IFPRI Discussion Paper 01971

November 2020

Spatial Food and Nutrition Security Typologies for Agriculture and Food Value Chain Interventions in Eastern DRC

Wim Marivoet

John M. Ulimwengu

David M. Bugeme

Blandine Sanginga

Sarah Thontwa

Africa Regional Office

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

The International Food Policy Research Institute (IFPRI), a CGIAR Research Center established in 1975, provides research-based policy solutions to sustainably reduce poverty and end hunger and malnutrition. IFPRI's strategic research aims to foster a climate-resilient and sustainable food supply; promote healthy diets and nutrition for all; build inclusive and efficient markets, trade systems, and food industries; transform agricultural and rural economies; and strengthen institutions and governance. Gender is integrated in all the Institute's work. Partnerships, communications, capacity strengthening, and data and knowledge management are essential components to translate IFPRI's research from action to impact. The Institute's regional and country programs play a critical role in responding to demand for food policy research and in delivering holistic support for country-led development. IFPRI collaborates with partners around the world.

AUTHORS

Wim Marivoet (w.marivoet@cgiar.org) is a Research Fellow in the Africa Regional Office (AFR) of the International Food Policy Reseach Institute (IFPRI), Dakar, Senegal.

John M. Ulimwengu (j.ulimwengu@cgiar.org) is a Senior Research Fellow in IFPR's AFR, Washington, DC.

David M. Bugeme (d.bugeme@cgiar.org) is a TAAT Country Liaison Officer at the International Institute of Tropical Agriculture (IITA), Bukavu, Democratic Republic of the Congo.

Blandine Sanginga (s.blandine@cgiar.org) is a Consultant at IITA, Bukavu, Democratic Republic of the Congo.

Sarah Thontwa (sarah.thontwa@uantwerpen.be) is a Researcher at the Institute of Developtment Policy of the University of Antwerp, Antwerp, Belgium.

CONTENTS

TABLES

FIGURES

ABSTRACT

To guide the design of future agriculture and food value chain interventions, this paper combines two existing spatial food and nutrition security typologies and applies them to the eastern part of the Democratic Republic of the Congo (DRC). Apart from estimating absolute and relative inefficiencies along the food system from agricultural potential to nutrition, the integration of both typologies resulted in nine unique low efficiency profiles across the territories and major cities of the Greater Kivu region and Tanganyika. In addition to low utilization efficiency observed in some areas, most PICAGL intervention zones, especially Uvira and Kalemie, suffer from significant market constraints and therefore could substantially benefit from food value chain development. Although this paper relies on the most recent and spatially disaggregated data (which is a major improvement with respect to agricultural statistics of the country), the proposed typologies cannot uncover all bottlenecks hindering the development of agricultural value chains in the region.

Keywords: food and nutrition security, food systems, value chains, spatial typologies, Democratic Republic of the Congo (DRC)

ACKNOWLEDGMENTS

This research was undertaken as part of the Integrated Agricultural Growth Project in the Great Lakes (PICAGL), a World Bank funded project, managed by the International Institute of Tropical Agriculture (IITA). The opinions expressed here belong to the authors and do not necessarily reflect those of IITA or other PICAGL partners.

1. INTRODUCTION

For several decades, the eastern part of the Democratic Republic of the Congo (DRC) has been the center stage of a long-protracted crisis, characterized by multiple episodes of war and violence, waves of internal and cross-border refugees and an increasing death toll making it one of the deathliest conflicts since World War II (C. Soderlund et al., 2013; Coghlan et al., 2006; Reyntjens, 2009). At the same time, given its moderate climate and frequent precipitation, agroecological conditions in this region are favorable to various forms of agriculture, including livestock and horticulture. However, the DRC's agricultural potential remains largely untapped, with only 10% of an estimated 75 million hectares of arable land under cultivation (MINAGRIDER, 2013) and with large shares of the Congolese population, estimated at 86.8 million people in 2019,[1] suffering from various forms of malnutrition; about 43% and 47% of children under the age of five years are stunted and have anemia, respectively (République démocratique du Congo, 2014a).

This paradox between high agricultural potential and low levels of nutrition has been repeatedly documented in several studies (Trefon, 2016; Ulimwengu et al., 2012). Both dimensions, agricultural potential and nutrition, also bound the conceptual framework of a spatial typology recently developed by Marivoet et al. (2019) to help locate and identify food and nutrition security (FNS) bottlenecks across the country's 145 territories. The same paradox was the basis of a mapping project to identify localized "explanations", ranging from idiosyncratic causes and structural constraints to specific livelihoods strategies pursued by farming households (Marivoet et al., 2018). If anything, this mapping exercise indicated that the DRC's agricultural paradox is multifaceted and spatially heterogeneous. These observations are of course not unique to the DRC. In fact, the friction between agriculture and nutrition outcomes observed in many developing countries has prompted scholars and development practitioners to adopt a food system or food environment approach to better account for the many complex interactions at play (Ericksen, 2008; Gillespie & van den Bold, 2017; Herforth & Ahmed, 2015; Jones & Ejeta, 2015; Pinstrup-Andersen, 2013; Tendall et al., 2015).

The present paper geographically focuses on Eastern DRC; in particular on the economic corridor stretching from Bukavu in South Kivu to Kalemie in Tanganyika (see Figure 1). This axis is the main intervention zone of the Integrated Agricultural Growth Project of the Great Lakes region, called *PICAGL*[2], which aims to increase agricultural production of rice, cassava and livestock (including milk) and develop their corresponding food value chains. In line with the food system's approach currently advocated by many scholars to study FNS, the overall objective of this paper is to provide key insights and policy recommendations to make agricultural and food value chain interventions in Eastern DRC more nutrition sensitive.

