Spatial typology to identify food and nutrition security bottlenecks in Burundi

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Executive summary

To help address the alarming food and nutrition security situation in Burundi, this study contributes to a better identification and understanding of the major bottlenecks and constraints within the country’s food system. To improve spatial targeting of interventions, the adopted typology approach decomposes nutritional outcomes of different provinces as a combination of inefficiencies of different types and degrees. Whereas the inefficiency types refer to the three sequential food security pillars (production, access and utilization), the inefficiency degrees are derived using a relative national benchmarking procedure.

The findings of this study show significant gaps between high agricultural potential (with some provinces such as Muramvya and Mwaro reaching a potential production of more than 8,500 kcal per person/day) and low levels of nutrition outcomes, with especially Karuzi, Ruyigi, Kirundo and Ngozi suffering from chronic child malnutrition. The exact policy and intervention matrix needed to fully tap into the country’s potential while yielding acceptable nutrition outcomes is diverse and location specific.

Whereas almost all provinces perform worse than the country’s average on at least one dimension, four provinces are facing severe constraints on exactly two dimensions: Muramvya and Kirundo regarding production and access, and Muyinga and Kayanza with respect to production and utilization. To some extent, the spatial profiles of production, access and utilization efficiency could be traced back to differences in provincial performance on six underlying indicators, which include: population density, male-to-female ratio, poverty headcount, road density, access to drinking water, and morality rate.

The simulation and optimization results of this study indicate that a geographical focus on the most deprived provinces, as opposed to a country-wide approach, yields the highest returns on investment and therefore represents the most efficient use of public resources. In addition, investing earlier in the food system while pursuing a coordinated and comprehensive approach across sectors often proves to generate the most sustained and synergetic outcomes. The exact dose of additional efficiency needed to bring down child stunting to exactly 5% in each province in the most efficient way is provided in Table 3 of this report.
Résumé analytique

Pour aider à faire face à la situation alarmante de la sécurité alimentaire et nutritionnelle au Burundi, cette étude contribue à une meilleure identification et compréhension des principaux goulots d'étranglement et contraintes au sein du système alimentaire du pays. Pour améliorer le ciblage spatial des interventions, l'approche typologique adoptée décompose les résultats nutritionnels des différentes provinces comme une combinaison d'inefficacités de différents types et degrés. Alors que les types d'inefficacité font référence aux trois piliers séquentiels de la sécurité alimentaire (production, accès et utilisation), les degrés d'inefficacité sont dérivés à l'aide d'une procédure de comparaison nationale relative.

Les résultats de cette étude montrent des écarts importants entre le potentiel agricole élevé (avec certaines provinces comme Muramvy et Mwaro atteignant une production potentielle de plus de 8 500 kcal par personne et par jour) et les faibles niveaux de résultats nutritionnels, avec notamment Karuzi, Ruyigi, Kirundo et Ngozi souffrant de malnutrition chronique des enfants. La matrice exacte des politiques et des interventions nécessaires pour exploiter pleinement le potentiel du pays tout en obtenant des résultats nutritionnels acceptables est diverse et spécifique à chaque endroit.

Tandis que presque toutes les provinces obtiennent des résultats inférieurs à la moyenne du pays sur au moins une dimension, quatre provinces sont confrontées à de sévères contraintes sur exactement deux dimensions : Muramvy et Kirundo en ce qui concerne la production et l'accès, et Muyinga et Kayanza en ce qui concerne la production et l'utilisation. Dans une certaine mesure, les profils spatiaux de l'efficacité de la production, de l'accès et de l'utilisation peuvent être attribués aux différences de performance des provinces sur six indicateurs sous-jacents, à savoir : la densité de population, le ratio hommes/femmes, le taux de pauvreté, la densité routière, l'accès à l'eau potable et le taux de mortalité.

Les résultats de simulation et d'optimisation de cette étude indiquent qu'une concentration géographique sur les provinces les plus démunies, par opposition à une approche à l'échelle du pays, permet d'obtenir les meilleurs retours sur investissement et représente donc l'utilisation la plus efficace des ressources publiques. En outre, investir plus tôt dans le système alimentaire tout en poursuivant une approche coordonnée et globale dans tous les secteurs s'avère souvent générer les résultats les plus durables et synergiques. La dose exacte d'efficacité supplémentaire nécessaire pour ramener le retard de croissance des enfants à exactement 5 % dans chaque province de la manière la plus efficace est indiquée dans le Tableau 3 du présent rapport.
1. Introduction

The food security and nutrition situation in Burundi remains alarming as evidence suggests that the country is experiencing the ninth-worst food security crisis in the world. Indeed, about 80% of households rely on farming to meet their daily food needs while more than 65% of Burundians live below the poverty line and 52% are chronically hungry. With the onset of the COVID-19 outbreak in 2020, the food security and nutrition situation could deteriorate further.

The World Food Programme (WFP) intends to generate research-based evidence on nutrition-sensitive agriculture and related bottlenecks in Burundi to improve targeting of food and nutrition security (FNS) interventions. This evidence will be holistic and follow a food system approach to ensure context specific solutions. A food system encompasses all the elements and activities that relate to the production, processing, distribution, preparation and consumption of food, as well as the output of these activities, including socioeconomic and environmental outcomes (HLPE, 2020).

This report presents the findings of a spatial typology to improve the identification and understanding of the major bottlenecks and constraints impeding FNS in Burundi. After describing the main data sources and methodology adopted for this analysis in the next section, Section 3 will discuss the spatial distribution of various constraints. Subsequently, Section 4 will present and discuss a series of simulations which assess the impact of efficiency changes on various outcome indicators. Section 5 will provide conclusions.
2. Data and methodology

The main objective of the spatial FNS typology is to “explain” nutritional outcomes of different areas as a combination of inefficiencies of different types and degrees. To achieve this objective and based on the sequential food security pillars, the methodology adopted involves (i) the construction of four basic FNS indicators, (ii) the outline and pair-wise assessment of indicators using scatterplots, and (iii) the estimation of corresponding efficiency levels. The basic building blocks of this approach are captured in Figure 1, where panel (a) presents the overall conceptual framework and panel (b) provides the basic intuition behind the estimation of efficiency.¹

To achieve acceptable (based on global or national benchmarks) nutritional outcomes for its population, an area could increase its production of nutritious food, which depends first on the biophysical characteristics of available arable land as well as on the efficiency level by which agricultural potential is converted into food production. While most environmental and climate conditions could be treated as given at a point in time, food production can be improved by addressing various production constraints, ranging from insecure land rights, imperfect credit and insurance systems, and lack of access to quality agricultural inputs and extension services.

Aside from increasing production, nutritional outcomes can also be improved by increasing people’s access to nutritious diets, either homegrown, supplied by neighboring areas, or both. Although access constraints are heterogeneous, physical and economic aspects are two important and interrelated dimensions. If food is not supplied to a certain market, it generally means that the total transaction cost of transporting food from production sites to consumption centers may result in food prices being unaffordable for the final consumers.

