paquet, boîte, sachet non man	1	unit	1	47	carton (poisson, poulet, viande	30	L	1
4	Demi-boîte	0.5	unit	1	48	carton (cigarettes)	30	L	1
5	tas	3.3	L	1	49	rame (poisson)	15	L	1
6	botte	10	unit	1	50	mois		x	0
7	morceau	1	unit	1	51	trimestre		x	0
8	assiette, bol, plat, sakombi	0.5	L	1	52	semestre		x	0
9	ekolo	1.494	L	1	53	an		x	0
10	main	0.3716	L	1	54	heure		x	0
11	régime	10	unit	1	55	jours, nuits		x	0
12	milligramme	0.001	g	0	56	yard		x	0
13	gramme	1	g	0	57	pantalon (tissus)		x	0
14	kilogramme	1000	g	0	58	pièce de tissu (12 mètres)		x	0
15	millilitre	0.001	L	0	59	demi-pièce de tissu (6 mètres)		x	0
16	litre	1	L	0	60	pagne (2 mètres)		x	0
17	millimètre	0.002826	L	0	61	kilowattheure		x	0
18	centimètre	0.02826	L	0	62	mètre cube	1000	L	0
19	mètre	2.826	L	0	63	sac	10	L	1
20	bouteille de 30 cl (coca)	0.3	L	0	64	caisse	15	L	0
21	bouteille de 33 cl	0.33	L	0	65	fagots	0.157	L	1
22	bouteille de 66 cl	0.66	L	0	66	mètre carré		x	1
23	bouteille de 72 cl (bière)	0.72	L	0	67	are		x	1
24	bouteille de 75 cl	0.75	L	0	68	centiare		x	0
25	bouteille de 1 litre	1	L	0	69	hectare		x	0
26	bouteille de 1,5 litres	1.5	L	0	70	tonne	1000000	g	0
27	bouteille de 2 litres	2	L	0	71	douzaine	12	unit	0
28	casier 12 bouteilles	3.96	L	0	72	demi-douzaine	6	unit	0
29	casier 24 bouteilles	7.92	L	0	73	Ampoule, tube	0.02	L	0
30	bidon de 5l	5	L	0	74	paire	2	unit	0
31	bidon de 10l	10	L	0	75	course		x	0
32	verre bambou	0.25	L	0	76	voyage		x	0
33	Demi-verre	0.12	L	0	77	salon		x	0
34	tasse	0.15	L	0	78	place		x	0
35	libanga	0.012	L	1	79	cure		x	0
36	bassin (gros ou Brazza)	80	L	1	80	flacon	0.2	L	0
37	bassin (moyen)	40	L	1	81	comprimé		x	0
38	panier	22	L	1	82	taxi, taxi-bus (transport)		x	0
39	sceau (katini)	10	L	1	83	measure	0.23659	L	1
40	cueillere à café	0.005	L	0	84	quaker	4.5	L	1
41	cuillerée à soupe	0.015	L	0	85	meka	2700	g	1
42	boule	0.0654	L	1	99	indéterminé	1	byprice	0
43	tête		special	1					

Some conversions involve converting unidimensional units into volumetric units. The food products concerned by such units have been examined and a rough estimation of the section for those products has been used in order to perform volumetric conversion. Other units are left flagged as “by price”, meaning that we will only rely on the price regression to estimate the quantity of those. Some “special” units are left out and careful estimation on a case-by-case basis is done for each product.

This table will help pre-estimate quantities, which can prove beneficial when no better data is available. Note that the estimation of these non-standard quantities is likely subject to ample variation (especially for the units like “bag”, “bunch”, “stack” or even “hand”). Those units are flagged as “unsafe” and will likely be altered more than safer units, throughout the analysis.

4.1.4 Density Computation

In order to help bootstrap the computation of consumed quantities, we pre-compute the density of a food product roughly based on its nutrient composition (especially if the FCT table contains information about water content, fats, carbohydrates and fibers). The basic values used for each nutrient are as follows (Table 9):

Table 9. Nutrients densities

Protein	~= 1.33 g/cm^3
Fat	~= 0.93 g/cm^3
Starch/Carbohydrates	~= 1.60 g/cm^3
Fiber	~= 1.31 g/cm^3
Water	= 1.00 g/cm^3
Ash (K, Na,.)	~= 2.20 g/cm^3

Reference: "Introduction to Food Process Engineering" by Albert Ibraz & Gustavo V. Barbosa-Cánovas (2014)"—visible here.

This will help compute the grams-per-unit for the local non-standard units that convert into volumetric scientific units—like "bag", "hand" or "glass".

4.1.5 Nutrients Requirements Table

The Nutrient Requirements Table (NRT) is a table that contains—for each nutrient of interest—a set of thresholds associated with *population groups* (gender x age + pregnant | lactating female). Those thresholds should be associated with Estimated Average Requirement (EAR), Recommended Nutrient Intake (RNI) or Recommended Dietary Allowance (RDA) thresholds (see below).

The NRT is a key table that will guide the global methodology in identifying deficiencies in the population. It is very important to get this table right as its impact on a decision is directly linked to the value set for each given nutrient's threshold.

The NRT is used at two stages of the analysis:

1) To normalize the intakes according to the adult female category, for each nutrient of interest
2) To compare the final aggregated intakes to the adult female thresholds

Which NRT?

Currently, the NRT table for the DRC is based on the FAO RNI tables with 5%-bioavailability for iron and "low" bioavailability for zinc.

While EAR ratios should be applied, we had to opt for RNIs due to lack of EARs for iron and zinc in the FAO reference documents so that we could ensure homogeneity across the types of thresholds used in the analysis (Table 9).