To pursue this objective, Section 2 will first compile and discuss available data on national agricultural production. This is a longstanding issue in the country which impedes the pursuit of reliable agricultural research and implementation of effective policies. In a subsequent section (Section 3), we take stock of existing food value chain studies in the DRC. Section 4 will then conceptually combine and apply two existing FNS typologies to the territories of the Greater Kivu region (which includes the provinces of North and South Kivu and Maniema) and Tanganyika. As such, the focus is broader than the immediate intervention zone of PICAGL, which is warranted in order to capture spillover effects, synergies and economies of scale. A final section (Section 5) will draw conclusions and provide policy recommendations while identifying remaining knowledge gaps.

[1] World Development Indicators (downloaded on November 5, 2020). For several reasons discussed in Marivoet & De Herdt (2017), population estimates of the DRC are highly contentious.

[2] In French, PICAGL stands for "Projet Intégré de Croissance Agricole dans les Grands Lacs". Despite its relevance and importance, the project has no particular focus on conflict.

Figure 1. PICAGL intervention zone

Source: The Authors based on spatial data from Référentiel Géographique Commun (www.rgc.cd).

2. AGRICULTURE PRODUCTION DATA

Despite being earmarked as a sector of huge importance for development and poverty reduction, many African countries struggle to build an accurate information system to produce reliable, comprehensive and regular data on agriculture to guide the design of effective sectoral policies (Carletto et al., 2015). The DRC is no exception. The last agricultural census dates back to 1970, and, until recently, the last primary data collection of agricultural production at provincial level goes back to 1996/97; all other agricultural statistics are mere projections (Tollens & Biloso, 2006). Even until 2015, when the country's National Institute of Statistics (INS) published its sixth statistical volume for the year 2014 after an interruption of 20 years, agricultural crop production was estimated using extrapolation techniques, reflected by suspiciously consistent growth rates across crop, time or province; most of which were close to the assumed population growth rate of 3% (République démocratique du Congo, 2015). Because of the poor quality of agricultural data fed into the country's food balance sheets, FAO discontinued the DRC's series on the prevalence of undernourishment in 2007 (FAO et al., 2011).

There have been various attempts to produce more reliable estimates at sub-national level, such as the pilot surveys conducted in Bas-Congo, Bandundu and Kinshasa in 2002, 2003 and 2004, yet without extension to other provinces (Tollens & Biloso, 2006). In recent years, these attempts became more comprehensive in scope and methodology. In our view, two major data collection initiatives stand out, each of which gave rise to several estimates of agricultural crop production.

The first initiative is the second round of the national household consumption and expenditure survey (HCES), called *Enquête 1-2-3* (henceforth 123 Survey), conducted in 2012/13 (République démocratique du Congo, 2014b). Compared to the first round in 2004/5, this survey was complemented with a dedicated module on agriculture. Unfortunately, not all crops cultivated by the same household were correctly captured or processed, resulting in the ditching of the module's data.[3] Given detailed food consumption data within the same 123 Survey (2012/13), some authors have also used the corresponding module to estimate agricultural production (Marivoet et al., 2019). The main underlying assumptions are that market integration is very poor in many remote areas in the DRC (so that local food consumption might roughly equal local food production), and that post-harvest losses are also virtually close to zero.

The second major data collection initiative is the establishment of CAID (*Cellule d'Analyses des Indicateurs de Développement*), which is a unit set up in 2015 to compile and regularly collect development data across the country's 145 rural territories. Within this newly established unit at the Prime Minister's Office, several other initiatives were hosted with various development partners, such as the *m-Kengela* project with WFP to track food prices or the implementation of agricultural surveys with FAO and WFP. After an unsuccessful attempt to collect data from 100 farmers per territory in 2016/17 due to insecurity problems, a similar exercise was conducted in 2017/18, which produced data for each territory on total agricultural production, yield and cultivated area for 15 crops (maize, rice, millet, sorghum, cassava, yam, taro, sweet potato, Irish potato, beans, cowpeas, small peas, pigeon peas, peanuts and soya) and a counting of total livestock for five animal types (cattle, sheep, goats, pigs and poultry) (MINAGRI, 2018).

Figure 2 presents an overview of annual production estimates for cassava, maize, rice, and beans, across 11 former provinces and four different data sources. All estimates have been expressed in 2017/18-terms using a fixed population growth rate of 3%, which is the typical approach adopted by INS when lacking primary data and which underscores the importance of subsistence farming in the DRC.[4] Despite methodological differences, Figure 2 highlights the profound discrepancies among the four data sources: clearly, very little can be said about agricultural production in the DRC with any reasonable degree of certainty. This being said, the following observations are worth mentioning.

[3] As a matter of fact, it appears that only the most important crop per household has been recorded, resulting in serious underestimation of agricultural production.

[4] Of course, apart from their different timeframe, many other issues in terms of methodology and representativity complicate a neat comparison across data series.

First, largely in line with overall diet information on the DRC, cassava is by far the most important crop followed by maize, rice and then beans. Second, also consistent with public knowledge, most cassava production takes place in former Bandundu, Equateur, Orientale and Katanga provinces, which happen to be the most populated provinces of the country. A similar geographical distribution applies to maize, though the relative importance of Katanga and both Kasai provinces is slightly higher, which aligns with local food preferences. Rice on the other hand is mainly produced in Orientale and Kasai-Oriental, while Maniema's contribution to total rice production is relatively high given its small population. Regarding beans, most production is concentrated in the more populated provinces, but the relative share from provinces such as North and South Kivu is significantly higher. Third, the magnitude of annual crop production lies roughly in the same range for the official INS figures and those most recently produced by CAID-FAO-WFP. However, both are substantially higher than the other two datasets, except for rice where the 123 production estimates are generally higher. Fourth, in many cases the estimates based on *consumption* data from the 123 Survey are strikingly lower than the CAID-FAO-WFP production estimates.