Finally, for a nutritious diet to translate into meaningful nutritional outcomes, food should be properly utilized or processed. This involves appropriate cooking habits, equitable intra-household allocations and adequate conditions in terms of drinking water, sanitation and health. As summarized in panel (a) of Figure 1, the nutritional outcomes of an area depend on its initial level of agricultural potential combined with its efficiency in converting (i) agricultural potential into food production (production efficiency); (ii) food production into food access (access efficiency); and (iii) food access into nutritional status (utilization efficiency).

¹ The basic methodological features of the spatial FNS typology are described in detail in Marivoet et al. (2019).
Figure 1. Core building blocks of spatial FNS typology

DIMENSIONS

Potential  Availability  Access  Utilization

INDICATORS

Agricultural potential  Food production  Food access  Nutritional status

CONSTRAINTS

Biophysical constraints  - Soil types  - Temperature  - Precipitation  - Land cover  - Topography
Production constraints  - Land rights  - Credit systems  - Input markets  - Extension services
Access constraints  - Trade  - Urbanization  - Transport  - Transaction costs  - Real income
Utilization constraints  - Cooking habits  - Intra-hh allocation  - Food safety  - Quality of care  - Health services

Stochastic constraints
Climate variability, seasonality, conflict, price fluctuations, epidemics

Stability

Panel (a): Conceptual framework

Panel (b): Efficiency estimation

Source: The authors.
To provide a measure of efficiency at each conversion stage, panel (b) of Figure 1 displays the same information in four quadrants, each being populated with a scatter plot where dots represent different areas/locations in a country and take on the values of two sequential indicators. The lines of average efficiency, which run through the origin of each scatterplot, are estimated using OLS regressions and indicate the mean performances of a country in converting agricultural potential into food production (northeast quadrant); food production into food access (southeast quadrant); and food access into nutritional status (southwest quadrant). The line of average efficiency in the northwest quadrant represents the combined performance of a country in yielding nutritional outcomes based on its agricultural potential.

Using the lines of average performance as benchmarks, we define the efficiency level of each area as the relative distance between the actual observation and what is expected based on the country performance, whereby all relative distances are scaled to one. In mathematical terms, efficiency \( E \) of type \( T \) can be written as

\[
E_T = 1 + \frac{(T-T^*)}{T^*} \tag{1}
\]

where \( T \) equals P for production, A for access and U for utilization.

As such, an efficiency level equal to one means that the area has the same performance as the country average, while efficiencies lower (higher) than one point to worse-(better)-than-average performances. For example, consider the area represented by the points P-A-U-N. For each efficiency type, this area is performing worse than the country’s average as shown by the location of points in the grey triangles. However, its underperformance is highest for access efficiency followed by production and utilization efficiency, which is immediately visible from the length of each arrow and reflected in each efficiency score \( E_T \). This information is also summarized in the northwest quadrant, where the total nutrition constraints (NC) of the area (that is its overall underperformance) are decomposed into production (PC), access (AC) and utilization constraints (UC) of corresponding length. The same reasoning can be applied to all areas represented by the other points in each scatterplot.

To operationalize the present typology, Table 1 provides a short description of all basic steps behind the construction of each indicator. It is worth highlighting here that only four indicators are needed to run this typology, which is a welcome feature in settings characterized by imperfect data and information systems. The operational choices made are mainly driven by accessibility of data, which should cover the same period and level of spatial disaggregation across all dimensions. To be useful for future policy design, it goes without saying that more recent and higher resolution data are to be preferred. In case of competing alternatives to reflect the same dimension, it might be worthwhile to perform correlation analysis on the available options to see if areas rank differently using different indicators.
Table 1. Construction of core indicators

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Indicator</th>
<th>Description</th>
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| Agricultural potential | Balanced potential kilocalorie production per person/day                  | - Arable land using current crop land extent (Xiong et al., 2017) and deforested areas (Hansen et al., 2013) with additional masks for urbanized areas, permanent water bodies, natural reserves and disadvantageous topography.  
- Land allocation in line with diet proposed by EAT-Lancet Commission (Willett et al., 2019)  
- Highest yields as observed per food group across 18 East African countries (FAOSTAT 2017-2019)  
- Food composition table for multiple African countries developed by FAO/INFOODS (Vincent et al., 2020)  
- Population estimates as derived from latest national population census |
| Food production    | Balanced actual kilocalorie production per person/day                     | - Official annual production statistics of crops, fish and farming estimated by the corresponding national ministries  
- Estimation of animal-based food production (meat, milk, eggs) by applying FAOSTAT indirect estimation technique to the spatial distribution of livestock  
- Food composition table for multiple African countries developed by FAO/INFOODS (Vincent et al., 2020)  
- Correction for imbalanced food production based on the diet proposed by EAT-Lancet Commission (Willett et al., 2019)  
- Population estimates as derived from latest national population census |
| Food access        | Prevalence of households with acceptable FCS (%)                         | - Food consumption Score (FCS) based on consumption frequency of food items and assigned weights to 8 food groups.  
- Thresholds for poor, borderline and acceptable food consumption as defined by WFP country office  
- Data from WFP country assessments. |
| Nutritional status | Prevalence of children under five years who are not stunted (%)           | - Chronic malnutrition (stunting) as defined by height-for-age scores below -2 standard deviations from the median height-for-age of the reference population  
- Data from DHS, MICS or similar surveys |

Source: The Authors.

For **agricultural potential**, the final indicator is estimated in two steps. The first step involves the estimation of total arable land by combining current crop land extent (Xiong et al., 2017) and total deforested areas (Hansen et al., 2013), of which the latter is assumed to be suitable for agriculture. The importance of deforestation is underscored by the fact that a large majority of households in Burundi use wood or charcoal as their primary fuel source for cooking (UNICEF, 2021; WFP, s.d.). To assure that arable land pixels do not fall within urbanized areas, permanent water bodies, natural reserves or on slopes steeper than 15 degrees, corresponding masks are used to obtain a final estimate of total arable land for each area (Brown de Colstoun et al., 2017; Farr et al., 2007; Pekel et al., 2016; UNEP-WCMC & IUCN, 2021). The second step allocates total arable land to different food groups in line with the energy proportions reflected in the diet proposed by the EAT-Lancet Commission (Willett et al., 2019). This diet is estimated
to be both nutritious for people and environmentally sustainable, without being too specific in terms of individual food items. The estimated arable land allocation is then converted to potential production using the highest FAOSTAT yields observed across 18 East African countries for each of the food groups identified in the EAT-Lancet diet. Adding all production estimates and relying on the most recent food composition table developed for various African countries (Vincent et al., 2020), agricultural potential is then expressed as the total amount of balanced kilocalories that could be produced per person/day. Here, ‘balanced’ refers to the notion of diversity introduced using the EAT-Lancet diet when assigning arable land to food groups. As such, this measure of agricultural potential includes a dimension of extensification (by including arable land that is not yet cultivated), intensification (by using the highest yields as observed in the region) and diversification (by imposing a nutritious combination of crops). On the other hand, the same measure remains proportionate as opposed to a metric that uses an enlarged concept of arable land or that applies technologies close to the production frontier observed in advanced agricultural settings.