Table 9. Extract of the Nutrient Requirement Table (NRT) from FAO RNIs with low bioavailability for iron and zinc avg 62 kg adult men + 61 kg adult women 1.75 x BMR

age_gender_	age_min	age_max	gender	pregnancy	Energy_kcal_(	Proteing_d	Camg_d	Femg_d	Mgmg_d	Znmg_d	VitARAEmcg_
1	0	0.5	0		*491*	10.2	350	1	31	6.6	375
2	0.5	1	0		*491*	11.6	400	18.6	54	8.4	400
3	1	3	0		*1066.16667*	12	500	11.6	60	8.3	400
4	4	6	0		*1349.5*	16.65	600	12.6	76	9.6	450
5	7	9	0		*1700.875*	26.05	700	17.8	100	11.2	500
6	10	14	m		*2559.8*	40.5	1300	29.2	230	17.1	600
7	15	18	m		*3277.5*	51	1300	37.6	230	17.1	600
8	19	51	m		*3125*	51	1000	27.4	260	14	600
9	51	65	m		*3050*	51	1000	27.4	260	14	600
10	65	199	m		*2550*	47	1300	27.4	224	14	600
11	10	14	f	0	*2251.8*	41	1300	46.7	220	14.4	600
12	15	18	f	0	*2449.25*	47.4	1300	62	220	14.4	600
13	19	51	f	0	*2300*	51	1000	58.8	220	9.8	500
14	51	65	f	0	*2250*	48	1300	22.6	220	9.8	500
15	65	199	f	0	*2050*	47	1300	22.6	190	9.8	600
16	13	199	f	1	2585	65	1200	90	220	15	800
17	13	199	f	2	2975	67	1000	30	270	17.0	850

References:

Energy: http://www.fao.org/3/a-y5686e.pdf
Protein: WHO_TRS_935_eng.pdf
Nutrients: FAO-minerals+vitamins Reqs-9241546123.pdf
Average weight for men and women in DRC was found here:
https://www.who.int/ncds/surveillance/steps/STEPS_DRC_Final.pdf

4.1.6 Retention Factors and Cooking Habits Tables

Towards the last stages of the process, we apply retention factors as well as a "cooking habit factor" in order to account for cooking practices and their impact on a given nutrient for a specific food product or EAT-Lancet category. Currently we mostly model this step of the food chain through the EAT-Lancet categories, but further development should allow the parameterization to be dependent on the food product.

The retention factors account for the "destruction" of the nutrient caused by heating. The following document helped us sketch a preliminary table:

Vitamin A: https://www.sciencedirect.com/science/article/pii/030881469190068Y

Vitamin A/Vegetables: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6049644/

The resulting retention factors table is as follows (Table 10)

Table 10. Retention factors used by EAT-Lancet categories

LANCET	Proteing_cx	Femg_cx	Znmg_cx	VitARAEmcg_cx
Red meat	1	1	1	1
Starchy vegetables	1	1	1	1
Eggs	1	1	1	1
Poultry	1	1	1	1
Dairy foods	1	1	1	1
Fish	1	1	1	1
Vegetables	1	1	1	0.85
Fruits	1	1	1	1
Legumes	1	1	1	1
Grains	1	1	1	1
Nuts	1	1	1	1
Oils	1	1	1	0.79
Sugars	1	1	1	1
Insects	1	1	1	1

This table is still premature and will need to be completed with time. The model needs to be improved and a food-product-based retention factors table should be developed in the future (specific to each country).

A cooking occurrence table has also been established in order to account for the prevalence of cooking vs. raw consumption, for each category. The following table shows the values used per EAT-Lancet categories (Table 11):

Table 11. Cooking occurrences per EAT-Lancet categories

LANCET	cooking_occurence	repeatedTimes
Red meat	1	1
Starchy vege	1	1
Eggs	0.9	1
Poultry	1	1
Dairy foods	0.2	1
Fish	1	1
Vegetables	0.5	1
Fruits	0	1
Legumes	0.5	1
Grains	1	1
Nuts	0.1	1
Oils	0.9	2
Sugars	0.5	1
Insects	0.7	1

The same remarks apply: a better table, on a food-product basis, specific to the country, should be developed in the future. The "repeated times" parameter is not currently used but further models could use this parameter to geometrically apply retention factors.

4.2 Step 2: Consumption Data Processing

Common pre-processing methods are applied to the raw consumption tables.

This includes:

- Standardizing all consumption tables into one common format
- Replacing "99,999" type values to missing values
- Fixing interview dates
- Applying thresholds to consumption frequencies based on an interview span

4.3 Step 3: Grams-per-unit Bootstrapping and Calculations

In order to engage the calculation of the consumed grams, a first pass at calculating the grams-per-unit is done through a crude estimation based on the non-standard units conversion table. For this step, the following applies:

$$grams\_per\_unit = factor \cdot density \cdot 1000 \text{ for units convertible to volume}$$
$$grams\_per\_unit = factor \text{ for units convertible to weight}$$
$$grams\_per\_unit = factor \cdot unit_weight \text{ for units labeled as 'unit'}$$
$$grams\_per\_unit = ... \text{ for units labeled as 'special'}$$

Where *factor* is the value present in the conversion table, "special" units follow a case-by-case scenario, based on the food product and the actual non-standard unit.

Another grams-per-unit variable is computed per unit and per product type, based on the "known-grams" variable present in the database (and the number of units variable). A value per region is calculated as well as a national value, as default.

The grams-per-unit value is then updated from the latest estimation in case of "unsafe" units.

Finally, the purchased grams are computed following the formula:

$$purchased\_grams = grams\_per\_unit \cdot num\_units$$

The purchased-gram variable is finally overwritten by the known-purchased-grams in the case of unsafe units. This step will update a very large number of entries in the case of DRC (around 75%).

Note: Having the known-purchased-gram variable can strongly reduce the risk of errors on the initial purchased-gram estimation. However, this is not always possible, as not a[9]ll surveys can provide this information. If this variable is not available, relying on crude bootstrapping for the quantities could prove to be more uncertain, and so it may be recommended to replace the crude estimation with the price regression result in a greater number of cases. In that case, performing the local marketplace/regression analysis prior to the outlier detection may be recommended (where a robust regression could be used). In the case of DRC, the overriding of quantity values with the price regression estimation was not needed thanks to the presence of the known-purchased-gram variable.

4.4 Step 4: Outliers Detection

Once the purchased quantity is estimated, we can detect the outliers based on quantity and/or price. To do so, we use *Tukey's* criteria with a factor "*k*" of 1.5.

Two databases are available for consumption: one for exceptional expenses and one for more usual expenses. The detection of outliers will treat those databases separately in order to not systematically register the "exceptional expenses" as outliers.

The detection of outliers is done per product and per region.

4.5 Step 5: Local Marketplace Reinforcement

A regression is performed on the estimated quantity purchased vs. the cost of purchase. Extra parameters of the regression include household size, milieu and region. Outliers are manually excluded from the regression in our case.

The regression is used to update the "by-price" units by direct replacement.

Further replacements are performed when a high discrepancy is detected between the estimated quantity from the regression and the original estimated quantity—for certain units.

4.6 Step 6: Outliers Treatment/Filtering

We filter the outliers using one of the following methods:

- Windsorization: replacing the outliers by their Tukey thresholds
- Regression replacement: replacing the outliers by their regression estimation.

Currently, the first method is used.

4.7 Step 7: Nutrient Intake Computation

Once we have a final quantity for each consumption entry, we can start converting this quantity into nutrient values.