Figure 2. Annual production estimates using various sources (in tons), DRC (2017-2018)

Source: The Authors based on République Démocratique du Congo (2015), 123 Survey data (2012/13) and CAID-FAO-WFP data (2017/18).

Table 1 presents the correlation matrix of total crop production (i.e. total of cassava, maize, rice and beans productions) according to the four data sources mentioned, combined with an estimate of currently arable crop land obtained through 2015 remote sensing data.[5] All data are aggregated at former provincial level. Following the findings reported in Figure 2 above, it is not surprising to see that correlations are rather low, especially for agricultural production from the 123 Survey. In line with previous observations, the CAID-FAO-WFP estimates are highly correlated with official INS figures. This means that either the assumptions of extrapolation used to obtain the INS figures are close to reality, that comparable data have been used to guide both methodologies, or simply that statistics are similar by coincidence. In any case, both crop production series appear to be strongly correlated with the size of cultivated crop land in each of the 11 provinces. This is an important validity check, given that arable crop land is obtained from remote sensing and thus methodologically unrelated to ground-level estimates of agricultural production. Notwithstanding its slightly weaker correlation with current crop land compared to official INS data, this paper will rely on agricultural production statistics produced by CAID-FAO-WFP. The latter statistics are not only the most recently available, they are also the most geographically disaggregated (that is at territorial level (145)) and the most extensive in terms of crop coverage and livestock population.

Table 1. Correlation matrix of four crop production series and crop land, DRC (2015-2018)

N=11 provinces	**INS official**	**123 Survey (prod)**	**123 Survey (cons)**	**CAID-FAO-WFP**	**Crop land**
INS official	1.000				
123 Survey (prod)	0.485	1.000			
123 Survey (cons)	0.754*	0.387	1.000		
CAID-FAO-WFP	0.858**	0.308	0.721*	1.000	
Crop land	0.886***	0.536	0.764*	0.802**	1.000

Notes: * = significant at .05, ** = significant at .01, *** = significant at .001.

Source: The Authors based on République Démocratique du Congo (2015), 123 Survey data (2012/13) and CAID-FAO-WFP data (2017/18).

The following three figures present various maps of annual crop production, livestock populations and annual meat, milk and egg production, all based on CAID-FAO-WFP estimates.

Figure 3 displays annual production estimates for each of the six most important crops produced in the Greater Kivu region and Tanganyika. In order of importance, these crops include cassava, maize, Irish potato, rice, sweet potato and beans; the other nine food crops collected by CAID-FAO-WFP (2017/18) are much less important to this part of the country. With cassava production well over 2 million tons per year, Mwenga is by far the breadbasket of the region. In addition, Mwenga is also a top producer of sweet potato and, to a lesser extent, of maize with production estimates around 62,000 tons and 49,000 tons, respectively. In second place, in terms of overall crop production, comes Fizi, with slightly more than 1 million tons of cassava and 52,000 tons of maize per year. Further south along the PICAGL corridor, Kalemie produces slightly less than 1 million tons of cassava and around 55,000 tons of sweet potato per year. Most other territories within or close to the PICAGL corridor do not produce a lot of food crops, which for some is likely due to their relatively small size and limited arable land. Uvira seems to be the exception as it produces more than half of all Irish potato production, reaching almost 200,000 tons per year. In addition, Shabunda is the most important supplier of rice (around 74,000 tons) and a top producer of maize (around 59,000 tons); Manono also produces significant quantities of rice (around 46,000 tons) in combination with beans (around 34,000 tons); and Moba has also a sizeable maize (around 56,000 tons) and bean (around 28,000 tons) production. Compared to cassava, the production of rice along the PICAGL corridor is largely insignificant, both in absolute and relative terms.

[5] See Marivoet et al. (2019) for a more detailed discussion of remote sensing products and methodology to derive current arable crop land.

The maps in Figure 4 display the size and distribution of five livestock types and their aggregation in Tropical Livestock Units (TLU).[6] The map with TLUs shows that most livestock is located along the PICAGL corridor as well as in Lubutu and Lubero. Whereas Lubero has high TLUs due to relatively large herd sizes for almost all livestock types, the performance of Lubutu is mainly driven by the rearing of goats and especially poultry.[7] Further, for most territories along the PICAGL corridor, higher TLUs mainly stem from higher ownership of cattle, followed by goats and pigs. Fizi and Mwenga clearly stand out with cattle herd sizes well above 100,000 heads and 75,000 heads, respectively, but also Walungu and Uvira are important cattle breeders, notwithstanding their smaller territories and grazelands. Exceptionally, most rearing of sheep takes place in Kalehe with estimated herd sizes well above 240,000 heads, which is much higher than the second most important sheep breeder (i.e. Lubero with around 60,000 heads). Compared to the territories in PICAGL, Kabambare and especially Kalemie do not have significant livestock size.

