Spatial typology for targeted food and nutrition security interventions

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ABSTRACT

In this paper we develop a typology to help design and improve spatial targeting of food and nutrition security (FNS) interventions. Using a comprehensive framework, the proposed approach allows for the broad identification and location of major food security bottlenecks. The resulting typology is based on an amendable demarcation of areas in a four-indicator diagram representing the four core dimensions of FNS. The proposed typology is applied to the rural territories of the Democratic Republic of the Congo (DRC). Despite a continuum of heterogenous development challenges across the country, the typology helps identify clusters of territories that suffer from production, access, and utilization constraints. For the nine territories (out of 145) with the highest child stunting levels, we identify four broad intervention zones and analyze their efficiency profile in more detail. Despite its reductionist nature, our typology is conceptually sound, operationally flexible, and less data intensive, important features to promote evidence-based policymaking in contexts characterized by imperfect and scarce data.

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1. Introduction

As stated by Runge et al. (2003) and Timmer (2015), ending hunger and malnutrition is a complex process because it requires sustained policy discipline and the right mix of public resources over an extended period of time. This complexity is manifest in the definition of food and nutrition security (FNS), which points to a diverse set of requirements in terms of food access, its characteristics, and surrounding health conditions (CFS, 2012). In many developing countries, this process is further encumbered by a lack of reliable, regularly produced, and spatially disaggregated data (Carletto, Jolliffe, & Banerjee, 2015; Carletto, Zezza, & Banerjee, 2013; de Haen, Klasen, & Qaim, 2011; Hyman, Larrea, & Farrow, 2005). As a result, scholars and policymakers are often left to rely on household data, which, depending on the survey methodology, allow for the calculation of different metrics to assess the levels, profiles, and trends of FNS. This methodological diversity stems from the gradual refinement of underlying concepts and the associated involvement, over the years, of various disciplines, each with its own merits and limitations (Carletto et al., 2013; Coates, 2013; de Haen et al., 2011; Jones, Ngure, Pelto, & Young, 2013; Pistrup-Andersen, 2009). On the downside, this proliferation of tools and concepts causes confusion, or at least prevents straightforward use or comparison of different indicators. On the upside, when the content and interrelation of different metrics are well understood, the diversity of approaches may turn into an asset, because it allows for the identification of critical constraints to FNS as well as the broad formulation of corresponding policies and programs (Coates, 2013; Pangaribowo, Gerber, & Torero, 2013).

In this paper, we develop and apply a comprehensive typology for the design and implementation of spatially targeted FNS interventions. Such targeting represents a good compromise between the needs for accuracy (that is, minimizing errors of inclusion and exclusion) and feasibility of proposed policy interventions. For developing countries, empirical evidence suggests that geographic targeting is indeed a cost-effective alternative to other methods, such as targeting based on household characteristics (Bigman & Fofack, 2000). Evidently, household targeting outforms all other methods in terms of accuracy; however, its financial and nonfinancial costs are often very high (Bigman & Fofack, 2000; Houssou & Zeller, 2011; Sen, 1995). In addition, the literature on equality of opportunity (Ramos & Van de Gaer, 2012) typically identifies location attributes as “circumstance variables,” which generally lie beyond the immediate control of an individual household and therefore should be eligible targeting criteria. On the other hand, to address the issue of reduced accuracy, geographic targeting should always be complemented or further
refined using additional (household or community) data (Bigman & Fofack, 2000; Elbers, Fuji, Lanjouw, Özler, & Yin, 2007). The typology presented in this paper should be interpreted as a first general indication of where and what type of public investment is most needed – after which, conditional upon available data, a more refined targeting scheme should be elaborated by better delineating the content of the intervention as well as the intended beneficiaries.

The main characteristics of the proposed typology include its comprehensive nature, in the sense that it incorporates the full pathway from agricultural potential to nutritional outcomes, and its limited data requirements. Regarding comprehensiveness, many conceptual schemes with increasing levels of sophistication have been developed over the years to better capture the multiple and interrelated causal linkages affecting nutritional status. As a result, many scholars explicitly promote a system or holistic approach to study FNS (Erickson, 2008; Gillepsie & van den Bold, 2017; Global Panel on Agriculture and Food Systems for Nutrition, 2016; Jones & Ejeta, 2015; Pinnstrup-Andersen, 2013; Stephens, Jones, & Parsons, 2018; Tendall et al., 2015). In light of this evolution, it is no surprise to see the development of only a few typology applications adopting a more comprehensive approach to identify the drivers and types of interventions needed to address poverty, malnutrition or food insecurity. Indeed, reconciling comprehensiveness and practicability can be challenging and inevitably requires a number of compromises. In our case, the most important one entails the selective focus on the sequential or hierarchical (Barrett, 2010) nature underneath the food system chain, as opposed to other, more transversal determinants to improved FNS (such as stability, quality of care, and health conditions). As a result, the proposed typology primarily identifies and locates food security bottlenecks while being more silent on other types of determinants. Despite this limitation, the typology provides insight into the relative importance of these bottlenecks across various subnational locations within a country. Other analytical frameworks, such as impact evaluation studies (Cumming & Cairncross, 2016; Masset, Haddad, Cornelius, & Isaza-Castro, 2012; Ruel, Quisumbing, & Balagamwala, 2018; Sibhatu & Qaim, 2018), can be very rigorous in terms of detecting causal relationships and measuring the precise impact of an intervention on nutritional status, yet they often focus on one hypothesized bottleneck and rely on small samples, which in turn limit their external validity.