For food production, a similar indicator is constructed, but instead of potential, it estimates the actual production of balanced kilocalories per person/day based on official agricultural statistics obtained from the Ministry of Environment, Agriculture and Livestock (MINEAGRIE, 2020). Compared to previous applications, this indicator is no longer based on crop statistics alone, which typically covers main cereals, tubers and beans. But it also includes data on fish and pisciculture (which is important for communities close to natural water resources) as well as statistics on meat, offal, milk and eggs (which is important for pastoral communities). The latter animal-based food statistics are derived using the indirect FAOSTAT estimation technique applied to area-specific livestock population numbers for cattle, sheep, goat, pig and poultry. Again, the same food composition table (Vincent et al., 2020) is used to convert agricultural output into its corresponding energy content while counting unbalanced kilocalories for only half their value. Unbalanced kilocalories are kilocalories obtained from food groups for which no corresponding energy content is available in the other food groups defined by the EAT-Lancet diet. This procedure assures that areas with substantial monocropping of energy-dense food items are penalized for lack of production diversity. At the same time, it makes the measure of food production directly comparable with the previous measure on potential and consistent with the following on food access.

The indicator chosen for food access is based on the food consumption score (FCS) developed by WFP (2008). The FCS is estimated using a 7-day recall period of food consumption within eight distinct food groups, each with a specific weight reflecting the overall nutrient density. Two thresholds are typically defined to identify households with poor, borderline and acceptable food consumption levels. The final measure used in the typology is the percentage of households with an acceptable FCS, that is a score

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2 Given their different level of aggregation, food groups of the EAT-Lancet diet first needed to be aggregated to match those of the food group specific yields in the FAOSTAT database. In addition, no land is assigned to fish for obvious reasons or to poultry/eggs as the latter are typically kept in the vicinity of the farm. Despite the presence of other animal-based food items (including dairy products) within the EAT-Lancet diet, we were unable to assign land to livestock as precise “yield” factors per hectare are lacking. Given that livestock can also be kept landless, this issue might be less prominent since the unearmarked share of grazeland will now be cultivated with other crops which can be used as animal feed.

3 These higher yields are the combined outcome of improved seeds, better agricultural practice, and a more rational use of soil, water and other natural resources.

4 To obtain estimates of livestock distribution by province, we made use of the national offtake ratio for each main livestock type combined with available provincial estimates on slaughtered animals and egg production. Fish production data on Lake Tanganyika have been proportionally assigned to the four bordering provinces based on their relative population weight in 2018. Crop statistics for all three seasons were combined.
higher than the upper threshold defined by the national WFP country office. The data used are obtained from a national household survey conducted in 2018 (ISTEEBU, 2019). Despite other indicators and more recent data being available to capture the food access dimension, such as the household dietary diversity score (HDDS) obtained from the national survey on nutrition and mortality (ENSNMB 2020) (MSPLS & MFBPE, 2020), we opted for the slightly older FCS data. Lacking spatially disaggregated statistics on agricultural production for 2020, the most recent year for which we have data on all four dimensions is 2018. In addition, Annex 1 shows that the prevalence rates based on FCS and HDDS are highly and significantly correlated, which means that the exact choice of the food access indicator is unlikely to affect the typology results a lot.

For nutritional status, the indicator used is based on chronic malnutrition among children under the age of five years old, which is another well-established measure typically derived from DHS and MICS surveys. More specifically, we will use the percentage of non-stunted children as defined by a height-for-age score above minus two standard deviations from the median height-for-age of the reference population. The fact that all constructed indicators need to be positively scaled (that is higher values point to better conditions) explains our focus on non-stunted children. Again, for reasons of time consistency, the stunting data used are obtained from the same survey conducted in 2018 (ISTEEBU, 2019). To be able to identify the more structural constraints affecting malnutrition in Burundi, we opted for child stunting as opposed to wasting rates – the latter which is more sensitive to short-term stochastic shocks, such as health epidemics and conflict. Apart from our conceptual preference to focus on chronic malnutrition, Annex 1 shows that the 2018 prevalence rates of stunted and wasted children are highly and significantly correlated, again indicating their substitutability.

Compared to the original edition of the typology documented in Marivoet et al. (2019), the present version incorporates various revisions to improve on construct validity (that is the extent by which an indicator accurately reflects its underlying dimension) while addressing some methodological issues related to the estimation of efficiency. Box 1 provides an overview of these changes.

In terms of indicator development, most of the revisions focus on bringing in the notion of food diversity both within the measure of potential and production. As such, going through the four dimensions of FNS, the core indicators will specify to what extent (i) areas are able to produce a sufficiently diversified diet, (ii) areas actually produce a sufficiently diversified diet, (iii) households in various areas have access to a sufficiently diversified diet, and (iv) sufficiently diversified diets result in good nutritional outcomes. These revisions facilitate a more intuitive interpretation of areas characterized by monocropping and low food access scores: unless the food production measure is penalized for its poor diversity, the resulting low efficiencies could be erroneously interpreted as an access constraint whereas it is an issue of poorly diversified food production.

In addition to the conceptual strengthening by accounting for food diversity across dimensions, the transformation of indicators and application of unweighted regressions further help address another issue at play between production and access. It concerns the regression of an unbounded indicator (number of kilocalories) against a bounded one (percentage). By consequence, breadbaskets are almost by nature

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5 In fact, the standard thresholds of 21 (lower) and 35 (upper) are revised upwards in case the consumption of sugar and/or oil products is widespread among the population, which is not considered for Burundi.
6 By assessing the impact of COVID-19 on Burundi’s food system, the second component of this research project will focus more on stochastic shocks.
characterized by low access efficiency, even if most households in such areas have an acceptable food consumption level. In addition to penalizing for unbalanced kilocalorie production, this improved version of the typology relies on inverse power transformations to further reduce right skewness provoked by such breadbaskets. Furthermore, by using unweighted regressions, we avoid that capital cities (which are conceptually the opposite of breadbaskets) exert a disproportionate influence on the line of average efficiency given their high demographic weight, which could again unduly assign a low access efficiency status to areas with high levels of acceptable food consumption. An important implication of relying on unweighted regressions is that each average efficiency line should be understood as the average performance of all areas (not all households), with each area receiving an equal weight.
Box 1. Revisions to the initial typology version (Marivoet et al. 2019)

Improvements on indicator development

- **Arable land**: an additional mask based on SRTM elevation data (Farr et al., 2007) is applied to the model as to remove areas with disadvantageous topography defined as areas with slopes higher than 15 degrees.

- **Agricultural potential**: instead of working with observed diets in each country, the current version of the typology makes use of the EAT-Lancet diet to assign arable land to broad food groups. In addition, the current version no longer relies on yield information coming from in-country agricultural stations but uses the regional best yield performance per food group as reference. Both revisions result in more comparable estimates across countries.