This includes:

- Translating the entry's quantity into grams-per-day according to its purchase frequency
- Scaling FCT nutrients data (per 100 g) to the entry's grams-per-day
- Applying retention factors x cooking practices
- Applying household *nutri-coef*, for each nutrient

The cooking practice and retention factors are applied as follows:

$$cooked\_intake_{nutrient,prod} = intake_{nutrient,prod} \cdot (cook\_occ_{lancet} \cdot ret\_factor_{lancet} + (1.0 - cook\_occ_{lancet}) \cdot 1.0)$$

This will scale down the nutrient intake for all things related to cooking.

Other cooking habits include the use of oil for frying. It was confirmed that oil was mainly used for frying and cooking in DRC (according to FAO and WFP Kinshasa, DRC). For that reason, we applied a specific "trashing factor" due to the oil being wasted (and not transferred to the aliments) after a certain time. This factor is still very arbitrary and set to 1/6 at the moment. The prevalence of red palm oil in DRC, and its consequent impact on vitamin A intake suggest that further analysis should be vested in this part of the food chain.

In the same way we applied a trashing factor for oil, we set a factor of 1/10 for salt, as a lot of salt is trashed/lost through cooking water. Here too, this factor remains largely arbitrary at the moment.

Finally, the *nutri_coef* of the household for each nutrient is multiplied by the intake in order to account for the food distribution of the household nutrients' intake, as well as the scaling into the adult male category.

$$final\_intake_{nutrient,prod} = cooked\_intake_{nutrient,prod} \cdot hh\_nutricoef_{nutrient}$$

The formula above lets us introduce an important part of the analysis, centered around the concepts of "*nutri-coefficients*", "*DRI ratios*" and "*nutri-sizes*": because the consumption tables only list food entries per household, we have to try to account for the household to differentiate nutrient dimensions according to its members. For example, a household with two adult parents and a baby won't be the same as a household with two adult parents, three teenagers and a baby. This introduces the concept of nutri-size: like the usual household size (the household members' count) we can derive from the NRT a *household size* for each nutrient dimension. To do so, we normalize the NRT table by dividing each nutrients threshold by its associated adult female threshold—which gives us the *DRI ratios* table. For example, for a baby, the protein ratio would be something like 0.2 whereas a teenager female would be around 0.8. Summing the household's members' *DRI ratios* can then give an idea of the "size" of the household on a given nutrient's dimension.

From the NRT table above, the DRI ratios table is as follows (Table 12):

Table 12. The adult-female equivalent DRI ratios table from NRT

age_gender	age_min	age_max	gender	pregnancy	Energy_kcal_d	Proteing_d	Femg_d	Znmg_d	VitARAEmcg_d
1	0	0.5	0		0.213478261	0.2	0.0170068	0.67346939	0.75
2	0.5	1	0		0.213478261	0.22745098	0.31632653	0.85714286	0.80000001
3	1	3	0		0.463550725	0.23529412	0.19727891	0.84693878	0.80000001
4	4	6	0		0.58673913	0.32647059	0.21428571	0.97959184	0.89999998
5	7	9	0		0.73951087	0.51078431	0.30272109	1.14285714	1
6	10	14	m		1.112956522	0.79411765	0.49659864	1.74489796	1.2
7	15	18	m		1.425	1	0.63945578	1.74489796	1.2
8	19	51	m		1.358695652	1	0.46598639	1.42857143	1.2
9	51	65	m		1.326086957	1	0.46598639	1.42857143	1.2
10	65	199	m		1.108695652	0.92156863	0.46598639	1.42857143	1.2
11	10	14	f	0	0.979043478	0.80392157	0.79421769	1.46938776	1.2
12	15	18	f	0	1.064891304	0.92941176	1.05442177	1.46938776	1.2
13	19	51	f	0	1	1	1	1	1
14	51	65	f	0	0.97826087	0.94117647	0.38435374	1	1
15	65	199	f	0	0.891304348	0.92156863	0.38435374	1	1.2
16	13	199	f	1	1.123913043	1.2745098	1.53061224	1.53061224	1.6
17	13	199	f	2	1.293478261	1.31372549	0.51020408	1.73129252	1.7

One goal of this methodology is to present bar graphs that will give a clear idea of the average intake for a given region, per nutrient. Those bar graphs will also display the recommended/required intake threshold, which will provide insight on the nutritional status of the region. To be able to average those intakes, we need to normalize them to one unique category: the adult female category. This is where the *DRI ratios* come into action. For a given intake issued from a consumption entry, we need to somewhat distribute this intake across the household's members ("food distribution"), normalize all the intakes to the adult female category, and calculate an average over the household's members. The formulas unfold below.

Given the following definitions:

$$
\begin{aligned}
Th_{nutrient}(cat) &: nutrient\text{'s EAR/RNI threshold for category } cat \\
nutrient &: the\ "nutrient"/"dimension"\ of\ interest\ [Fe, Prot, Zn, VitaA, kcal] \\
i &: \text{the individual} \\
H &: \text{the household} \\
cat(i) &: \text{age-gender category of individual } i \\
cat^{eq} &: \text{age-gender reference category (adult female)} \\
DRI_{nutrient}(i) &: \text{DRI ratio of individual } i \\
hh\_nutrisize_{nutrient} &: \text{household's nutrisize for } nutrient
\end{aligned}
$$

We define the *DRIs ratios* by the following formula:

$$DRI^{eq}_{nutrient}(i) = \frac{Th_{nutrient}(cat(i))}{Th_{nutrient}(cat^{eq})}$$

And the household's *nutri-size* by:

$$hh\_nutrisize^{eq}_{nutrient}(H) = \sum_{i \, \epsilon \, H} DRI^{eq}_{nutient}(i)$$

The average intake of the household *H*, per adult equivalent *eq* is given by:

$$avg\_intake^{eq}_{nutrient}(H) = \frac{1}{hh\_size} \sum_{i \, \epsilon \, H} normalized\_intake^{eq}_{nutrient}(H, i)$$

Where:

$$normalized\_intake^{eq}_{nutrient}(H, i) = \frac{portion(H, i) \cdot intake_{nutrient}(H)}{Th_{nutrient}(cat(i))} \cdot Th_{nutrient}(cat^{eq}) = portion(H, i) \cdot \frac{intake_{nutrient}(H)}{DRI^{eq}_{nutrient}(i)}$$

$portion(i)$: portion % for individual i based on the food distribution model

$normalized\_intake^{eq}_{nutrient}(i)$: $nutrient$ intake normalized for the matching $"adult\_female"$ reference threshold

We use the following food distribution model:

$$portion(H, i) = \frac{Th_{kcal}(cat(i))}{\sum_{j \epsilon H} Th_{kcal}(cat(j))} = \frac{DRI^{eq}_{kcal}(i)}{nutri\_size^{eq}_{kcal}(H)}$$

The formula above exhibits the core of the “food distribution model”: we distribute each consumption entry across household members by rationing based on the energetic requirements ratios within the household. It is like saying: “We will give a newborn roughly 4 times less food than to a teenager”. We feel humans are intuitively aware of the calorific demands of an individual, and the energetic ratios presented in the NRT/DRI tables can somewhat match this intuition. This does not account, however, for the nonlinearities and disruptive distributions that can occur through local customs, cultural habits, or the different diets advocated across age-gender categories.