In Section 2, we first lay out the conceptual framework in the form of a four-dimensional scatterplot that allows for the identification of broad intervention types and nutrition constraints. After discussing the relative merits of our approach compared to other typologies, we end this section with a brief overview of data sources used to apply the typology to the rural territories of the DRC. In Section 3, we introduce the empirical analysis by first constructing a proxy for each FNS dimension, before applying and mapping the proposed typology. In Section 4, we discuss the typology results by focusing on four possible intervention zones. Concluding remarks are presented in Section 5.

2. Materials and methods

2.1. Conceptual framework

Since the World Food Summit in 1996, food security has been defined as a situation “when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life” (FAO, 1996). This definition embraces the four dimensions, or pillars, typically identified in the food security literature: availability, access, utilization, and stability. Whereas the first three imply a chronological sequence, stability is a cross-cutting dimension and refers to the absence of shocks along the food system from production to consumption. For the purpose of our typology, we adapt this basic framework in two important ways, as shown in Fig. 1.

The first adaptation entails the explicit distinction between status indicators and constraining factors. Whereas the status indicators aim to provide a statistic summary of the sequential dimensions of food security, the constraints offer a set of conditional and less chronological factors affecting the transition from one dimension to the next. For instance, the total food acquired by a household as proxied by one of the many food access indicators not only depends on the amount of food previously being produced, but also on whether the latter reaches the household’s market at an affordable price. This in turn is conditional upon numerous factors, summarized as access constraints. Yet some of them, despite their typical association with this dimension, may be equally at play elsewhere in the conceptual scheme. In addition, each type of constraining factors can be split into structural and stochastic components. The former reflects the more permanent conditions characterizing a geographic and socioeconomic landscape; the latter refers to any steep and sudden deviation from the permanent state, resulting from climate variability, conflict, epidemics, or any other shock. Given the difficulty of finding a suitable indicator to summarize the transversal nature of stability, which naturally aligns with the stochastic component, this dimension of the food security framework is left out in the proposed typology.

The second adaptation concerns extension at both ends of the causal chain: upstream, by including an additional dimension on agricultural potential; and downstream, by considering nutritional outcomes to be an integral part of the utilization dimension. Regarding the latter, food is only satisfactorily utilized if quality of care, food safety, and health infrastructure are good enough to assure its absorption by individuals. To include these nonfood constraints in the broader framework and to reemphasize the ultimate goal of nutrition, the common definition of food security was correspondingly extended and labelled as food and nutrition security (Benson, 2004; CFS, 2012; Pangaribowo et al., 2013). While doing so, the complicated nature of the utilization dimension was also somewhat reduced. Indeed, it required “mental gymnastics” (Coates, 2013:191) to think of this dimension from a pure food security perspective without equally considering the outcome in terms of nutrition. Further, by adding agricultural potential as an extra dimension to the overall framework (see also Yu et al. (2010)), any food production outcome can be qualified as the result of varying combinations of adverse biophysical characteristics and production constraints. More generally, the black wavy line in Fig. 1 captures the chronological sequence as well as different sets of constraints affecting the conversion at each step from agricultural potential to nutritional outcomes.

2.2. Typology of intervention types and nutrition constraints

Having distinguished between key indicators and constraining factors along each of the four sequential FNS dimensions, we can now easily reproduce the conceptual framework of Fig. 1 using a combined scatter diagram. This diagram (Fig. 2) comprises the same information but also displays the magnitude of each type

1 Torero (2014) and Yu et al. (2010) are among the most cited.
2 Whereas sequential or hierarchical determinants have only a direct impact at particular stages within the food system chain (and thus only affect subsequent stages indirectly), transversal factors may exert a direct influence throughout the food system chain.
3 For a comprehensive overview of various FNS concepts, definitions, frameworks and indicators, see Pangaribowo et al. (2013).
of constraint for a hypothetical case, which can be a region, territory, or any other spatial unit. Starting from the axis measuring agricultural potential, this diagram should be read clockwise. More specifically, let’s assume a region with an agricultural potential and production represented by point P. Compared to the 45-degree line of no constraints, such a region suffers from production constraints. Indeed, if farmers in this region could fully tap into the biophysical potential of their region, they would produce P*. As a result, the difference P*-P could be considered a proxy for the magnitude of production constraints (PC) faced by farmers in that region. In a similar vein, the level of access and utilization constraints can be graphically visualized, when moving from food production to nutritional outcomes.
production, through food acquisition, to nutrition. Whereas the difference A’-A gives an idea of the magnitude of access constraints (AC) faced by households, U’-U represents the same deficiency in terms of utilization constraints (UC) experienced by individuals. The northwest (NW) panel in Fig. 2 provides a summary of all three types of constraints. When moving anti-clockwise from a measure of agricultural potential to an indicator of nutritional status, the population in our hypothetical region is clearly suffering most from access constraints, followed by production and, to a much lesser extent, utilization constraints.

As exemplified by Fig. 2, it is important to highlight that only four key indicators are needed to capture the relative importance of different nutrition constraints. This approach is further developed by considering the following practical changes to the generic four-dimensional diagram.