In absence of reliable registration systems and to account for the high degree of informal activities, indirect methods are typically used to estimate the annual production of animal-based products, such as meat, milk and eggs. These methods rely on the combination of livestock population numbers and offtake rates, the latter which indicate the amount of milk and eggs used for human consumption or the estimated proportion of animals slaughtered per year multiplied with their net carcass weights (in the case of meat). Where possible, we rely on offtake rates derived from in-country case studies for each of the five animal types while differentiating between the three main agroecological zones of the DRC (which are humid, sub-humid and highland). Resulting estimates of meat, milk and egg production based on this approach are far from perfect. First, offtake rates are not necessarily representative despite being derived by agroecological zone. This is reflected in the wide range of parameters observed in several case studies, which points to crucial factors beyond agroecological conditions that affect final production, such as breed types and quality and access to basic livestock infrastructure. Second, and reinforced by issues of representativity, derived meat, milk and egg estimates can be an indication both of actual and potential production. This depends on the precise case study selected and the extent to which actual production reaches maximum potential. For example, due to limited access to end-markets, livestock farmers may only produce the amount of milk needed for own consumption. But under conditions of insatiable demand the same farmers may produce the maximum amount of milk possible. As a result, meat, milk and egg estimates presented below will be generally considered in between actual and potential production.

The maps in Figure 5 present estimated production of beef, pork, shoat[8] and chicken meat as well as cow milk and egg production after applying offtake rates to the 2017/18 livestock population numbers of CAID-FAO-WFP. Unsurprisingly following the approach adopted, these production estimates align with the distribution of animals. Most beef production is concentrated along the PICAGL corridor and especially in Fizi and Mwenga where annual production exceeds 2,400 tons. Lubero in the north of North-Kivu is also an important beef producer. With less than 800 tons per year, beef production is however significantly lower in Kalemie compared to other territories in the same corridor. The same spatial distribution applies to cow milk with Fizi producing more than 800,000 liters per year, followed by Mwenga and Lubero which record an annual production between 400,000 and 600,000 liters. Shoat meat production is higher in Kalehe, Lubero, Lubutu and Fizi compared to the other territories in East-DRC. Kalehe exhibits higher presence of sheep, the same is true for Lubutu and Fizi with respect to goats while Lubero has substantial herd sizes for both animal types. Given minor differences in meat offtake rates across agroecological zones, the location of pigs largely determines the spatial distribution of pork production. With an annual production higher than 1,600 tons, most pork is produced in Lubero. Except for Nyunzu which performs slightly better, pork production in various territories between Rutshuru and Fizi falls between 400 and 800 tons per year. Since offtake rates for poultry are not different across

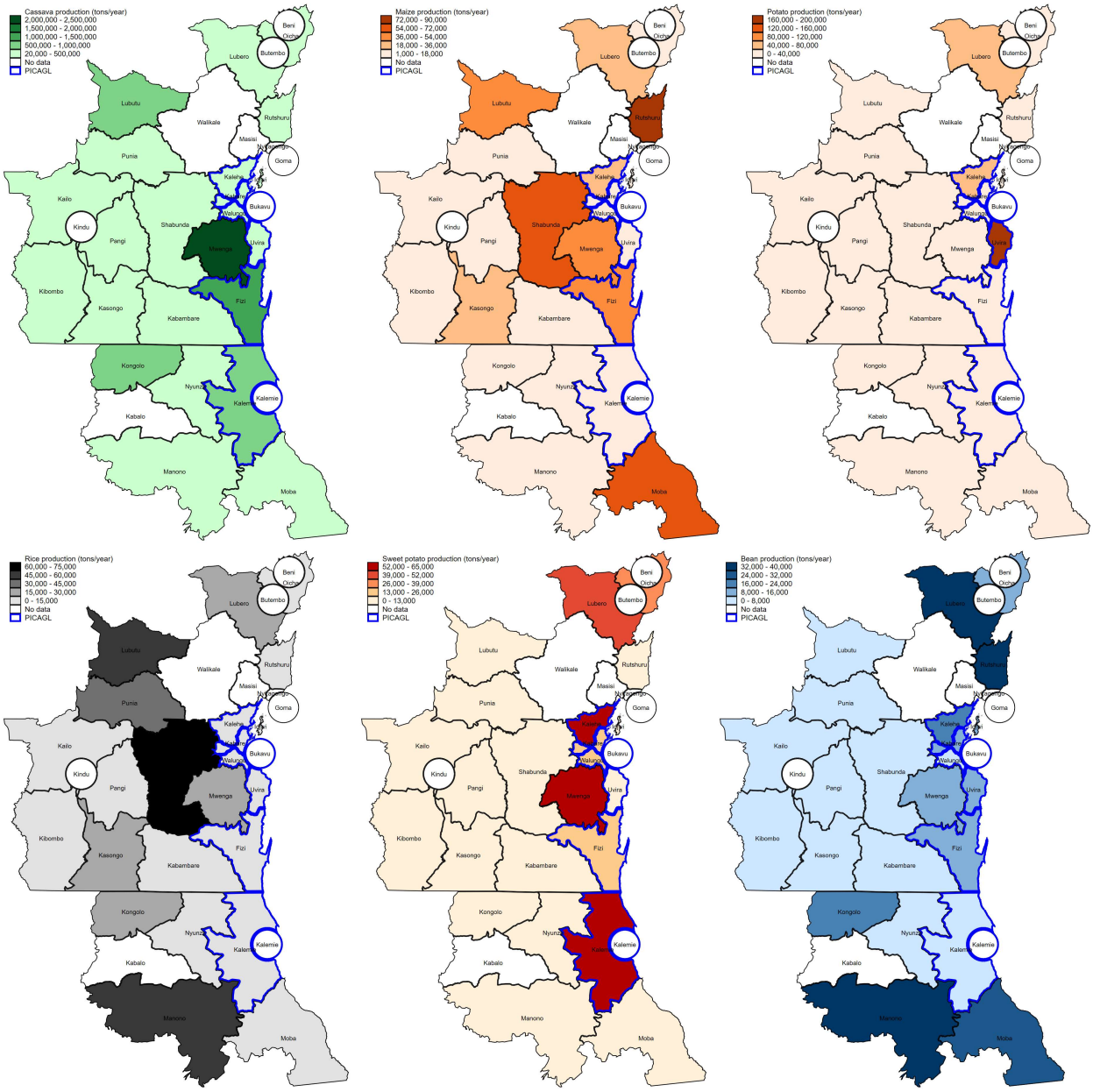
[6] Tropical Livestock Units defined for Africa South of Sahara equal 0.50 for cattle, 0.10 for sheep and goats, 0.20 for pigs and 0.01 for poultry (FAO, 2011).