The average intake including our food distribution model translates to:

$$avg\_intake^{eq}_{nutrient}(H) = \frac{1}{hh\_size} \sum_{i \, \epsilon \, H} \frac{DRI^{eq}_{kcal}(i)}{hh\_nutrisize^{eq}_{kcal}} \frac{intake_{nutrient}(H)}{DRI^{eq}_{nutrient}(i)}$$

food distribution model normalization

Which gives the following household’s *nutri-coefficient* value:

$$nutricoef^{eq}_{nutrient}(H) = \frac{1}{hh\_size} \sum_{i \, \epsilon \, H} \frac{DRI^{eq}_{kcal}(i)}{hh\_nutrisize^{eq}_{kcal}} \frac{1}{DRI^{eq}_{nutrient}(i)}$$

Finally, we can note that the ratio below is invariant with "*eq*" and only depends of the population characteristics, its consumption pattern as well as the NRT table (which means the shape of the graphics is unchanged, whichever adult equivalent we choose):

$$\frac{avg\_intake^{eq}_{nutrient}(H)}{Th_{nutrient}(cat^{eq})} = \frac{1}{hh\_size} \sum_{i \, \epsilon \, H} portion(H,i) \cdot \frac{intake_{nutrient}(H)}{Th_{nutrient}(i)}$$

Similarly, we compute the average portion in grams-per-day-per-adult equivalent for the EAT-Lancet pie charts. It is calculated as follows:

If we define the following variables:

$$\begin{aligned} g_{LANCET}(H) &: LANCET \text{ grams intake per day for the household } H \\ G^0_{LANCET} &: LANCET \text{ grams per day target (2500 kcal reference)} \\ G_{LANCET}(cat) &: LANCET \text{ grams per day target for category } cat \\ g^{eq}_{LANCET}(H) &: LANCET \text{ grams intake per day per adult-equivalent for household } H \end{aligned}$$

We have:

$$G_{LANCET}(cat) = \frac{Th_{kcal}(cat)}{2500} \cdot G^0_{LANCET} = \lambda(cat) \cdot G^0_{LANCET}$$

The average daily adult equivalent intake (in grams) for the household is:

$$g^{eq}_{LANCET}(H) = \frac{1}{hh\_size} \sum_{i \epsilon H} portion(i) \cdot \frac{g_{LANCET}(H)}{G_{LANCET}(cat(i))} \cdot G_{LANCET}(cat^{eq})$$

With our simple distribution model:

$$g^{eq}_{LANCET}(H) = \frac{1}{hh\_size} \sum_{i \, \epsilon \, H} \frac{DRI_{kcal}(i)}{hh\_nutrisize^{eq}_{kcal}} \cdot \frac{g_{LANCET}(H)}{\frac{Th_{kcal}(cat(i))}{2500} \cdot G^0_{LANCET}} \cdot \frac{Th_{kcal}(cat^{eq})}{2500} \cdot G^0_{LANCET}$$

$$g^{eq}_{LANCET}(H) = \frac{1}{hh\_size} \sum_{i \, \epsilon \, H} \frac{DRI_{kcal}(i)}{hh\_nutrisize^{eq}_{kcal}} \cdot \frac{g_{LANCET}(H)}{DRI_{kcal}(i)}$$

$$g^{eq}_{LANCET}(H) = \frac{g_{LANCET}(H)}{hh\_nutrisize^{eq}_{kcal}}$$

The same way of the nutrients intakes, the shape of the EAT-Lancet graphs remains invariant with the adult reference "*eq*":

$$\frac{g^{eq}_{LANCET}(H)}{G_{LANCET}(cat^{eq})} = \frac{g_{LANCET}(H)}{G^0_{LANCET} \cdot \sum_{i \epsilon H} \frac{Th_{kcal}(i)}{2500}}$$

4.8 Aggregate and Export

Before aggregation, we sum the intakes and quantities by {household, food product}, and then we complete the database by filling the missing {household, food product} entries with zeros.

We now have a table of entries consisting of a food product/EAT-Lancet-category, a household/region/milieu and values of nutrients intakes (per day) as well as grams eaten per day. This allows us to aggregate any way we want to compile the data we want:

- Aggregate nutrients intakes by food products and region to compute “top products list”, for each nutrient and region
- Aggregate nutrients intakes by households and EAT-Lancet categories, and compute the mean over the household’s population>> bar graphs
- Aggregate grams-per-day by households and EAT-Lancet categories, and compute the mean over the household’s population>> pie charts

5 Gender and NSmartAg

Future teams preparing NSmartAg Country Profiles may want to pay special attention to gender, by adding additional gender-specific questions in the survey administered to agri-businesses (Appendix 7.4). Collecting information disaggregated by gender (beyond the current question on ownership) can help to inform strategies to support NSmartAg practices.

6 Discussion

On one hand, food producers are still largely uninformed of their potential impact on malnutrition. On the other hand, those food producers who are interested in investing in food quality improvements (such as food safety practices, biofortified crops, etc.) find that these improvements are not yet recognized by the market. Improving the nutritional value of their food products is an extra cost that puts them at a disadvantage in relation to their competitors.