First, instead of working with theoretical and unrealistic “lines of no constraints,” which in fact represent the technological optima along each of the dimensions, it is more feasible and practical to estimate lines of average efficiency. Indeed, using data for each of the four dimensions, one can estimate the average performance in terms of agricultural production, food access, and food utilization for a larger geographical unit (such as a country). Not only does this change have a direct operational convenience, it might also generate more relevant policy recommendations, in that underperformance of a region with respect to its national average will be more telling than underperformance with respect to some unreachable technological ideal. An important implication of this adjustment is the shift from absolute to relative benchmarking. Second, given the wide variation in performance around the average, it might be useful to delineate additional graphical areas, each of them indicating various levels of efficiency. Third, to optimize the use of limited resources, one should also be able to distinguish high- from low-priority regions, while indicating the most optimal type of intervention. Whereas nutritional status will be used to set priority levels, we rely on the measure of potential to identify regions where agricultural development programs would be most rewarding. In the opposite case, and depending on the level of priority, other types of interventions might be suitable, like direct food assistance, cash transfers, nutrition campaigns, or nonagricultural development programs.

These changes are incorporated in Fig. 3 with the following specifications. First, the lines of average efficiency are based on simple ordinary least squares (OLS) regressions with intercepts through the origin. As such, and unlike in Fig. 2, we have observations on both sides of the estimated lines. Second, for each type of constraint we define three levels of efficiency (low-medium–high), depending on whether a region’s performance falls below, between, or above 75% and 125% of the country’s average estimated efficiency level. As a result, each region can be characterized by a specific set of efficiency based on the magnitude of production (P0-P1-P2), access (A0-A1-A2), and utilization (U0-U1-U2) constraints. And third, we set an upper- and lower-bound poverty line for nutrition to identify low-, medium-, and high-priority regions. The level of agricultural potential that corresponds to 125% of the average efficiency between potential and nutrition is used to differentiate regions with more and less agricultural opportunities. This means that regions with an agricultural potential below this threshold will not reach a nutritional status above the higher-bound poverty line, unless they perform better than 125% of what is, on average, observed in the country. Based on these benchmarks, and largely in line with Torero (2014), seven generic intervention types can be identified by crossing the three priority levels – High-Priority region (HPr), Medium-Priority region (MPr), and Low-Priority region (LPr) – with the two levels of agricultural potential, either higher (Ag) or lower (nAg). Within the category of “low-priority region with higher agricultural potential (LPr-Ag),” one can further classify regions as “High Performance (HiPerf)” when their overall efficiency level is higher than 125% of the country’s average.

Combining all information, this four-dimensional scatterplot depicts two sorts of classification: the northwest (NW) panel indicates the level of urgency and whether a focus on the agriculture sector is warranted; the second classification, based on the northeast (NE), southeast (SE), and southwest (SW) panels, roughly details where along the pathway from agricultural potential to nutritional status the biggest gains can be realized in terms of reducing production, access, or utilization constraints. For example, the population in region R1, labelled as a “high-priority region with higher agricultural potential (HiPr-Ag),” suffers from a combination of production and access constraints, as indicated by the region’s coordinates (P2-A2-U1). Region R2, which falls within the category of “high-priority region with lower agricultural potential (HiPr-nAg),” should also be given immediate attention. Yet as highlighted by its coordinates (P1-A0-U2), not much should be expected from a removal of production constraints (as the region’s agricultural potential is rather low), nor from improving access to food (which is already far better than the country’s average), but from a focus on reducing utilization constraints.

Despite its limitations, the combined typology allows better targeting (both geographically and conceptually) of the main nutrition security challenges and relevant policies needed to address them. Indeed, in the case of region R2, one can largely exclude the prioritization of investments that aim to increase agricultural production or improve market integration, as the main bottleneck for the population in this region is inadequate absorption of the available food. Yet we do not know whether the latter is the result of inadequate health services, misguided care or cooking practices, poor hygienic conditions, or any other related aspect. Therefore, no recommendation can be made in terms of building health centers, organizing training on care or cooking, or improving water and sanitation infrastructure. To address these issues, it is essential not only to analyze more detailed information on these constraining factors, but also to spatially map up and compare them with neighboring regions. Such an approach might help capture spillover effects, realize economies of scale, or create synergies, while providing guidance to any future policy intervention.

2.3. Comparative perspective

The typology outlined in this paper aligns with various aspects of Yu et al. (2010) and Torero (2014), from which much inspiration was drawn. First, both of these studies use a similar sequential pathway analysis from agricultural potential up to nutrition or poverty. Second, they also construct typologies by crossing one or more FNS measures to highlight the diversity of possible interventions. More specifically, Yu et al. (2010) develop a typology for 175 countries by using data on agricultural potential, food production, imports, distribution, and consumption. As such, the focus of their typology corresponds with the NE and SE panels of Fig. 3. Moreover, given the explicit inclusion of two measures covering the access dimension of FNS (food imports and food distribution), the typology can indicate whether countries with inadequate food consumption should boost their food production or instead rely on more secure food imports combined with improved distribution schemes. Relying on a stochastic profit frontier model applied to three countries (Mozambique, Armenia, and Honduras), Torero (2014) links agricultural potential to poverty/nutrition using the concept of profit efficiency, which considers the gap between current and maximum production profits under prevailing prices and...
levels of production factors. Then, by crossing the three measures (potential, poverty, and efficiency), a typology of seven micro-regions emerges, each of which relates to a distinct priority level and whether agricultural opportunities are more or less present. Hence, Torero’s typology can be largely retrieved using the areas identified in the NW panel of Fig. 3.

The value addition of our typology lies in the combination of the most attractive features of both: from Torero (2014), we use a similar identification of intervention types by relying on the concept of efficiency; from Yu et al. (2010), we adopt a more detailed chronological sequence, which captures better the location and relative importance of bottlenecks along the pathway from agricultural potential to nutrition. In this respect, it is worth noting that Torero’s (2014) approach does not explicitly specify how to tap into any agricultural opportunity by reducing either production, access, or utilization constraints through improved infrastructure and institutions. Furthermore, unlike the heavy data requirements imposed by Torero’s (2014) Stochastic Frontier Analysis (SFA), our typology requires the use (or construction) of geographically disaggregated data for only four key indicators, one for each FNS dimension. Of course, when more and better data are available, either the robustness of the typology itself or the nature of production, access, or utilization constraints can be further analyzed.