- **Food production**: instead of only considering crop production, the current version of the typology also relies on direct production statistics for fish and pisciculture, and indirect production statistics for meat, offal, milk and eggs. Completely absent from the initial version is the penalization for poorly diversified food production. This series of revisions is important, not only to better align with the measure of agricultural potential upstream and food access downstream, but also to better account for pastoral and fishing communities, where a substantial share of kilocalories is obtained through the consumption of animal-based food items.

- **Food composition table**: the conversion from agricultural output to kilocalories for the two indicators above is performed using on the latest FAO/INFOODS Food Composition Table for Western Africa (2019) (Vincent et al. 2020).

Improvements on efficiency estimation

- **Indicator transformation**: compared to the initial version, all indicators have been transformed to better capture variation as well as to correct for skewness. The same (inverse) power transformation has been applied to the measures of access and nutrition (potential and production), as they were left (right) skewed, with all transformed data being scaled between 0 and 100. As such, having the same initial unit of measurement, both pairs of indicators can still be sensibly compared.

- **Unweighted regression**: to avoid outlier observations with high demographical weight (such as capital cities) exert disproportionate leverage on the location of the regression line and thus on the estimation of efficiency, the current version applies a non-weighted OLS regression through the origin. Of course, all individual data observations still appropriately account for variations in demography and sampling design.

- **Numeric estimation**: compared to a simple categorization into high/medium/low efficiency levels based on a 80-120% fork around the average country performance, the current version of the typology derives numeric scores for each efficiency type using the relative distance between actual and average country performance, with a calibration around 1.
3. Typology results

By way of introducing the typology results, Figure 2 presents two maps which describe the food system paradox in Burundi. The left-hand side map displays balanced potential kilocalorie production per person/day as described in the methodological section above while the right-hand side map shows the spatial distribution of stunting among children below the age of five years old. In general terms, it is fair to say that Burundi is endowed with enough agricultural potential (with some provinces such as Muramvya and Mwaro even reaching a potential production of more than 8,500 kcal per person/day) while most households across the country (except those living in Bujumbura) are still suffering from very high chronic malnutrition rates, especially in Karuzi, Ruyigi, Kirundo and Ngozi.

Figure 2. Food system paradox, Burundi (2018)

Using the various efficiency scores and related information as described above, the overall objective of this typology analysis is precisely to identify and locate the various bottlenecks which prevent a full realization of each area’s agricultural potential while improving final nutritional outcomes of its population. Whereas the food system paradox is captured by the northwestern quadrant of Figure 3, the northeastern, southeastern and southwestern quadrants respectively display the production, access and utilization efficiencies of each province. To bring in the spatial dimension, the efficiency rates of each of these quadrants are subsequently mapped and discussed to better understand the paradoxical nature of nutrition outcomes in Burundi.
Figure 3. Four-dimensional scatterplot, Burundi (2018)

Notes: Low, medium and high efficiency levels are displayed by black, grey and light grey dots, respectively, based on an 80-120% efficiency fork. Exact efficiency scores for each province are provided in Annex 2.
Source: The Authors based on Brown de Colstoun et al. (2017); Farr et al. (2007); Hansen et al. (2013); ISTEEBU (2019); MINEAGRIE (2020); Pekel et al. (2016); UNEP-WCMC & IUCN (2021); Vincent et al. (2020); Xiong et al. (2017).
A first possible explanation behind the poor nutritional outcomes in the country relates to production constraints. Figure 4 maps production efficiency, defined as the extent in which provinces realize a level of agricultural production in line with what could be expected based on their level of agricultural potential. Cibitoke clearly has the lowest production efficiency score of all\(^7\), while three other provinces located in the western part of the country (Kayanza, Muramvya and Mwaro) are equally suffering from more severe production constraints. Although additional research is needed to pinpoint the precise drivers behind the low efficiency scores (which we will illustrate below), the map indicates that these provinces will certainly benefit most from a removal of production constraints. On the contrary, production efficiency is generally higher in the southern part of the country, and especially in Rutana, Gitega, Karuzi and Makamba.

**Figure 4. Production efficiency, Burundi (2018)**

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\(^7\) Bujumbura city has a very low production efficiency too, which in part has a methodological explanation in that most statistics tend to ignore any agricultural output realized in this city.
Figure 5 presents two maps to further investigate the variation in production efficiency. The map on the left-hand size shows population density, which can be considered as a measure of potential land disputes and therefore may relate to an increased reluctance to invest in new production technologies. The second map shows the spatial distribution in male-to-female ratio within the working age population. Due to various episodes of violent conflict and related migration, some areas in the country may have a shortage of manpower to farm the available land, thus resulting in lower production efficiencies.

To some extent, the variation in production efficiency between northern and southern provinces can be traced back to differences in competition over land, as approached by population density, which appears to be generally lower in southern part of the country. In a similar vein, Bujumbura city and, to a lesser extent, Kayanza and Muramvya are confronted with both lower production efficiencies and higher population densities. However, the same reasoning does not apply to Ngozi and Cankuzo, which are both characterized by average production efficiencies despite being densely and scarcely populated, respectively. With male-to-female ratios below 0.90, the hypothesis of missing men to farm the land might be an explanation for the low production efficiencies observed in Mwaro and Muramvya. For Cibitoke (with a very low rate) as well as Gitega and Karuzi (with very high rates), other drivers need to be inspected to better understand their differential performance in production efficiency.

Figure 5. Population density and male-to-female ratio, Burundi (2018)

Another possible explanation behind the poor nutritional outcomes in Burundi is related to access constraints (see Figure 6), or the extent by which people’s food access is not in line with what could be expected based on their respective province’s level of food production. Various areas in the center part of the country are significantly affected, with Karuzi and Cankuzo recording the lowest access efficiency scores of all provinces. On the contrary, access constraints appear less severe in Cibitoke, Kayanza and especially in Bujumbura. Far from being a production zone, the capital has become a net consumer area, supplied with various products from inland provinces and abroad (imports). It is therefore not surprising that many agricultural and food products (including fresh produce) are available in Bujumbura at more affordable prices compared to the other provinces. Even the design of the national road network is more favorable to the city, as Bujumbura is easily accessible from almost all provinces. This might explain why Bujumbura is the most efficient province in the country in terms of access to food.

**Figure 6. Access efficiency, Burundi (2018)**

Source: The Authors.