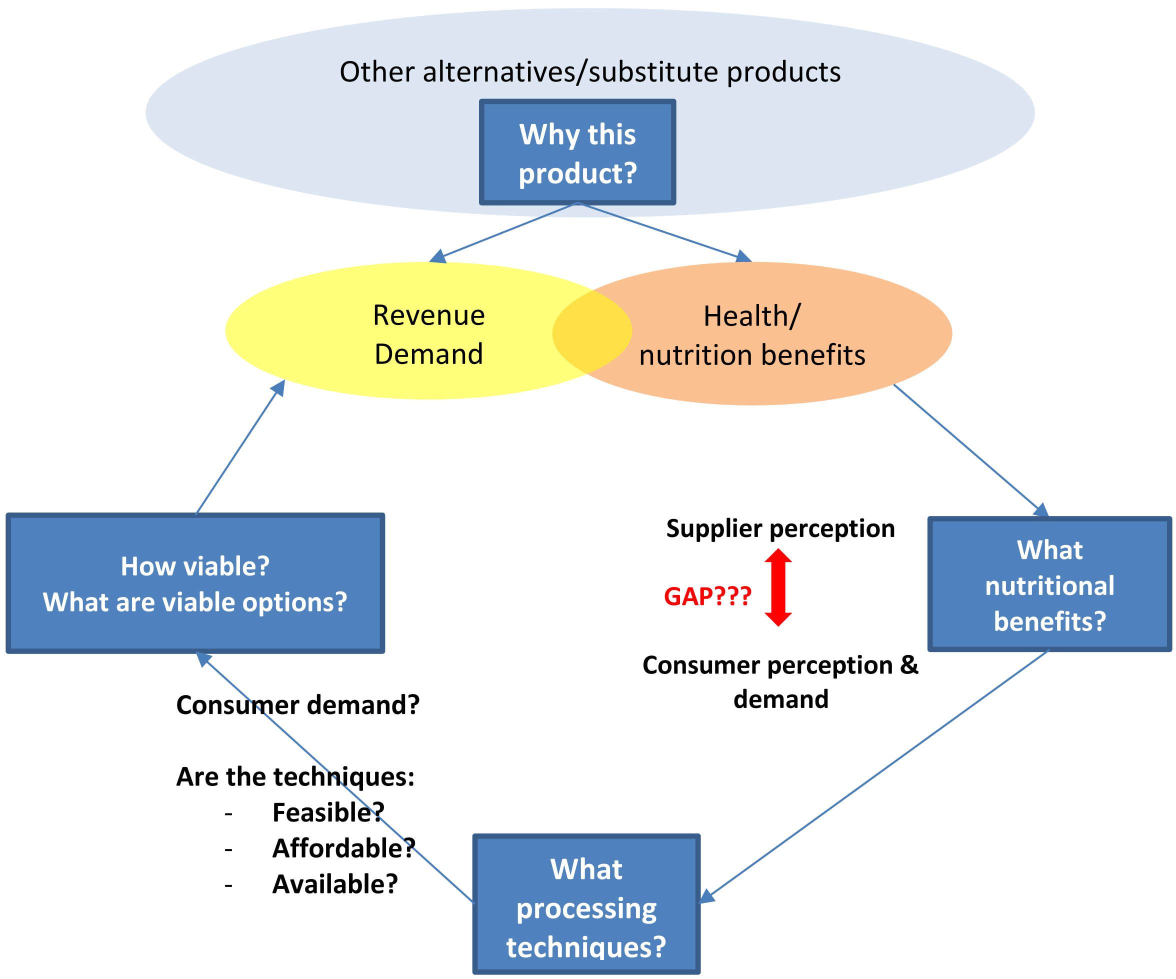
If we can support policies and programs that allow food producers to increase revenues while also having a positive impact on nutrition in the markets they supply, we will be achieving a much-needed double bottom line for the food system. There are many practices and technologies that can be leveraged towards investments and policy-support programs that help countries address their agriculture development and nutrition challenges simultaneously.

The NSmartAg approach identifies these practices and technologies, and channels public investments in agriculture towards a double objective: improving the bottom line for farmers and agribusinesses while also contributing to improve the nutrition of the local population.

With this document, we intend to present a conceptual framework and template that others can use to develop NSmartAg Country Profiles in other countries/regions. The Methodology and Country Profile templates will be finalized after in-country validation workshops in the four countries where they were first developed for (DRC, Guatemala, Haiti, and Mozambique) which are planned for March—May 2020.

7 Appendices

7.1 Nutrition Smart Agriculture Post-harvest Interview Guide and Questionnaire



Questions inserted in KoboToolBox data collection platform https://www.kobotoolbox.org/

1. Name of owner/employee
2. Gender
3. Name of entity (if any)
4. Location
5. District
6. Province
7. Type of entity

- Farmer association
- MSME
- Cooperative
- Other

8. Type of activity
   - Agricultural production (if so, do not administer the survey)
   - Ag/food transformation
   - Ag/food transportation

9. Number of employees

10. What type of customers do you sell food product/service to?
    - Direct to food consumers
    - Wholesalers
    - Distributors
    - Retailers
    - Other

11. Where are customers located?
    - Rural
    - Market towns
    - Cities
    - Other

12. Does your entity have a documented Business Plan for the company, or for the food product/service?

13. Are you aware of your country's current food safety regulations?

14. Does your company have the following quality assurance schemes (more than one answer possible)?
    - Good Hygienic Practices (GHP) or Good Manufacturing Practices (GMP)
    - Critical Control Points (CCP)
    - HACCP
    - No, the company has no quality assurance schemes in place
    - Other

15. Is your entity legally registered?

16. Does your company have the official [Health Code] or [Sanitary Permit] for food business operations?
    - Yes
    - No
    - If no, can you specify why?
      - I have not applied for an official permit for food business operations
      - I am not aware of an official permit for food business operations

        - Permit was rejected due to non-compliance with sanitary requirements such as employee training or infrastructure
        - Company had permit but lost it due to repeated non-compliance
        - Other

17. Which of the following risk management procedures are applied by your company?
    - Time and temperature control mechanisms
    - Cold-chain procedures
    - Documented withdrawal/recall mechanisms
    - Traceability mechanism
    - Other

18. Food product/service name (photo)

19. Food product/service name (description)

20. Food groups
    - Red meat
    - Starchy vegetables
    - Eggs
    - Poultry
    - Dairy foods
    - Fish
    - Vegetables
    - Fruits
    - Legumes
    - Grains
    - Nuts
    - Oils
    - Sugars
    - Insects

21. Ingredients (natural or added) (photo)
    - Sugar added
    - Saturated fat
    - Essential amino acids
    - Dietary fiber
    - Essential fatty acids
    - Major and trace minerals
    - Other

22. *If response to Question 8, was Type of Activity: Ag/food transformation, then Question 22 is:* Please describe in detail the type of processing taking place, or check all processing techniques that apply
    - Milling
    - Slaughter
    - Cutting
    - Fermentation

- Freezing
- Chilling
- Cooking
- Grilling
- Frying
- Sterilization
- Pasteurization
- Drying
- Cold press
- Other

23. What are the main reasons that you chose this product/service?
    - Profitable
    - Subsidized
    - Popular/high demand
    - Easy to process
    - Long shelf life
    - Good for health/nutrition
    - Other

24. What is (are) the alternative/substitute product(s) in the market?

    Note: General definition of "alternative/substitute" would be "similar food products that consumers would choose from", but it can be defined by the producer (e.g., if the producer wants to compare with "other <u>healthy</u> products", that should be noted).