### 2.4. Data on food and nutrition security in the Democratic Republic of the Congo

Table 1 summarizes the six data sources used for the application of the proposed typology. All sources take on a national perspective, fall within a relatively short and recent time interval, and allow for the calculation of various FNS metrics, each of which

| Dimension                                         | Data characteristics                                                                 |
|---------------------------------------------------|--------------------------------------------------------------------------------------|
| Potential                                         | GFSAD30AFCE 2015/Pixel-based (30 m) (no sample) Cropland extent                     |
| Availability & access                             | Hansen_GFC 2000–2016/Pixel-based (30 m) Deforestation                               |
| Access                                            | 123 Survey 2012/2013/24,454 HH R/U, 26 provinces Food production and consumption   |
| Utilization                                       | CFSVA 2011/2012/24,454 HH R, 145 territories FCS                                    |
| Availability, access & utilization               | DHS 2013/2014/18,171 HH R/U, 26 provinces Anthropometry                             |
|                                                   | CAID 2015–2018/145 territories (rural) Various development domains (local economy, |
|                                                   | agriculture, health, education, infrastructure, energy)                             |

Source: CAID (2015, 2016); Hansen et al. (2013); République démocratique du Congo (2014a, 2014b); WFP (2014); Xiong et al. (2017).

Note: FCS = Food Consumption Score; HH = households; R/U = rural/urban.
fits within one of the conceptual dimensions discussed in Section 2.1. For the construction of our measure on agricultural potential, we rely on two remote sensing data sources, of which the unit of analysis is aggregated to match the administrative level of household data (Hyman et al., 2005). The first source concerns the “Global Continent Cropland Extent (GFSAD30AFCE),” which provides a 30 m-resolution map of cropland for continental Africa in the year 2015, combining pixel- and object-based algorithms with imagery from Sentinel-2 and Landsat-8 sensors (Xiong et al., 2017). The second source is the “Global Forest Change (GFC)” product, developed by Hansen et al. (2013), which provides 30 m-resolution data on global forest cover, gains, and losses between 2000 and 2016.

For the other three FNS dimensions, we make use of household survey data. Unfortunately, no accurate data sources currently exist on the level of food availability in the DRC: since 2007 FAO no longer produces estimates on the prevalence of undernourishment, which are typically based on food balance sheet data (FAO, 2001). Furthermore, two major initiatives recently undertaken to overcome this lack of agricultural production data have not yielded expected outcomes. To resolve this issue, we make use of the most recent Household Consumption and Expenditure Survey (HCES) of 2012/2013, called the 123 Survey, which provides sufficient detail and analytical flexibility to construct a proxy for agricultural production, and thus circumvent the lack of data on food availability. To cover the access dimension, we make use of the latest Comprehensive Food Security and Vulnerability Analysis (CFSVA) survey conducted in 2011/2012. This survey allows for computation of the Food Consumption Score (FCS), a food access indicator capturing both diet quantity and quality based on the frequency of household food group consumption. For utilization we resort to anthropometric data captured by the most recent Demographic and Health Survey (DHS) conducted in 2013/2014.

Except for satellite data, which do not involve sampling, each of the socioeconomic surveys have reached at least 18,000 households, yet with varying levels of subnational representativeness. Given the substantial sample size of the household surveys combined with the level of spatial representativeness comprised in the CFSVA (2011/2012), we apply our typology to the 145 rural territories of the DRC. With respect to the 123 Survey (2012/2013) and the DHS (2013/2014), this certainly involves a violation of standard practice. However, given the erratic sampling frame used by all DHS household surveys to claim representativeness (Marivoet & De Herdt, 2017), limiting the analysis to the provincial level, in our view, will not necessarily be less problematic. Moreover, a territory-level FNS study is more relevant for a country the size of the DRC, while the unit of analysis aligns with the data collected by Cellule d’Analyses des Indicateurs de Développement (CAID), which will be used to further study the findings obtained by the typology. In other words, what might be lost in terms of data accuracy when moving from provinces to territories will be largely compensated by the increased level of spatial precision.

CAID differs from the other data sources as it mainly concerns secondary data on various socioeconomic domains (such as local economy, agriculture, education, health, infrastructure, energy, etc.) for each of the 145 territories in the DRC.8 Trained and equipped with a computer and motorcycle, territorial agents on the ground collect data from key persons and institutions, before data are centralized using a mobile-based data collection platform. In addition to quantitative data, which allow for direct comparison with other territories, this government initiative offers an extensive narrative along several themes to describe the challenges and opportunities of each territory.

3. Results

Based on the data sources identified above, this section first details how a proxy indicator for each FNS dimension is derived. Inevitably, given the problematic nature of some data, we resort to various second-best strategies. After discussing each key indicator, we generate the four-dimensional scatterplot and map the different intervention types and nutrition constraints.