[7] In fact, with almost 4.5 million units of poultry, Lubutu is clearly a regional outlier; a statistic which therefore should be considered with caution.

[8] Shoat meat is the term often used to denote goat meat or sheep meat.

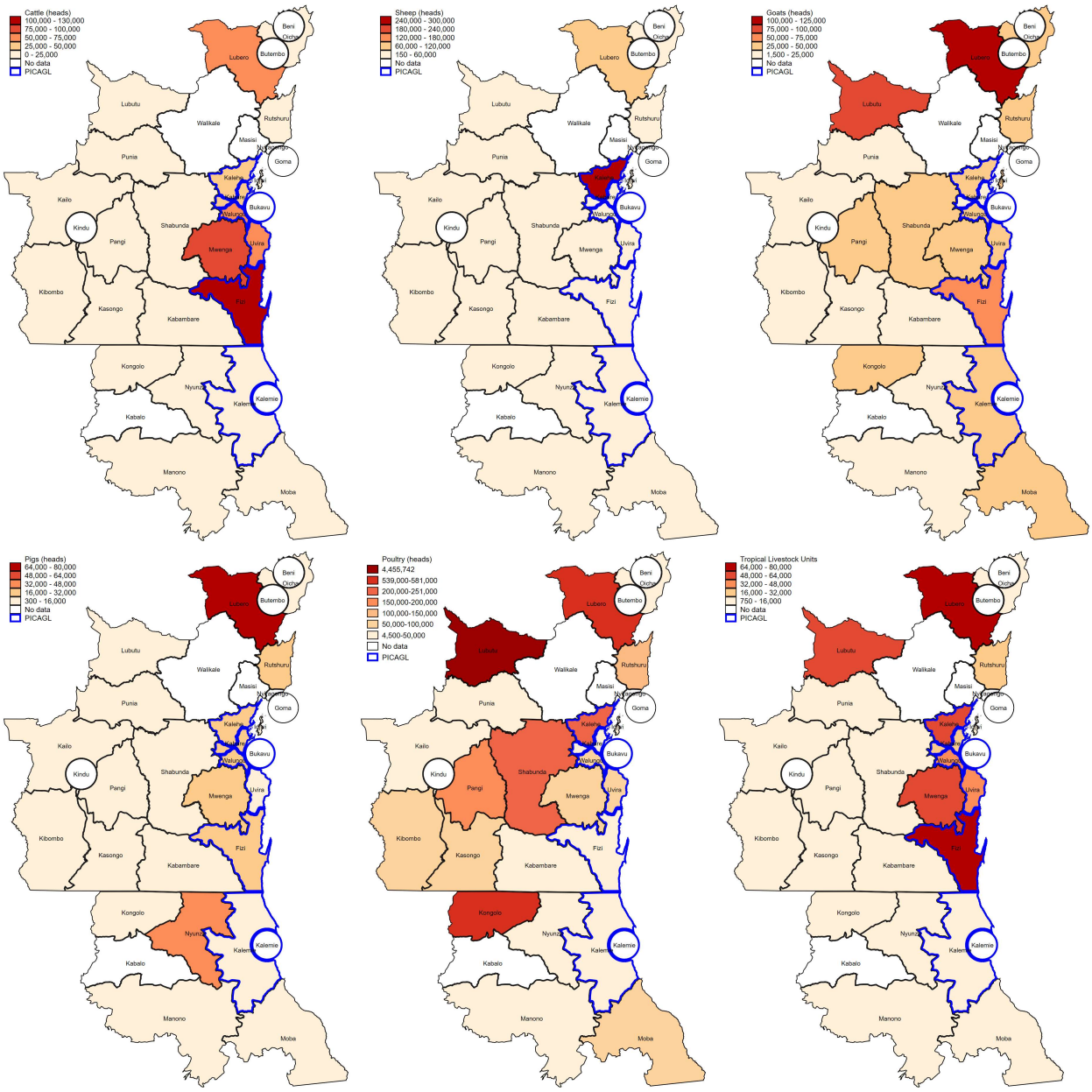
agroecological zones, the spatial distribution of this animal type fully matches that of chicken meat and egg production. Depending on the accuracy of poultry statistics, this means that by far the most chicken meat and eggs are produced in Lubutu, with respectively 2,320 tons and 1,353 tons per year, followed by Lubero and Kongolo with annual production estimates around 290 tons for chicken meat and 170 tons for eggs.