25. Do you consider your food product of higher nutritional quality than the alternatives in the market? If a service, do you consider that your service adds or preserves nutritional value to the food product?

26. If so, how?

27. In your view, what types of nutritional issues does your product(s) contribute to? [suppliers' perception]

    - Micronutrient deficiencies (e.g., vitamin A deficiency, iron deficiency/anemia, zinc deficiency)
    - Protein deficiency
    - Energy deficiency
    - Healthy growth of children
    - Better pregnancy outcome (healthier/stronger baby)
    - Prevention of overweight/obesity (e.g., reduced sugar/fat)
    - Prevention of chronic diseases (e.g., reduced salt/trans fats)
    - I don't know
    - Other

28. What nutritional benefits would your consumers expect from your product? [producers' perception]

    - Micronutrient deficiencies (e.g., vitamin A deficiency, iron deficiency/anemia, zinc deficiency)
    - Protein deficiency
    - Energy deficiency
    - Healthy growth of children
    - Better pregnancy outcome (healthier/stronger baby)
    - Prevention of overweight/obesity (e.g., reduced sugar/fat)
    - Prevention of chronic diseases (e.g., reduced salt/trans fats)
    - I don't know
    - Other

29. What are the other products that your consumers demand for their better health/nutrition? [consumers' demand]

30. What is (are) the product processing/transformation techniques you use for your product(s) that enhance the nutritional values/health impacts for your consumers?

    - Not using any particular techniques
    - Food fortification [→for which food product/with what nutrients?]
    - Increasing nutrient variety (e.g., by adding more nutrient-dense products) [→what products are added?]
    - Use of biofortified crops as input [→which biofortified crops?]
    - Reducing nutrient loss through improved transformation [→how?]
    - Processing to reduce antinutrient functions (e.g., soaking of legumes to reduce phytates) [→what product and how?]
    - Aflatoxin control
    - Improved storage (e.g., packaging materials, storage environment, etc.) [→How?]
    - Other

31. What are the reasons for not using any nutrition enhancing processing/transformation?
    - Already nutritious
    - High cost (cannot make business)
    - No demand
    - Logistically difficult (e.g., capacity not enough)
    - Techniques/technology/ingredients not available in the locality
    - I don't have information about such techniques

32. Are you using more or less food inputs per kg or unit produced as a result of the adoption of the nutrition-enhancing technology/practice?
    - More
    - Less
    - I don't know

33. Why? How?

34. Has the amount of food losses changed in the past 2 years or since the adoption of the nutrition-enhancing product choice and/or technology/practice?
    - No change
    - Significantly increased
    - Increased somewhat
    - Significantly decreased
    - Decreased somewhat

35. Where do you buy your food inputs?
    - Delivered at company
    - Purchase in the field, markets
    - Other

36. Do you experience losses during transport of inputs towards your entity (coop, MSME, etc.)?

37. What percentage of food inputs is lost during transport?

38. Do you transport your product outside for sale? (in addition, or not of sales at your site)

39. What percentage of your product do you transport for sale?

40. What is the business viability of the product/service?
    - Positive
    - Negative

41. (If positive) Why do you think the business viability is positive?
    - There is already a general demand for it
    - There is a law to prohibit other alternatives/substitutes
    - No price change because of low or no-cost techniques
    - No price change because of subsidies
    - Other

42. (If negative) Why do you think the business viability is negative?
    - Low demand—consumers don't know the benefit
    - Low demand—higher price than other alternatives/substitutes
    - Small market (only specific consumers buy)
    - Other

43. What other processing/transformation techniques do you think you could adopt to contribute to nutrition and make it a viable business at the same time?

44. Has your amount of net revenues changed because of the adoption of the nutrition-enhancing product choice and/or technology/practice?
    - No change
    - Significantly increased
    - Increased somewhat

- Significantly decreased
- Decreased somewhat

45. What constraints do you face to increase your net revenues?

46. Is the market for your food product/service large (for example, almost every household consumes it) or niche?

47. Overall, is the market for your food product/service growing, stable or shrinking?

48. Is there anyone producing or selling your same food product/service?

49. How many sale points are there in your village/city approximately?

50. Does the production process of your product require more energy than traditional processing of the same food inputs?

51. What percentage of your product requires more energy than traditional processing of the same food inputs?

52. What energy source do you use?
    - Electricity
    - Gaz (LPG)
    - Wood/charcoal
    - Other

53. Does your production require any fermentation?

54. Does the production process of your product result in increased unprocessed waste?

7.2 The EAT-Lancet Commission Food Groups and Targets

LANCET	g_target	kcal_target
Grains	232	811
Starchy vege	50	39
Vegetables	300	78
Fruits	200	126
Dairy foods	250	153
Red meat	14	30
Poultry	29	62
Eggs	13	19
Fish	28	40
Legumes	75	284
Nuts	50	291
Oils	51.8	450
Sugars	31	120
Insects	5	32

Note: the EAT-Lancet targets have been augmented with the "Insect" category

7.3 Development of Visualization Tools for an Interactive NSmartAg WebPage

Web technology generates the graphics for NSmartAg LANCET graphs and has been used from the very beginnings of the project. SVG technology (vector graphics) dynamically generates pie charts and bar graphs based on CSV tables produced from Stata data analysis. This allows the creation of a webpage displaying the different graphics (such as production and consumption pie charts, and key nutrient bar graphs) needed in the profile.

One of the important steps of the methodology is the establishment of the menu of options from a list of food groups identified through the nutrient-adequacy analysis. The standard approach developed by the team is to conduct field-based agro-enterprise surveys, using these long lists of food groups, to identify specific NSmartAg technologies and practices.

During the course of the development of the current four country profiles (DRC, Guatemala, Haiti, and Mozambique), the webpage was extended with a feature to quantify the relevance of various food products by applying key variables such as, for example, their average price, daily consumption, and "popularity" (defined by frequency of purchase), in addition to their nutrient content. We did not assess additional key variables for the development of the current four country profiles as this feature came to fruition after the field surveys were completed. The feature could, however, possibly serve as an "automated NSmartAg filter" while listing out the potential items for inclusion in the menu of options. It is important to highlight that it was created as a supplementary tool to verify the relevance of the menu of options from different angles, but not to replace the field-based in-depth assessment and identification process for the final menu of options. We present it here as a possible extension to the methodology; if the country profile were to go online, for example, the feature could offer an interactive experience to its users.