Figure 7 investigates two possible drivers for the observed spatial variation in access efficiency. A first obvious driver is poverty (as captured by the prevalence of people living below the national poverty line): if people lack the financial resources, then access to a sufficiently diversified diet is compromised. The second driver is market accessibility (as approached by the total number of acceptable roads per million inhabitants): if people are living in remote areas, then access to nutritious food can be problematic as well, irrespective of their purchasing power.
With a poverty headcount above 70%, the severe access constraints observed in Karuzi clearly have a financial component while the density of roads of acceptable quality in the same province is also mediocre. With a rate above 50%, poverty can easily be invoked again as a potential driver behind the lower access efficiencies in Cankuzo, yet road density in this province appears to be among the highest of the country with more than 280 km of acceptable quality roads per million inhabitants. On the other side of the scale, we could explain the higher access efficiencies in Bujumbura city, Cibitoke and Kayanza by the fact that poverty is less pervasive, especially in the economic capital of the country where the poverty headcount is below 10%. In addition, the people in Cibitoke on average appear to have better physical access to food markets, as can be inferred from the province’s road density.

In contrast, the same drivers do not seem to capture much of the higher access efficiencies observed Muyinga and Rutana, where both poverty is high and road density is low, which might relate to the presence of food assistance programs being deployed in each province.

**Figure 7. Poverty and road density, Burundi (2019-2022)**

A third broad explanation behind the poor nutritional outcomes in Burundi has to do with utilization efficiency (see Figure 8), or the extent by which nutritional status of the population (cf. children) is in line with what could be expected based on people’s food access in their respective locations. Various provinces scattered across the country appear to suffer from utilization constraints, but clearly Muyinga stands out. Further research is required to identify the precise nature of these constraints, which will be illustrated below using a WASH and a health indicator. In contrast, utilization efficiency is the highest in Karuzi and to a lesser extent Gitega, both located in the center of the country.
To inspect potential drivers behind the variation in utilization efficiency, Figure 9 presents two maps, one with access rates to drinking water (expected to be positively correlated with utilization efficiency), and the second one with morbidity rates (expected to be negatively correlated with utilization efficiency). Indeed, access to water from reliable sources will reduce the occurrence of diarrhea and other diseases, which in turn will contribute to a correct absorption of food and thus better nutritional outcomes.

Whereas the higher utilization efficiencies observed in Karuzi, Muramvya and Mwaro may be clearly driven by better access to drinking water and lower morbidity rates, the province of Muyinga, where utilization efficiency is the lowest, seems to suffer mainly from higher morbidity. Again, none of both explanations seems to apply to Gitega. Despite its average access to drinking water and a morbidity rate above 40%, Gitega performs relatively well in terms of utilization efficiency. An alternative explanation however may be found in the province’s lower male-to-female ratio, as observed in Figure 5 above. Aside from being a constraint to production efficiency, the relative shortage of men in Gitega may point to a higher prevalence of female-headed households, the latter which are typically (all things equal) more concerned with the family’s offspring, including its nutrition. This observation may also apply to Mwaro and Muramvya, which are equally characterized by a combination of lower male-to-female ratios and higher utilization efficiencies.
Figure 9. Access to drinking water and morbidity, Burundi (2019-2020)

Figure 10 displays all low efficiency (defined by a score below 80% for each dimension) combinations observed in Burundi. None of the provinces suffer from a triplet (all three combined) of low efficiency types, however there are four provinces facing severe inefficiencies on two dimensions. This is the case for Muramvya and Kirundo regarding the combination of production and access constraints; and for Muyinga and Kayanza with respect to production and utilization. Two provinces in Burundi (Bujumbura Rural and Makamba) do not seem to suffer from any major constraint. However, it is important to keep in mind that the efficiency scores were obtained using a relative benchmarking technique, which means that the absence of low efficiency scores does not necessarily point to high efficiencies in absolute terms.
Figure 10. Low efficiency types, Burundi (2018)

Source: The Authors.
4. Simulations

To better inform future policy design, this section will run various simulations to assess the impact of various efficiency improvements on key outcome indicators along the food system. Indeed, the maps in the previous section only display where production, access and utilization constraints are most severe; however, they do not indicate how much attention should be devoted to each dimension to yield meaningful outcomes for targeted population in each province and the entire country. To provide more insight into this, we first run 12 simulations, which are all combinations of two core intervention types that seek to increase the efficiency rates of production, access and/or utilization. To re-fine the results or to pursue other simulations, an Excel tool has been developed and shared along with the report.

The two core intervention types are the following:

1. **Laggards’ catching up**: this intervention involves increasing the efficiency rate of the worst performing individual provinces to join the country’s average level. This form of geographical targeting focuses on the underperforming provinces only, while leaving other areas unaffected. Visually, this means that all dots with lower-than-average efficiency (i.e. <100%) be brought to the dashed line (i.e. 100%) in each of the quadrants of Figure 3, thus reducing overall inequality in efficiency performance. The type of interventions best suited to target laggard areas may include: extension services and provision of agricultural inputs (for production); implementation of social protection schemes and construction of transportation infrastructure, storage and processing facility (for access), and the provision of WASH and health care services and infrastructure (for utilization).

2. **Rising tide lifts all boats**: this intervention type seeks to increase the overall efficiency level of the entire country, irrespective of the exact performance observed for the individual provinces. The extent of efficiency improvement being pursued depends to the targets set for the outcome indicators. For this exercise, we apply a country threshold of 2375 kcal/pp/pd (for production), and a 95%-prevalence rate for acceptable food access and decent nutritional status. Visually, this means that the slope of the dashed lines in Figure 3 is reduced, or equivalently that all dots are relocated towards higher efficiency by a certain percentage (to be simulated), in order to reach the above thresholds. Unaffecting the efficiency distribution around the average, this type of generic or country-wide interventions may include: land reform and introduction of national credit systems (for production); revision of national trade, tax and income policies which affect household purchasing power of food (for access); and awareness campaigns on (for example) national radio to improve cooking habits or inform people about food safety issues (for utilization).

Compared to the baseline summarized on the first line, Table 2 quantifies the effect of each of the 12 simulations on three core outcome indicators. These are: (i) balanced actual food production (expressed in kcal/pp/pd), (ii) diverse food consumption (expressed as the share of households with acceptable FCS), (iii) nutritional outcomes (both expressed as the share of children under five years of age who are not stunted and the absolute number of stunted children). In addition to the outcome variables, we include a final column showing the return on investment (ROI), defined as the number of stunting cases diverted.

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8 Though not being directly reflected in the typology format, a lot of policy attention often goes to reducing absolute numbers of stunted children.
per additional %-point efficiency, the latter which could be considered as the general effort or budget needed to yield the corresponding reduction in stunting. For simplicity, we assume that every %-point efficiency increase requires the same amount of effort or budget across and within all three efficiency types.⁹

All outcome statistics summarized in Table 2 are weighted country totals, for which the underlying shares of food consumption and non-stunting have first been truncated to 100%, where applicable, given the natural limit of both variables. The outcome values of the individual provinces (including their possible truncation) can be retrieved using the Excel simulation tool.

Given the direction of efficiency changes, all 12 simulations in Table 2 unsurprisingly yield better outcomes – with improvements occurring at and after the dimension where the hypothesized intervention takes place. For example, an increase in access efficiency will only affect food consumption and nutritional outcomes, downstream, not the level of food production, upstream. Despite being largely a hypothetical exercise, the following observations can be made.