Figure 3. Annual crop production, East-DRC (2017-2018)



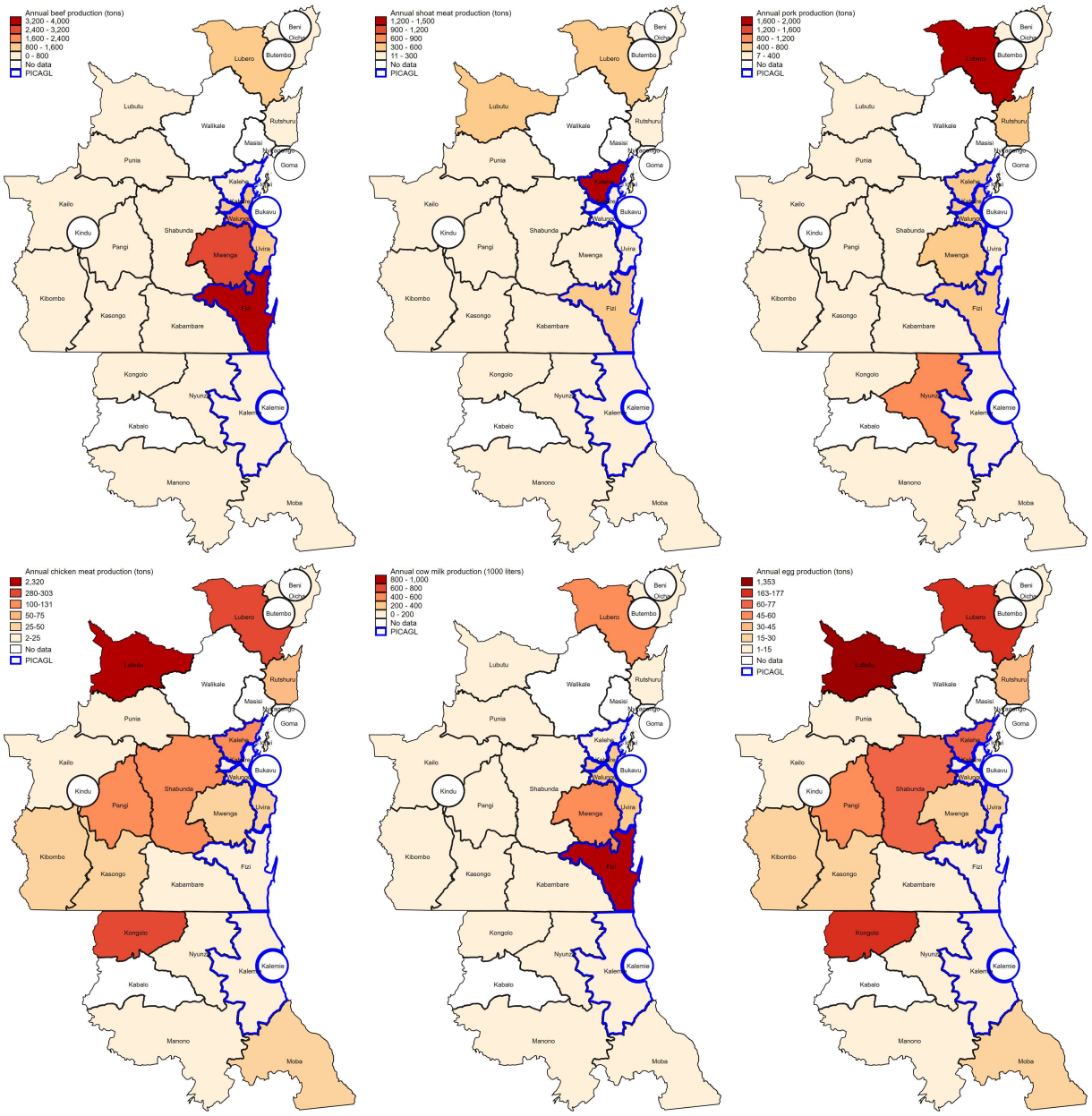
Source: The Authors based on CAID-FAO-WFP data (2017/18).

Figure 4. Livestock distribution, East-DRC (2017-2018)



Source: The Authors based on CAID-FAO-WFP data (2017/18).

Figure 5. Annual meat, milk and egg production, East-DRC (2017-2018)



Source: The Authors based on CAID-FAO-WFP data (2017/18) and Bacigale et al. n.d.; Batumike Banywesize 2018; Bisimwa Ntagereka n.d.-a, n.d.-b; FAO 2005, 2012; Ndomba Katokolo W'Owanga 2015; Otte and Chilonda 2002.

3. REVIEW OF FOOD VALUE CHAIN STUDIES IN EASTERN DRC

A food value chain generally refers to a sequence of activities and transactions operated by firms or/and individuals to produce and deliver food to end consumers. Key to any type of value chain analysis is the importance attached to the complex interaction and multiple linkages between actors in the course of creating value along the chain (Webber & Labaste, 2010). As such, value chain development refers to interventions aiming to connect, improve or strengthen linkages, not only horizontally (among actors operating at similar stages in the value chain) or vertically (between sequential stages in the value chain), but also with respect to the broader food system and food environment shaped by policies and public authorities (Devaux et al. 2018, Stoian et al. 2012). Specific topics of agricultural value chain analysis in Africa very much center around issues related to trust and cooperation, governance and market power, and innovation and knowledge sharing (Webber & Labaste, 2010). These same issues, combined with increased insecurity and deficient provision of public goods and basic infrastructure, very much determine the performance of agricultural value chains in the DRC.

For example, the National Agricultural Investment Plan (NAIP), elaborated by the DRC's Ministry of Agriculture and Rural Development in 2013, contains detailed information on the general opportunities and challenges to transform the agriculture sector into an engine for growth, food security and employment by 2020. The NAIP lists required investments to sustainably promote crop, livestock and fish value chains while stressing the importance of research development and its dissemination of evidence, the promotion of sound governance, gender equity, human and institutional capacity as well as resilience to climate change. To stimulate each of the agricultural value chains, the DRC's NAIP also points to the development of agroindustry through the creation of growth poles and agroindustrial parks. Given the strategic and unifying nature of this policy document, the NAIP however fails to identify concrete bottlenecks and opportunities to upgrade value chains in each region (MINAGRIDER, 2013).