3.1. Construction of key food and nutrition security indicators

To construct an indicator for agricultural potential, we first distinguish between immediately arable and non-arable pixels using cropland extent (GFSAD30AFCE) and deforestation (Hansen_GFC) data. Whereas the first source of data directly identifies land under cultivation in 2015, the second source points to the amount of cleared forests between 2000 and 2015, of which we assume that it has recently been or will soon be used for agriculture (Molinario, Hansen, & Potapov, 2015). To further increase the accuracy of our indicator, we use three additional remote sensing-based products to mask pixels that largely fall within (i) waterbodies and permanent wetland (Pekel, Cottam, Gorelick, & Belward, 2016), (ii) urban areas (Brown de Colstoun et al., 2017), and (iii) protected natural reserve areas (Référentiel Géographique Commun, 2012). Using data on yields obtained in local field stations run by the country’s national agricultural research institute (INERA), potential agricultural production is then estimated by subdividing and cultivating the surface of each immediately arable pixel (900 m²) with crops proportional to their share in the national food consumption (as derived from the 123 Survey of 2012/2013). Because our final indicator is expressed in terms of calories and given that we could retrieve yield estimates for only five calorie-dense food crops (République Démocratique du Congo, 2009), we assume that all immediately arable pixels are under cultivation of cassava, maize, rice, beans, and plantains at a fraction corresponding to their national food budget share. Then, controlling for inedible parts and applying the energy content of each of these crops, as compiled by Stadlmayr et al. (2012), the potential calorie levels were aggregated for each territory and divided by the corresponding population measure, as implicitly assumed under the 2012/2013 123 Survey sampling design. To reduce variation across territories, including positive or negative skewness, the measure for agricultural potential is obtained by taking the 4 th root transformation of daily potential calorie production per person.11

It is worth mentioning that the estimation of agricultural potential as described above suffers from several shortcomings. For example, it does not consider the scientific frontier of agricultural research and technology, multiple harvests (which are feasible for

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6 The most recent attempt concerns the launch of a national agricultural survey, which aimed to reach 100 farmers in each territory of the country in 2016. As a result of the political and humanitarian crisis that unfolded by the end of 2016, not more than 40 out of 145 territories have been successfully covered. The other attempt, which relates to the addition of an agricultural module to the household budget survey conducted in 2012/2013, failed as data were incomplete.

7 To further increase the accuracy of territory-level data, we also exclude all measures based on fewer than 25 observations.

8 See www.caid.cd (accessed on October 13, 2016).

9 With immediately arable land, we aim to construct a conservative and short-term measure for agricultural potential based on land currently or recently used for cultivation, or where trees have been logged to start cultivation (the latter is the assumed reason for logging). As such, our measure of potential will rather reflect a production system of intensification than of extensification.

10 To align the data of both mapping projects timewise, we excluded the amount of deforestation that occurred between 2015 and 2016.

11 Compared to the more common logarithmic transformation, which in our case converted positive into negative skewness, the 4th root transformation provided for normally distributed measures of agricultural potential and production.
Table 2

| Indicator                                      | Variable                                      | Obs. | Min  | Mean  | Max  |
|------------------------------------------------|-----------------------------------------------|------|------|-------|------|
| Excluded territories                          |                                               |      |      |       |      |
| Daily potential                              | 4th root transformation of daily potential    | 441  | 11.2 | 15.44 | 20.4 |
| Daily potential                              | Daily potential kilocalorie production per person | 117  | 100  | 2002.7| 7823.0|
| Food production                              | 4th root transformation of daily potential    | 117  | 5.6  | 9.4   | 16.1 |
| Food acquisition                              | % of people below regional FCS threshold      | 130  | 70.6 | 100.0 | 98.3 |
| Nutritional outcomes                         | % of stunted children (<5 years, below -2 standard deviations of the median height-for-age of the reference population) | 100  | 70.6 | 100   | 98.3 |
|                                                   | % of stunted children (<5 years, above +2 standard deviations of the median height-for-age of the reference population) | 100  | 70.6 | 100   | 98.3 |

Source: Hansen et al. (2013); République Démocratique du Congo (2014a, 2014b); Stadlmayr et al. (2012); WFP (2014); Xiong et al. (2017).

The biggest empirical challenge to applying our typology to the DRC comes from the computation of a reasonable estimate of agricultural production. As no reliable statistic currently exists, we opted for food consumption data, as collected by the latest 123 Survey (2012/2013). Though, given our focus on rural territories together with the inefficient nature of the DRC’s food markets (Marivoet, 2016) and the sizeable share of subsistence farming in the country, the underlying assumption of food production to be equal to food consumption might be less spurious than it seems. To improve our measure of food production, we exclude the following types of consumption: (i) food items of imported or unknown origin, (ii) food items with a reference to “import” in their descriptive label (such as “imported rice”), and (iii) food items of which it is known that the DRC is not a producer of their basic ingredients (like wheat, bread, spaghetti, etc.). Then, by using metric food prices for 66 different price zones, obtained from combining food prices and weights per local selling unit, we convert the total monetary consumption for each food item into its weight equivalent, before subtracting the inedible portion and determining its calorie content using Stadlmayr et al.’s (2012) Food Composition Table. The final steps are the same as those for agricultural potential where we aggregate the calorie content for each rural territory, divide the resulting sum by the implicit population from the 123 Survey’s sampling frame, and apply the 4th root transformation to the daily calorie estimates per inhabitant.

Conceptually, we agree that the derived estimate of food production does not account for food produced to serve a foreign market or wasted during and after harvest, processing, or transport; nor does it account for food locally traded across territories. Moreover, this measure of food production covers only 117 territories using the same incomplete population estimates. Contrasting with its potential as presented in Table 2, the DRC’s agricultural production is rather insignificant; indeed, on average, the rural sector only produces around 2000 kcal per person per day, whereas others can provide more than 60,000 kcal per inhabitant on a daily basis. With an average of more than 15,000 kcal, the rural sector of the DRC could easily feed its own population and its urban counterpart. This is further underscored given the conservative choices we took to construct our measure of potential.