First, interventions targeted at lagging provinces in order for them to reach the average performance observed in the country have by far the highest return on investment. For all four simulations, the total number of stunting cases diverted per additional %-point efficiency exceeds 700. Regarding outcomes, the number of stunted children diverted is most pronounced within the production and access dimension (~300k) as opposed to the utilization dimension (~100k). The combined approach of all laggard provinces catching up with the rest of country (across all three dimensions) brings the number of stunted children from 1,169,386 to 457,037 (being a reduction in stunting rate from 55% to 21%). The latter intervention would also yield a food production of 1,092 balanced kcal/pp/pd while 85% of households would enjoy an acceptable food consumption level.

Second, country-wide interventions in Burundi are clearly the least efficient use of resources. With a return on investment of only 442 and 318 stunting cases diverted per additional %-point efficiency, these interventions may perhaps still make sense within the utilization and production dimension, respectively, as they become a real waste of resources when targeting access constraints (ROI=34). This can be easily understood in that economy-wide approaches also aim to lift the efficiency rates of areas which do not really need any support. It also explains the marked difference in return on investment across dimensions, which directly reflects the difference in efficiency inequality observed within each dimension.

Third, unsurprisingly, the return on investment of approaches which combine both core intervention types, lies somewhere in-between the results of their individual components. The highest return on investment for this type of intervention is again observed within the utilization dimension, yielding 483 stunting cases diverted per %-point efficiency increase. This is obtained when first bringing all underperforming provinces to the country’s average efficiency level, after which the resulting rates are further increased with 109%.

Fourth, investing earlier in the food system chain might have bigger and sustained outcomes due to existing multiplier effects. This can be observed when considering two types of interventions within the production dimension. When a total balanced food production of 2,375 kcal/pp/pd is reached, the

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⁹ This assumption ignores the existence of “low-hanging fruit” or “quick gains”, which should be pursued immediately and in all circumstances.
subsequent outcome indicators “automatically” take on the highest values of all 12 simulations, with acceptable FCS and non-stunting shares close to 100% while the remaining number of stunted children is brought to 80,000 or even completely reduced to zero in one case. However, these interventions also require a substantial increase in overall efficiency, ranging from 118% to 184%. On the other hand, focusing on food self-sufficiency (as opposed to other approaches such as combining food production and trade) is probably a less efficient use of available resources as indicated by the lower returns on investment. Intuitively, this can be understood as pushing certain areas to become genuine food producers while their comparative advantage lies elsewhere.

Fifth, conceptually a bit different from the multiplier effect, the results of all 12 simulations are not conclusive regarding the existence of synergetic effects across the three dimensions.\textsuperscript{10} Whereas such effects might be well at play for the inclusive strategy focused on laggard regions, an exclusive focus on the utilization dimension appears warranted when a country-wide component is included in the intervention matrix. This issue has important policy implications both in terms of resource allocation and required coordination between different sectors and corresponding development partners (i.e. ministries, civil society, donors, private sector) – an issue to which we return when discussing a final simulation.

\textsuperscript{10} Although not immediately apparent from Table 2, the synergetic effect can be easily verified using the Excel simulation tool by comparing the sum or mean of impacts generated by one-dimensional interventions with the overall impact resulting from similarly sized multi-dimensional interventions. In general, synergies do apply to the Burundi data and amount to roughly 4% when efficiency is increased by 5%. In other words, the number of stunting cases diverted is 4% higher when interventions involve efficiency increases across all three dimensions combined than when they are applied and summed up from each individual dimension.
<table>
<thead>
<tr>
<th>Dimension</th>
<th>Type</th>
<th>Action</th>
<th>Balanced actual food production (kcal/pp/pd)</th>
<th>Diverse food consumption (% acceptable FCS)</th>
<th>Chronic child malnutrition (% non-stunted)</th>
<th>(number stunted)</th>
<th>Return on investment (cases diverted per %-point eff. increase)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BASELINE</strong></td>
<td></td>
<td></td>
<td>837</td>
<td>57</td>
<td>45</td>
<td>1,169,386</td>
<td>---</td>
</tr>
<tr>
<td><strong>Production</strong></td>
<td>Laggards’ catching up</td>
<td>Increasing PE of lagging provinces to 100%</td>
<td>1,092</td>
<td>70</td>
<td>60</td>
<td>855,734</td>
<td>735</td>
</tr>
<tr>
<td></td>
<td>Rising tide lifts all boats</td>
<td>Increasing PE of all provinces by 184%</td>
<td>2,375</td>
<td>98</td>
<td>100</td>
<td>0</td>
<td>318</td>
</tr>
<tr>
<td></td>
<td>Combination</td>
<td>Increasing PE of lagging provinces to 100% before increasing overall PE by remaining 118%</td>
<td>2,375</td>
<td>96</td>
<td>96</td>
<td>79,454</td>
<td>393</td>
</tr>
<tr>
<td><strong>Access</strong></td>
<td>Laggards’ catching up</td>
<td>Increasing AE of lagging provinces to 100%</td>
<td>837</td>
<td>72</td>
<td>60</td>
<td>866,587</td>
<td>781</td>
</tr>
<tr>
<td></td>
<td>Rising tide lifts all boats</td>
<td>Increasing AE of all provinces by 115%</td>
<td>837</td>
<td>95</td>
<td>92</td>
<td>177,232</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>Combination</td>
<td>Increasing AE of lagging provinces to 100% before increasing overall AE by remaining 43%</td>
<td>837</td>
<td>95</td>
<td>80</td>
<td>441,807</td>
<td>64</td>
</tr>
<tr>
<td><strong>Utilization</strong></td>
<td>Laggards’ catching up</td>
<td>Increasing UE of lagging provinces to 100%</td>
<td>837</td>
<td>57</td>
<td>50</td>
<td>1,068,348</td>
<td>745</td>
</tr>
<tr>
<td></td>
<td>Rising tide lifts all boats</td>
<td>Increasing UE of all provinces by 126%</td>
<td>837</td>
<td>57</td>
<td>95</td>
<td>117,076</td>
<td>442</td>
</tr>
<tr>
<td></td>
<td>Combination</td>
<td>Increasing UE of lagging provinces to 100% before increasing overall UE by remaining 109%</td>
<td>837</td>
<td>57</td>
<td>95</td>
<td>109,236</td>
<td>483</td>
</tr>
<tr>
<td><strong>Production, access and utilization</strong></td>
<td>Laggards’ catching up</td>
<td>Increasing PE, AE and UE of lagging provinces to 100%</td>
<td>1,092</td>
<td>85</td>
<td>79</td>
<td>457,037</td>
<td>750</td>
</tr>
<tr>
<td></td>
<td>Rising tide lifts all boats</td>
<td>Increasing PE, AE and UE of all provinces by same 32%</td>
<td>1,100</td>
<td>89</td>
<td>95</td>
<td>110,459</td>
<td>114</td>
</tr>
<tr>
<td></td>
<td>Combination</td>
<td>Increasing PE, AE and UE of lagging provinces to 100% before increasing overall PE, AE and UE by remaining same 14%</td>
<td>1,245</td>
<td>96</td>
<td>95</td>
<td>102,097</td>
<td>210</td>
</tr>
</tbody>
</table>

Notes: PE, AE and UE respectively stand for production, access and utilization efficiency. It is important to highlight that total %-point efficiency increases cannot be immediately read from this table as they depend on the baseline efficiency levels under the laggard approach and on the conversion from proportional increases (cf. slope) into line-segment increases under the country-wide approach.