That gap was later addressed in a series of reports produced by *IDEA Consult International* (2014a, 2014b, 2014c, 2014d). This consulting firm implemented surveys among 1600 value chain operators and conducted around 50 focus group discussions across the DRC to help the Congolese government formulate strategies to revive the agriculture sector and related agroindustry. For most, if not all, selected agricultural value chains, the DRC has a sizeable international comparative advantage, as indicated by measures such as the Domestic Resource Cost ratio. This is further confirmed by SWOT analyses conducted with key stakeholders which underscored the unique and favorable agroecological endowments of the country combined with increasing international and domestic demand for various products and primary materials. Against these generic strengths and opportunities, most of the agricultural value chains in the DRC are confronted with equally generic weaknesses, such as the country's poor enabling environment as exemplified by its dilapidated infrastructure, lack of support services and depletion of all sorts of capitals (see also Marivoet et al. 2018). Some of the constraints might be more chain- or location-specific, such as those related to plant and animal diseases or to various degrees of international competition or levels of insecurity. However, discouraging and unpredictable taxation, theft and hassle are cited among the cross-cutting factors impeding the development of agricultural value chains in the DRC (IDEA Consult International, 2014a).

More tailored to the eastern part of the DRC and the commodity chains considered under PICAGL, cassava has been identified by IDEA Consult International as a priority value chain to various territories of Maniema, where its production has been recently incentivized through the introduction of improved varieties. Being the most important national staple and a good substitute for imported wheat, domestic demand for cassava will remain solid. In addition, there is little threat of international competition. In addition, cassava is also increasingly used as animal feed. In contrast, productivity and processing capacity of cassava (for example milling facilities) are generally poor or absent. Despite having less potential, the cassava value chain could be equally profitable in Sud-Kivu and northern Katanga, which is more proximate to the PICAGL axis.

With respect to rice, the same consulting firm highlights Maniema for its potential to upgrade the current value chain. Indeed, rice production is already substantial in this area of the DRC, especially in the territories of Pangi and Kasongo where big rice mills used to operate. Furthermore, as only 0.5% of arable land is currently under cultivation, there is a lot of untapped agricultural potential. On the demand side, breweries also increasingly tend to use rice as raw material for beer production. In contrast, there is fierce international competition, as shown by increasing rice imports. As a result, developing an efficient rice value chain along the PICAGL axis (probably on the Ruzizi plains between Bukavu and Uvira) certainly shortens the distance to domestic markets, but also increases vulnerability to international competition.

Regarding the development of cattle value chains, IDEA Consult International lists Nord-Kivu, Sud-Kivu and northern Katanga as priority areas, based mainly on favorable breeding conditions for different animal types combined with the growing demand for meat and derived products domestically as well as worldwide. Whereas livestock farming and its related processing into dairy products, such as milk and cheese, appear to be at best semi-intensive in Sud-Kivu and northern Katanga, the same value chains attract substantially bigger and more industrial players in Nord-Kivu. Related to the PICAGL corridor, it is important to note that any upgrading of the cattle value chain may not only result in increased meat supply in the more populated markets of Nord- and Sud-Kivu but may also reach markets as far as Lubumbashi. Indeed, the territory of Moba, between Kalemie and Pweto, was traditionally home to various industrial or semi-industrial livestock actors whose herds were largely decimated due to war and insecurity. Any economic activity south of the PICAGL axis will create both additional market opportunities as well as additional competition (IDEA Consult International, 2014a).

For the value chains considered under the PICAGL framework, Table 2 reprints the profitability rates as estimated by IDEA Consult International. Overall, the value chains of cattle meat and rice appear to be three times more profitable than cassava which generates only a profit of 1.9 *Franc Congolais* (FC) for every FC invested in the chain. In addition, profit margins are almost equally shared between cassava farmers and traders, that is 1.1 and 0.8 respectively. In contrast, the rice value chain in the DRC not only presents higher profitability rates overall, the financial position of farmers is substantially better, with profitability rates being twice as high compared to traders and processors. The high profit margin for rice farmers underscores the importance generally attached to this crop. Regarding cattle meat, overall profitability is higher for meat originating from traditional compared to modern breeders and largely in line with profit margins observed in the rice chain. However, the position of livestock farmers is much less dominant compared to rice, especially for the chain of modern cattle meat where traders and processors (butchers) show higher profits margins (IDEA Consult International, 2014a).

Table 2. Profitability rates for various actors in cassava, rice and cattle meat value chains, DRC (2014)

Profit rate (profit/total chain cost)	**Cassava**	**Rice**	**Cattle meat**	
			Traditional	Modern
Farmer	1.1	3.6	2.6	1.4
Traders	0.8	1.8	2.4	2.4
Processors	.	1.6	1.6	1.6
Restaurant owner	.	.	1.0	1.0
Total	1.9	6.9	7.6	6.4

Note: Profitability rates listed in this table are not necessarily representative to the eastern part of the DRC.
Source: Reprinted from IDEA Consult International (2014c).

In 2015, USAID (2015) conducted a value chain assessment for six agricultural crops in both Kivu and Katanga; however, only the livestock component matched with PICAGL's focus. Despite its historical tradition and the nutritional potential in providing animal proteins and calcium, developing or

reviving the livestock and derived milk value chain in the Kivu region proves to be complicated. Among the constraints, USAID (2015) cites competition for land with crop farmers, the lack of quality breeding and improved feeding methods, and people's reluctance to keep large animals out of fear for thieves and pillagers. If these constraints were overcome, it remains unsure whether the meat and milk sector in Kivu could finally compete with low-priced imports of reasonable quality coming from Rwanda, South Africa and Europe.