Unfortunately, we did not have population statistics in 28 territories, as derived from the 123 Survey. Thus, despite having comprehensive remote sensing information across the DRC, only 117 territories out of 145 have a measure of agricultural potential. As summarized in Table 2, considerable variation arises in agricultural potential. Given the immediately available arable land, some territories are not able to produce more than 1000 kcal per person per day, whereas others can provide more than 60,000 kcal per inhabitant on a daily basis. With an average of more than 15,000 kcal, the rural sector of the DRC could easily feed its own population and its urban counterpart. This is further underscored given the conservative choices we took to construct our measure of potential.
by Marivoet et al. (2017), this indicator captures reasonably well variations in diet quantity and quality across regions in the DRC. However, the same study highlights the importance of setting spatially different nutritional cutoffs to distinguish food secure households from insecure ones, as compared to the generic WFP cutoff. Therefore, our measure of food acquisition is defined as the prevalence of households with an FCS above their respective nutrient-consistent regional threshold for each of the rural territories.12 As reported in Table 2, wide variation in food access exists across the 130 territories covered by the CFSPA (2011/2012), from almost no one within a territory reaching the nutritional threshold to all people reaching it. On average, more than 60% of the rural population has access to a sufficiently diversified set of food items as embodied by the FCS.

For nutritional status, we use available child anthropometric indicators. Given that wasting is highly sensitive to short-term effects (like diarrhea or seasonal food shortages), underweight (weight-for-age) is a combination of wasting (weight-for-height) and stunting (height-for-age), the latter being a more long-term and structural indication of malnourishment. Therefore, we define the proxy of nutrition for each territory as the prevalence of children under the age of five years who are not stunted (that is, having a height-for-age above minus two standard deviations from the median height-for-age of the reference population). Although the DHS (2013/2014) was not intended to be representative at the territorial level, we managed to assign most households to their territory by means of GPS coordinates; 100 out 145 territories were covered. More than one-half of the children in rural areas are, on average, not stunted (see Table 2). In some territories, the situation is markedly better, with more than 75% of the children not stunted; in others, less than 25% are not suffering from chronic malnutrition, an alarming figure.

3.2. Application and mapping of proposed typology

Having constructed a measure for each required FNS dimension, Fig. 4 plots all key indicators for the rural territories in the DRC. This combined scatterplot fully aligns with Fig. 3. The upper- and lower-bound poverty lines for nutrition are set to 60% and 40%, respectively, the former of which produces a threshold for potential close to 10 to distinguish territories with higher (Ag) and lower (nAg) agricultural potential. It follows that with an agricultural potential of less than 10, any increase in overall nutrition efficiency (that is, a combination of production, access, and utilization efficiency) will not be sufficient to bring the nutritional status of the population above the upper-bound poverty line unless the territory performs better than 125% of the country's average. Based on these various benchmarks, each of the seven types of interventions can be visually delineated. For the other three panels, we use the same cutoffs with respect to the estimated slope as previously set in Fig. 3, thus identifying territories with low (<75%), medium (75–125%), and high (>125%) efficiency levels. The grey color scheme used in Fig. 4 reflects the territory’s performance with respect to these benchmarks and is subsequently used for mapping.

Fig. 4 has four largely uncluttered scatterplots, indicating a continuum rather than a discrete set of realities characterizing the rural areas of the DRC. However, this continuum differs in terms of dispersion across the different types of efficiency; whereas more than two-thirds of all observations fall within the fork of 75–125% for production and nutrition efficiency, the dispersion is clearly more pronounced for the other two types of efficiency, and especially for utilization. When a territory’s efficiency falls outside this range, we generally see an underperformance with respect to production and access, and a more equal distribution on both sides of the fork with respect to utilization and nutrition efficiency.

Based on the schematic demarcation of areas along each pair of indicators, Fig. 5 presents four country maps with colors assigned to rural territories according to their intervention type and level of production, access, and utilization efficiency. For this analysis we decided to maintain all rural territories with a known intervention type (that is, having nonmissing data on both measures of potential and nutrition), even if complete information on the other pairs of indicators is lacking. Therefore, in some cases, we might know the intervention priority without being able to trace down the precise bottlenecks – we qualify the former piece of information more important than the latter.

First, with respect to the seven intervention types, there is a highly scattered landscape of different realities. To improve nutritional outcomes, highest priority should be given to nine distinct territories, of which two are not endowed with much agricultural potential in the short run, whereas the other seven territories (indicated by a green belt around their surface) are highly dispersed across the country. Equally, territories of medium priority can be found in various corners of the country, with some apparent clustering of territories with lower agricultural potential in the south of Kwilu and Kwango (located in the southwestern part of the country) as well as in Kivu region in the country's east. The category of medium priority with higher agricultural potential houses the largest number of territories and occupies large shares in the northwest, center, and southeast of the country. Furthermore, the low-priority territories, including the high-performance type, are again very much scattered throughout the DRC. Given this pronounced diversity, generic statements such as “the DRC is a country with unlimited agricultural potential and a vastly undernourished population” are not necessarily true.