Source: The Authors.
A particular subset of simulations involves optimizations, which imply solving an objective function subject to a number of constraints. In the context of this report, two basic optimizations could be pursued. The first one entails the maximization of a nutritional outcome indicator given a defined amount of resources. The second involves the minimization of total resources needed to yield a certain nutritional threshold. To solve these optimizations, linear programming tools are typically employed to obtain the maximum (or minimum) value as well as the precise allocation of resources (van Dooren, 2018).

Table 3 presents the minimal amount of additional resources needed as well as their allocation over the three FNS dimensions to reduce stunting rates to at least 5% of the under-five child population in each individual province. As mentioned above, we simply equate ‘additional resources’ to ‘extra %-points of efficiency’.

<table>
<thead>
<tr>
<th>BASELINE</th>
<th>LET</th>
<th>ALLOCATION OF ADDITIONAL EFFICIENCY</th>
<th>OUTCOME</th>
<th>ROI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stunting rate</td>
<td>Stunted children</td>
<td>Low efficiency types (&lt;80%)</td>
<td>PE</td>
</tr>
<tr>
<td></td>
<td>(%)</td>
<td>(number)</td>
<td></td>
<td>(extra %-points)</td>
</tr>
<tr>
<td>Bubanza</td>
<td>52.8</td>
<td>52,194</td>
<td>A</td>
<td>12%</td>
</tr>
<tr>
<td>Bujumbura Mairie</td>
<td>24.3</td>
<td>32,283</td>
<td>P</td>
<td>1%</td>
</tr>
<tr>
<td>Bujumbura Rural</td>
<td>50.0</td>
<td>60,043</td>
<td>none</td>
<td>34%</td>
</tr>
<tr>
<td>Bururi</td>
<td>51.8</td>
<td>34,640</td>
<td>A</td>
<td>0%</td>
</tr>
<tr>
<td>Cankuzo</td>
<td>52.8</td>
<td>33,588</td>
<td>A</td>
<td>0%</td>
</tr>
<tr>
<td>Cibitoke</td>
<td>56.5</td>
<td>78,932</td>
<td>P</td>
<td>31%</td>
</tr>
<tr>
<td>Gitega</td>
<td>55.6</td>
<td>86,199</td>
<td>A</td>
<td>0%</td>
</tr>
<tr>
<td>Karuzi</td>
<td>61.5</td>
<td>70,903</td>
<td>A</td>
<td>0%</td>
</tr>
<tr>
<td>Kayanza</td>
<td>57.9</td>
<td>78,256</td>
<td>P-U</td>
<td>43%</td>
</tr>
<tr>
<td>Kirundo</td>
<td>62.7</td>
<td>114,478</td>
<td>P-A</td>
<td>33%</td>
</tr>
<tr>
<td>Makamba</td>
<td>52.5</td>
<td>68,491</td>
<td>none</td>
<td>0%</td>
</tr>
<tr>
<td>Muramvya</td>
<td>52.8</td>
<td>33,791</td>
<td>P-A</td>
<td>38%</td>
</tr>
<tr>
<td>Muyinga</td>
<td>59.2</td>
<td>111,456</td>
<td>P-U</td>
<td>33%</td>
</tr>
<tr>
<td>Mwaro</td>
<td>56.4</td>
<td>31,200</td>
<td>P</td>
<td>44%</td>
</tr>
<tr>
<td>Ngozi</td>
<td>63.1</td>
<td>101,815</td>
<td>A</td>
<td>20%</td>
</tr>
<tr>
<td>Rumonge</td>
<td>53.9</td>
<td>52,536</td>
<td>A</td>
<td>0%</td>
</tr>
<tr>
<td>Rutana</td>
<td>58.4</td>
<td>56,274</td>
<td>U</td>
<td>0%</td>
</tr>
<tr>
<td>Ruyigi</td>
<td>62.0</td>
<td>72,306</td>
<td>A</td>
<td>0%</td>
</tr>
<tr>
<td>BURUNDI</td>
<td>54.6</td>
<td>1,169,386</td>
<td>1106%</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Notes: PE, AE and UE respectively stand for production, access and utilization efficiency. Within the column of low efficiency types, P indicates “production only”, A “access only”, U “utilization only”, P-A “production & access”, and P-U “production & utilization”.

Source: The Authors.

Starting from an average stunting level of 55%, which corresponds to 1,169,386 children suffering from chronic malnutrition, the optimization results indicate that 1106 additional efficiency %-points would suffice to divert 1,063,390 cases and bring stunting rates down to exactly 5% in each province. Based on
the simulation parameters generated by the Burundi data, this outcome is obtained when the efficiency allocation scheme of Table 3 is met, that is when provinces marked by darker red cells receive more additional resources.

Unsurprisingly, this allocation scheme largely corresponds to the low efficiency types mapped in Figure 10 and Table 3. Indeed, the dimensions characterized by efficiency rates below 80% generally require more resources, with the exact degree illustrated by the additional %-points needed. It is also interesting to observe that for some provinces this correspondence is somewhat distorted due to existing multiplier effects, meaning that low efficiencies downstream could also be resolved by investing in increased efficiency upstream. For example, Kirundo and Muramvya are two provinces suffering from severe production and access constraints, yet the required resources to increase access efficiency are distinctly higher for the former than the latter province. This indicates that most of the efficiency gains realized at the production level in Muramvya will trickle down to the access dimension without much additional resources needed. This multiplier effect can be observed for other provinces as well.

The optimization results of Table 3 indicate that in most provinces collaboration across sectors is needed, while this is less important in some other provinces in which additional resources should best be tailored to one dimension only. However, where collaboration is key, the simulation tool indicates that synergies on average amount to almost 15%, meaning that another 136,905 stunting cases are diverted through a combined focus on all three FNS dimensions as opposed to the sum of diverted cases following efficiency increases applied to each dimension separately.
5. Conclusions

The main purpose of this component of the project is to analyze nutritional outcomes of different locations as a combination of inefficiencies of different types and degrees. Its findings are expected to improve the identification and understanding of the major bottlenecks and constraints impeding FNS in Burundi.

The relevance of the results presented in this analysis is largely based on the quality of the secondary data used to construct each of the four core FNS indicators. In addition, while preferring the most recent and most spatially fine data, the typology methodology requires that timing and geographical delimitations of the data align across the four dimensions. As a result, and mainly confined by the available agricultural statistics, this analysis focuses on the identification of the more structural FNS constraints for each of the country’s 18 provinces in 2018.