Following this idea, different implementation modalities have been explored to assist the generation of lists of food items based on different combinations of filtering variables. Most of them are centered on the concept of an "NSmartAg score" (or "AgSc"): a cost function that compounds weighted maluses and bonuses for each available statistic. The different implementation modes are described in more details in sections 1) – 4):

1) "V1" mode: NSmartAg score based on the logarithmic cost function of products
2) "Dynamic food product" mode: NSmartAg score based on customizable cost functions
3) "Dynamic food group" mode: Generation of region-dependent lists of food groups of interest as well as possible product candidates
4) "Plot" mode: NSmartAg filtering based on the range selection for the different distributions of the available statistics

Note: the "Red meat", "Processed foods" and "Prepared foods" categories will always systematically be excluded from the results (as explained under Section 2.2.2).

NSmartAg filtering — "V1" mode

The original implementation mode was created to easily filter out the products that did not seem fit for the menu of options. To achieve this, extraneous statistics are made available by the system, for each product:

- product's nutrient content for all nutrients of interest per 100 g (*Nc*)
- product's cost per gram (*P* for price)
- product's energy content per 100 g (*Es* for energy score)
- product's consumed/produced grams per nutri-capita (*G_d_nc*)
- product's popularity/frequency of purchase (*F*)
- product's price per nutrient content (*Np* = P/Ns)

Before computing the cost function, those variables' distributions are "standardized" by using the following formula:

$$X^{std} = (X — AVG(X))/(3 . sigma(X))$$

This is slightly different than a normal standardization as the distribution is more compressed to ensure most of it is contained between [-1, +1]. Further cropping is performed to ensure that the values are not equal to -1 or +1.

The original cost function is then calculated as follows:

Nsmartag_score = 2.0 * log(1.0 + Nc)

- 0.5 * log(1.0 + P)//malus for price

- 0.2 * log(1.0 + Es)//malus for energy (moderate)

+ 1.0 * log(1.0 - 0.8 * abs(G_d_pnc))//centered grams

+ 0.1 * log(1.0 + F)//only for consumption

The (empirical) formula above is based on the following logic:

- We tend to favor products with high nutrient content (on a nutrient-per-nutrient basis)
- We tend to disfavor products with higher price per grams
- We tend to disfavor products with excessive energy content (for consideration of obesity issues)
- We tend to favor products that are in the center of the consumed/produced quantity distribution (rather than at the extremes: this is to account for acceptability as well as avoiding over production/consumption)
- We also favor products that are already popular as their acceptability is higher (only for consumption)

Once the filter is applied, it will choose the products whose scores exceed a certain threshold. Currently a threshold of zero is used.

NSmartAg filtering — "dynamic food product" mode

Building on the original "V1" mode that applies filtering on food product lists, a more customizable function was developed, revolving around two features:

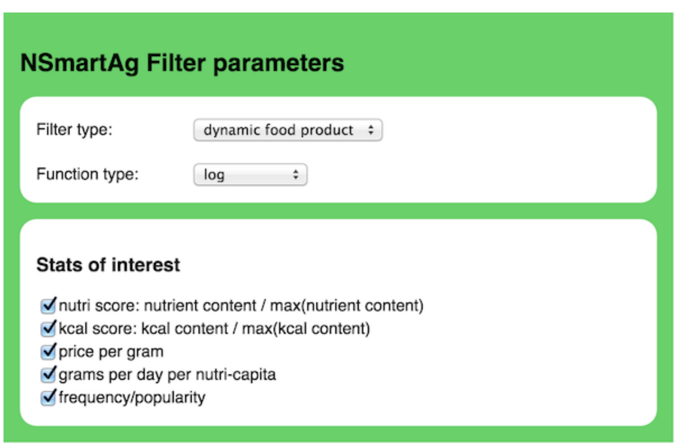
1) Ability to remove/add the contribution of any statistics in the formula
2) Ability to change the core functions to: logarithmic, linear and polynomial

The logarithmic functions remained: log(1 + x) and log(1 – 0.8 * abs(x))

The linear functions are: x and –abs(x)

The polynomial functions are: x^3 and $–x^2$

The filter is customizable through the following interface:



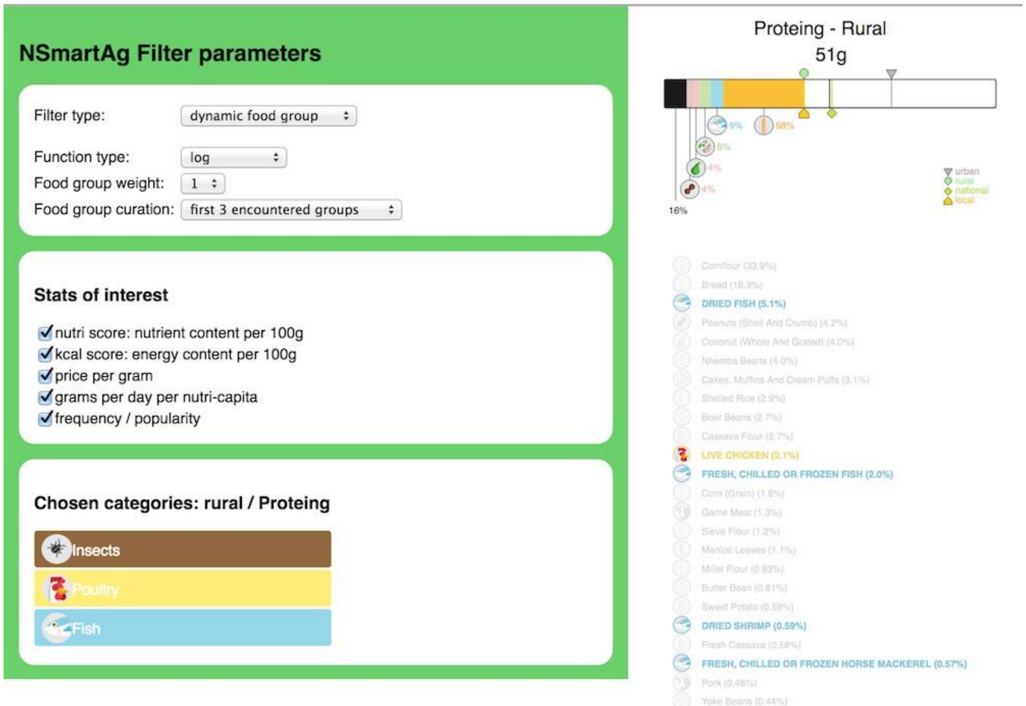
NSmartAg filtering — “dynamic food group” mode

While the previous two modes directly filter a list of food products, this third mode takes into account the relevance of each food group by establishing a “food group” score as an additional variable. This mode also allows users to opt in and out any of the variables made available in the filtering. More detailed steps are described below:

- Computing a food group score for each “food group” (per region) by quantifying the distance of the consumption level from the planetary health diet boundary in the consumption pie charts and then adjusting the score by cross-checking the production pie charts;
- Computing a NSmartAg score for each “food product”, by selecting a combination of variables of interest and adjusting the weight for the corresponding food group score as an extra variable (with a set “importance weight”);
- Sorting all products by the computed NSmartAg score (per region and per nutrient) and identifying a certain number of food groups that the high-score food products belong to.