Second, the several types of efficiency are also spatially diverse, yet some clustering seems to prevail. With respect to production, the most severe constraints are found in the northwest, center, and southeast of the country, which aligns well with the territories classified as medium and high priority with more agricultural opportunities. Moreover, based on a recent mapping exercise conducted by Marivoet et al. (2018), agricultural extension is at least one concrete production constraint that affects these regions. Regarding access, constraints are highest and somewhat clustered in the provinces of former Equateur and Kwango (located in the north- and southwest, respectively), as well as in Kasai-Central situated in the belly of the country. Relying again on Marivoet et al. (2018), these constraints often refer to the quality of road infrastructure, as roughly the same territories lack paved roads or unpaved roads of medium to good quality. And finally, with respect to utilization, efficiency is again more dispersed, but lowest in various territories in the center, southeast, and northeast of the country. Unlike for the other two types of efficiency, we could not identify any particular utilization constraint that matches well with this spatial pattern.

4. Discussion

Given the vast size of the country, the ubiquity of needs, and the coarse nature of nutrition constraints, a deeper analysis both in

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12 Given the data used for this validation study, the regional thresholds are only estimated for both sectors within each of the 11 former provinces. Therefore, the application of these cutoffs still falls short of giving due attention to variations in food diets across different territories within the former delimitation of 11 provinces. On the other hand, one can easily argue that this approach is at least better than the application of a uniform threshold for the entire country.
terms of spatial targeting and content is needed for any policy or intervention to be efficient. To achieve this, we limit our focus to the nine territories with the lowest nutritional status and group them in distinct intervention zones before studying their efficiency profile in more detail. For the latter, we mainly resort to data and information collected by CAID.

By leaving out the low-priority types of the NW map in Fig. 5, we identify four possible intervention zones (see Fig. 6). These zones emerge by grouping some of the nine high-priority territories, while considering neighboring territories of medium priority and high performance. The inclusion of these territories is valuable to capture spillovers, create synergies, or realize economies of scale.

A first intervention zone (Zone A) can be found in the south-center of the country, which covers the high-priority territories of Mweka, Kazumba, and Kahemba (that is, where more than 60% of the children under the age of five are stunted). Using our typology, the underperformance of Mweka seems to be the combined result of low production and low utilization efficiency, whereas Kazumba and Kahemba appear to mainly suffer from access constraints. As illustrated in Table 3, these findings are largely confirmed using CAID data, but require additional inspection for Kazumba. In the latter territory, the low access efficiency does not result from poor road infrastructure, but stems from poorly diversified agricultural production. Indeed, with 72% of unpaved roads being of good or medium quality, Kazumba performs relatively well in terms of market integration. On the contrary, CAID agents in Kazumba point to an extensive focus on the production of maize and cassava, and to untapped potential in terms of fish production. Therefore, the recommended policy interventions for Zone A should aim at reviving and diversifying agricultural production in Mweka and Kazumba, respectively, while unlocking local production sites in Kahemba to first serve the nutritional needs of rural families within this territory, before further extending market integration to neighboring regions.

In the country’s southeast, the second intervention zone (Zone B) is characterized by the high-priority territories of Moba, Malemba-Nkulu, and Bukama. In the south, the territory of Lubuli is classified as a high-performance territory. Following our typology, all three high-priority territories suffer from

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Fig. 4. Combined scatterplot with territorial data on the four key food and nutrition security measures, Democratic Republic of the Congo (2011–2015). Source: Hansen et al. (2013); République Démocratique du Congo (2014a, 2014b); Stadlmayr et al. (2012); WFP (2014); Xiong et al. (2017). Notes: LP, MP, and HP respectively stand for low-, medium-, and high-priority regions; Ag and nAg refer to higher and lower agricultural potential; and HPref stands for high-performance regions. PE, AE, UE, and NE, which refer to production, access, utilization, and nutrition efficiency, respectively, are estimated lines based on simple population weighted ordinary least squares (OLS) regressions with intercepts through the origin, respectively having a slope of 1.563, 0.096, 1.111, and 4.906. The E75 and E125 lines are derived from the previous lines, with slopes being 75% and 125% the size of the estimated slopes.
straints, while Moba also has low production efficiency. Again, this is largely supported by CAID data given the generally poor conditions observed in health, water, and sanitation infrastructure as compared to the high-performance territory of Lubudi, which performs much better in this respect (see Table 3). For Moba however, the low production and utilization efficiencies cannot be qualified by CAID data, as there is no mention of production chains being abandoned over time, nor are health and sanitation conditions equally or more alarming in Moba than elsewhere. Relying on other data, the low nutritional status of children in Moba may well stem from a lack of general knowledge about good healthcare practices. Indeed, DHS (2013/2014) highlights that only 3.8% of the population in Tanganyika (which comprises Moba as one of its six territories) provides the right treatment when confronted with diarrhea, by far the lowest percentage in the DRC. Therefore, and given their geographical location, interventions in Zone B should primarily focus on how the current health, water, and sanitation facilities of Lubudi could be replicated or gradually extended to the north (that is, to Bukama and Malemba-Nkulu). Information campaigns on basic healthcare may also help, especially in the territory of Moba.

Another possible intervention zone (Zone C) is found in the east, with Oicha and Lubero displaying very low nutritional outcomes. Along the border to the north, there are medium-priority territories with higher agricultural potential, whereas the southern part of this zone has fewer agriculture-related opportunities. Further south, we can also identify the high-performance territory of Fizi. Between the two territories that require immediate assistance (that is, Oicha and Lubero) and Fizi, we can hardly find any distinguishing factor in Table 3, except for the fact that the latter territory is located farther away from the epicenter of armed violence that plagued that region in recent years. Production efficiency is classified as “medium” for all three territories, with both existing and abandoned production chains. Moreover, the quality of health and sanitation facilities is relatively moderate and similar across the three territories. Conversely, access efficiency is lower in Lubero compared to Fizi, but this is not reflected in the quality of road infrastructure, as the former has more unpaved roads of better quality compared to the latter. As a result, we point to the conflict-prone nature of Oicha and Lubero as the most prominent constraint to nutrition, with Fizi possibly indicating how much lower child stunting would be in the absence of armed conflict.