Overall, the findings confirm significant gaps between high agricultural potential and low levels of nutritional outcomes across the country. In most of these provinces, well-defined infrastructural investments coupled with supporting policies should be enough to establish an efficient food system, capable of substantially improving nutritional outcomes for the Burundi population.

With respect to production, the province of Cibitoke has the lowest efficiency score while production efficiency tends to be higher in the southern part of the country, and especially in Rutana, Gitega, Karuzi and Makamba. Our findings also suggest that several locations in the center part of the country suffer from low access to food, with Karuzi and Cankuzo being at the bottom compared to other provinces. However, access constraints appear less severe in Cibitoke, Kayanza and especially in Bujumbura city. Regarding utilization efficiency, or the extent by which nutritional status of the population is in line with what could be expected based on people’s food access in their respective locations, the results suggest widespread constraints across the country while Karuzi and to a lesser extent Gitega are doing markedly better. To some extent, the spatial profiles of production, access and utilization efficiency could be traced back to differences in performance across province on six underlying indicators, which include: population density, male-to-female ratio, poverty headcount, road density, access to drinking water, and mortality rate.

Although additional research is certainly needed to further pinpoint the exact drivers of low efficiency, the results from the 12 generic simulations indicate that spatial targeting of the most disadvantaged provinces (as opposed to any country-wide approach) yields the highest returns on investment and therefore represents the most efficient use of public resources. In addition, investing earlier in the food system while pursuing a coordinated and comprehensive approach across sectors seem to generate the most sustained and synergetic outcomes. These observations are largely confirmed by the optimization results, which describe the minimal amount and allocation of additional efficiency needed to reduce child stunting to 5%. Indeed, every province requires the right dose of resources, with some profiting more from investments upstream, while all provinces where collaboration across sectors is needed, display the existence of synergetic effects.

By way of concluding, we add a final table with a non-exhaustive list of possible interventions to help improve nutritional outcomes in ten provinces with the highest child stunting rates (that is above 55%).
The scheme with additional efficiencies to be allocated over each dimension and province is drawn from the simulation exercise and thus corresponds to a reduction of child stunting to 5% in each province.

### Table 4. Possible interventions in high-stunting provinces, Burundi (2018)

<table>
<thead>
<tr>
<th>Province</th>
<th>Stunting rate (%)</th>
<th>PE (extra %-points)</th>
<th>AE</th>
<th>UE</th>
<th>Non-exhaustive list of possible interventions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ngozi</td>
<td>63.1</td>
<td>20%</td>
<td>50%</td>
<td>19%</td>
<td>Improve access to improved agricultural inputs, land, credit systems, and extension services; diversify household income sources, build strategic food stocks; promote food processing; improve cooking habits, food safety, and quality of health care services.</td>
</tr>
<tr>
<td>Kirundo</td>
<td>62.7</td>
<td>33%</td>
<td>32%</td>
<td>22%</td>
<td>Improve access to improved agricultural inputs, land, credit systems, and extension services; diversify household income sources, build strategic food stocks; promote food processing; improve cooking habits, food safety, and quality of health care services.</td>
</tr>
<tr>
<td>Ruyigi</td>
<td>62.0</td>
<td>0%</td>
<td>56%</td>
<td>34%</td>
<td>Diversify household income sources, build strategic food stocks; promote food processing; improve access to markets; improve cooking habits, food safety, and quality of health care services.</td>
</tr>
<tr>
<td>Karuzi</td>
<td>61.5</td>
<td>0%</td>
<td>45%</td>
<td>0%</td>
<td>Diversify household income sources, build strategic food stocks; promote food processing; improve access to markets.</td>
</tr>
<tr>
<td>Muyinga</td>
<td>59.2</td>
<td>33%</td>
<td>0%</td>
<td>44%</td>
<td>Improve access to improved agricultural inputs, land, credit systems, and extension services; diversify household income sources, build strategic food stocks; promote food processing; improve cooking habits, food safety, and quality of health care services.</td>
</tr>
<tr>
<td>Rutana</td>
<td>58.4</td>
<td>0%</td>
<td>30%</td>
<td>64%</td>
<td>Diversify household income sources, build strategic food stocks; promote food processing; improve access to markets; improve cooking habits, food safety, and quality of health care services.</td>
</tr>
<tr>
<td>Kayanza</td>
<td>57.9</td>
<td>43%</td>
<td>0%</td>
<td>1%</td>
<td>Improve access to improved agricultural inputs, land, credit systems, and extension services.</td>
</tr>
<tr>
<td>Cibitoke</td>
<td>56.5</td>
<td>31%</td>
<td>0%</td>
<td>0%</td>
<td>Improve access to improved agricultural inputs, land, credit systems, and extension services.</td>
</tr>
<tr>
<td>Mwaro</td>
<td>56.4</td>
<td>44%</td>
<td>0%</td>
<td>0%</td>
<td>Improve access to improved agricultural inputs, land, credit systems, and extension services.</td>
</tr>
<tr>
<td>Gitega</td>
<td>55.6</td>
<td>0%</td>
<td>66%</td>
<td>0%</td>
<td>Diversify household income sources, build strategic food stocks; promote food processing; improve access to markets.</td>
</tr>
</tbody>
</table>
References


Annexes


Food access

![Graph showing correlation between food access and nutritional status indicators]

Notes: The threshold used for poor HDDS is the consumption of food from less than 4 different food groups in the 24h preceding the survey. The identification of households with poor and borderline FCS is derived using the standard thresholds of 21 and 35.
* = significant at .05, ** = significant at .01, *** = significant at .001.
Source: The Authors based on data obtained from ENSNSAB (2018) and ENSNMB (2020) (ISTEEBU, 2019; MSPLS & MFBPE, 2020).

Nutritional status

![Graph showing correlation between nutritional status indicators]

Notes: The threshold used for child stunting (wasting) is set at minus 2 standard deviations of the median height-for-age (weight-for-height) z-scores of the reference population.
* = significant at .05, ** = significant at .01, *** = significant at .001.
Source: The Authors based on data obtained from ENSNSAB (2018) and ENSNMB (2020) (ISTEEBU, 2019; MSPLS & MFBPE, 2020).

<table>
<thead>
<tr>
<th>Province</th>
<th>Stunting</th>
<th>Efficiency</th>
<th>Access</th>
<th>Utilization</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>height-for-age scores &lt;-2 SD</td>
<td>production</td>
<td>access</td>
<td>utilization</td>
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<td>0.91</td>
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</table>

Notes: Efficiency rates are calibrated around 1, which represents the efficiency level that could be expected based on the performances observed in the entire country.

Source: The Authors based on Brown de Colstoun et al. (2017); Farr et al. (2007); Hansen et al. (2013); ISTEEBU (2019); MINEAGRIE (2020); Pekel et al. (2016); UNEP-WCMC & IUCN (2021); Vincent et al. (2020); Xiong et al. (2017).