The major utility of this mode is to help identify food groups that could be promoted for increased production and consumption, following the methodology established to develop the pie charts outlined in Section 2.3 (i.e., food groups that have not reached 100% of the EAT-Lancet Commission’s recommended planetary health diet boundaries). As the previous two modes apply the filtering function directly on food products, it is possible to select food products for increased production and consumption (that would have previously remained unselected) within the food groups that have already reached 100% of the EAT-Lancet Commission’s recommended planetary health diet boundaries.

The picture below illustrates the “dynamic food group” filter in action:



NSmartAg filtering — "plot" mode

Finally, another tool was developed in order to explore the menu of options according to the distribution of the extraneous statistics. This mode of operation does not rely on any cost function and is entirely manual.

This tool displays the standardized distributions of the different statistics (nutrient content, price, etc.) and allows the user to filter the products by defining a range for each of them. A visual example of this tool is provided below:

Webpage

The aforementioned webpage is available at the address below. It showcases the dynamic capabilities of the NSmartAg filter tool, and allows miscellaneous configuration on the graphics.

http://nsmartag.world

This remains an early mockup that relies on recent web technology developments. As such, we recommend using of the latest version of the Chrome browser, to ensure the page works properly.

7.4 Survey Questions with a Gender Focus for Country Profiles

Questions attempt to apply a gender lens on issues of decision-making, market participation, and access to market information.

1. Who decides what food is sold in the market?
    - You (male/female)
    - Someone else (male/female)
    - You AND someone else
    - Do not know
    - Other

2. Who controls the sale revenue?
    - Male
    - Female

3. Who has main responsibility for managing day-to-day business operations?
    - Male
    - Female

4. If female, are you in charge of selling higher value-inputs (like fufu instead of cassava) at the business/market? (regardless if you processed them)
    - Yes
    - No
    - If yes, how long does it take you

5. If female, what was the average number of hours per week that you spent managing or working in this agribusiness in the (last week/month/etc.)?

6. If female, do you have access to financing opportunities?
    - Yes
    - No

7. Do you have access to transportation?
    - Yes/No

What type of transportation?
- Private bicycle
- Private motorcycle
- Bicycle taxi
- Motorcycle taxi
- Bus to nearby community
- Bus to common agricultural market
- Bus to large city
- Truck (that can carry harvest or livestock) to nearby community
- Truck to common agricultural market

- Truck to large city
- Other

8. Do you have access to business-related groups or networks:
- Yes/No

What type?
- Cooperatives,
- Producers associations
- Savings Groups
- Professional networks
- Information networks
- Other

9. Do you have access to technical tools to use in your agribusiness?
- Yes/ No

What type?
- Computers
- Cash registers
- Digital scales
- Other

10. Can both men and women use communication channels/resources?
- Yes/No

What type?
- Telephone landline
- Cell phone and network signal
- Place to charge phone in community (including for payment)
- Place to purchase cell phone credit
- Other

11. In your opinion/ experience, are there business performance differences between male and female agro-entrepreneurs?

-Yes
-No
-I do not know
-If yes, what are these differences, and what contributes to them?

Additional resources are available here:

The Living Standards Measurement Study - Integrated Surveys on Agriculture (LSMS-ISA) and Gender Innovation Lab (GIL). Available at: http://surveys.worldbank.org/lsms/programs/integrated-surveys-agriculture-ISA

Shortening Supply Chains: Experimental Evidence from Fruit and Vegetable Vendors in Bogota 2016–2018. Available at: https://microdata.worldbank.org/index.php/catalog/3616/related-materials

IFPRI Women Empowerment in Agriculture Index (WEAI) Tool Center. Available at: http://weai.ifpri.info/weai-resource-center/guides-and-instruments/

Gender, Agriculture, and Assets Project (GAAP2) Qualitative Research Protocols. Available at: http://weai.ifpri.info/files/2018/04/GAAP2-Qualitative-Protocols-no-comments-.pdf

8 References

1. Bailey, RL., Keith P., West Jr., Black, R. E. 2015. "The Epidemiology of Global Micronutrient Deficiencies." Ann Nutr Metab; 66 (supply 2):22–33.

2. To note, DRC only had recent nationally representative prevalence data on anemia, which is presumably caused in large part by iron deficiency and therefore often linked with programmatic interventions to increase iron intake. Data on deficiencies of the other key micronutrients are very limited (e.g., there is vitamin A deficiency prevalence data from 1999 which showed very high rates) or non-existent.

3. Schönfeldt, H., and Gibson Hall, N. "Dietary protein quality and malnutrition in Africa." 2012. British Journal of Nutrition. 2012; 108 (S2); S69-S76.

4. In DRC, the Household Consumption and Expenditure Survey (HCES) 2012–2013, called the 1-2-3 Survey, was used.

5. This refers to the EAT-Lancet Commission on Food, Planet, Health adapted summary report of the Commission Food in the Anthropocene: the EAT-Lancet Commission on Healthy Diets From Sustainable Food Systems. 2019. Available at: https://eatforum.org/eat-lancet-commission/

6. This has been seen to a limited extent in DRC on such food items as "pondu", cooked cassava leaves, which is among the most commonly consumed dishes that people are starting to buy in a prepared form in markets, especially in big cities (personal communication with Mr. Matthieu Koy Matili, F.A.O. Kinshasa, August 2019). Due to lack of data on the consumption of "prepared pondu", our analysis had to record it as raw cassava leaves. More careful analysis may be necessary in the future when the relevant information is available.

7. Suggestion was reinforced through personal communication with FAO, September—October 2019.

8 . Personal communication with Mr. Matthieu Koy Matili, Kinshasa, FAO, and Mr. John Ulimwengu, IFPRI.

Nutrition Smart Agriculture

Contributing to income and nutrition through agriculture

Financial support for this work was provided by the Government of Japan through the Japan Trust Fund for Scaling Up Nutrition

Nutrition Smart Agriculture Contact:

Aira Htenas

ahtenas@worldbank.org