The final possible intervention zone (Zone D) is located in the northwest of the country around Yakoma, with Bongandanga and Kungu being two proximate high-performance territories. Adjacent to these three areas, we find several territories of medium priority,
which may indirectly benefit from any intervention policy targeting Zone D. Due to missing data on food acquisition for Yakoma, our typology is unfortunately not very informative in giving broad direction on how to best tackle nutrition insecurity in this territory. However, when using CAID data for Yakoma (see Table 3), we observe potential constraints in terms of access (with no paved roads and only 22% of the unpaved roads being of good to medium quality) and utilization (especially related to the poor functioning of school latrines). The better nutritional outcomes reached by Bongandanga and Kungu are mainly the result of the higher efficiency in utilization, because of better school sanitation observed in the former territory and the higher number of health centers per inhabitant in the latter. Compared to the other intervention zones, more analysis is needed to understand the magnitude and nature of challenges facing Zone D.

5. Conclusions

In this paper, we outline a methodology to classify locations according to their intervention type and magnitudes of nutrition constraints. Whereas the first combines information on nutritional status and agricultural potential, nutrition constraints are decomposed into various levels of production, access, and utilization efficiency, each of which emerge from a graphical opposition of four key indicators and an operationally flexible demarcation of areas. Using this comprehensive typology, we distinguish low- from high-priority regions, while indicating which of those have more agricultural opportunities, and what is broadly needed to tap into this potential. Since the typology requires only four indicators and a small number of open-ended operational decisions, the approach is light in terms of data requirements and can be easily replicated in various countries or adapted to other research settings. Additionally, when more information is available, the efficiency profile can be further refined without any structural change to the underlying procedure. The proposed approach fits well with the context of developing countries characterized by underperforming statistical systems.

The typology is applied to the rural territories of the DRC. The choice to focus on the rural sector stems from the most recent CFSVA survey, which provides a straightforward measure of food acquisition. Our findings suggest a continuum of heterogeneous FNS status, spatially scattered across the country. Despite this geographical diversity, our typology helped identify various clusters of territories that suffer mostly from production, access, and utilization constraints. The first set of territories is characterized by a lack of access to agricultural extension services and the second by poor quality of road infrastructure. Focusing on nine territories (out of 145) with the highest child stunting levels, we identified four broad intervention zones and studied the efficiency profile using additional information on the population, infrastructure, and overall economy of each of the targeted territories.

In the broader development framework, the typology presented in this paper provides the first layer of required information to guide the design and implementation of relevant food and nutrition policies. Indeed, to refine policy interventions, more detailed data and analysis are required. Furthermore, the proposed typology mainly focuses on food security bottlenecks, ignoring other, more transversal or less chronological determinants of FNS, such as factors related to health or stability. With respect to health-related determinants, this loss in information could be partly recovered by complementing the typology results with data from secondary sources. Regarding stability as one of the core pillars of food security, its omission can be partly countered by repeating the same typology over different time intervals. This could help
further characterize constraints by their level of stochasticity. Using only one typology round, all constraints are implicitly assumed to be structural.

Apart from these conceptual limitations, the policy relevance of the proposed typology relies much on the quality and completeness of available data to construct the four key FNS indicators. Indeed, despite minimal data requirements, applying the typology to the rural territories of the DRC required a number of second-best strategies. This was particularly true for the measure of food production, which, in the absence of any other viable alternative, was estimated from food consumption data. Overall, the typology’s usefulness in providing actionable insights can only be assessed when applied and confronted with other (typology) approaches or, more

| Intervention zone | Territory | Efficiency¹ | Access | Utilization |
|-------------------|-----------|-------------|--------|-------------|
| Zone A            | Mweka     | Low         | Medium | Low         |
|                   | Kazumba   | Medium      | Low    | Medium      |
|                   | Kahemba   | Medium      | Low    | High        |
|                   | Tshilenge (high performance) | Medium | Medium | Medium |
| Zone B            | Mobu      | Low         | Medium | Low         |
|                   | Malemba-Nkulu | Medium | Medium | Low         |
|                   | Bukama    | Medium      | Medium | Low         |
|                   | Lubudi (high performance) | Medium | Low    | High        |
| Zone C            | Lubero    | Medium      | Low    | Medium      |
|                   | Oicha     | Medium      | .      | .           |
|                   | Fizi (high performance) | medium | medium | medium     |
| Zone D            | Yakoma    | medium      | .      |             |
|                   | Bongandanga (high performance) | medium | low    | high        |
|                   | Kungu (high performance) | low   | medium | high        |

Source: CAID (2015, 2016); Hansen et al. (2013); République Démocratique du Congo (2014a, 2014b); Stadlmayr et al. (2012); WFP (2014); Xiong et al. (2017).

Notes:
1. The efficiency levels are simply reprinted from Fig. 5 with low, medium, and high respectively referring to below 75%, between 75% and 125%, and above 125% of the estimated average efficiency.
2. The additional information is mainly based on CAID data and narratives provided by local development agents (see www.caid.cd for the original data and methodology and http://eatlas.resakss.org/D.R-Congo/en for an extensive mapping of variables). If other data and statistics are used, then sources are explicitly mentioned.
forms of triangulation that we leave for future research. Importantly, with an informed reality check on the ground, two
recognized by SNV (The Netherlands) through its Voice For Change Part-
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Declaration of interest
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