Apart from the studies discussed above, there is little documented evidence on the three value chains under review in combination with a geographical focus on Eastern DRC. Mumbeya (2011) conducted a cassava value chain and market integration analysis and pointed out the high segmentation of markets across the country, but without a particular focus on the eastern part of the DRC.[9] In a similar vein, Birachi et al. (2013) and Njingulula et al. (2014) did focus on the Kivu region[10], but included other agricultural value chains such as banana and bean (seeds), respectively. The latter studies both stress the importance of farmers being organized in order to upgrade their respective value chains, to have more bargaining power and thus become less vulnerable to middlemen, and/or to be able to penetrate more profitable and distant markets. Aside from fragments of information pertaining to other value chains, there is very little knowledge on consumer preferences overall, let alone more detailed information on quality, taste, or food safety considerations.

Compared to the limited number of value chain analyses, the literature on violence/conflict and its complex interplay with mineral resources is abundant (for example, see Maystadt et al. 2014; Stearns 2014). Although there is no doubt that such factors have an immediate impact on the development of agricultural value chains, their precise direction and mechanisms are largely unknown. Intuitively, insecurity will in general discourage potential investors in value chain development while the mining sector may provide attractive employment alternatives to agriculture. In contrast, some studies on Eastern DRC point to increased economic exchange and market integration, not despite of, but rather *due to insecurity*, both indirectly, through the massive presence of humanitarian actors, or more directly, by so-called *entrepreneurs of insecurity* (Marivoet, 2016; Vlassenroot et al., 2012). Anyhow, any value chain analysis in Eastern DRC will need to seriously consider the dimension of insecurity as well as the opportunity cost provided by the mining sector.

[9] Despite its more country-wide perspective, the results of this study do illustrate that the city markets of Goma (Nord-Kivu) and Bukavu (Sud-Kivu) are highly integrated, which results from their relative proximity and acceptable quality transport infrastructure.

[10] Birachi et al. (2013) also focused on the neighboring markets of Rwanda (Irish potato) and Uganda (sorghum).

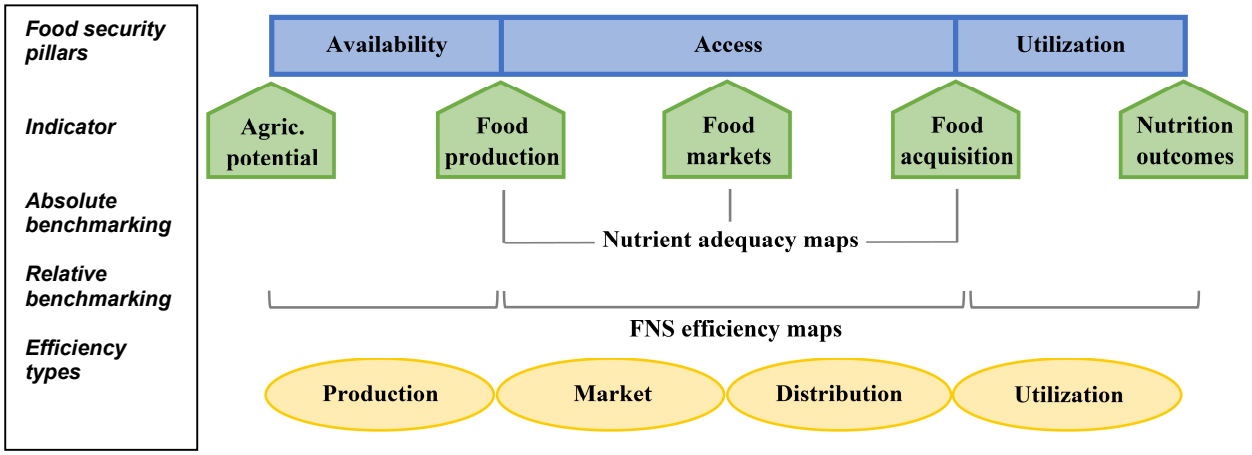
4. APPLICATION OF SPATIAL TYPOLOGIES TO TERRITORIES OF GREATER KIVU REGION AND TANGANYIKA

Given limited available information on food value chains as reviewed above, this section combines two existing spatial typologies to generate more insight into the range of obstacles and opportunities to improve FNS in Eastern DRC. Although not focused on any particular value chain, these typologies capture crucial information at various stages within the food system. As such, additional evidence is generated to both complement and cross-check existing knowledge. An attractive feature of these typologies is that they are light in terms of data requirements, while the unit of analysis (in this case, territories and major cities) allows merging data of different nature.

Figure 6 combines the conceptual schemes used for both typologies.[11] The basic technique for each typology involves the estimation and comparison of pairs of indicators along sequential stages of the food value chain. These stages roughly mimic three of the basic pillars of food security, known as availability, access and utilization (Pangaribowo et al., 2013). Key indicators along the food chain are indicated in green. The core difference between both typologies relates to their type of benchmarking. Whereas absolute benchmarking requires only one indicator and a reference value (which in our case is based on population food needs), relative benchmarking involves the comparison of two sequential indicators.

The first typology will present maps with food energy and protein adequacy levels at three critical stages; that is whether enough kilocalories or proteins are produced, marketed and acquired by households to cover the needs of a fixed and *absolute* number of people. These maps can guide the selection of food items to be targeted for increased production, market availability or consumption while loosely pointing to corresponding bottlenecks at each stage.

Figure 6. Conceptual scheme underneath both typologies



Source: The authors.

Relative benchmarking on the contrary focuses on a geographical area's performance *relative* to its own performance earlier in the food chain and that of other areas. Such benchmarking is obtained by comparing two sequential indicators, whereby each pair reflects another type of efficiency. For example, production efficiency evaluates actual agricultural production relative to its potential; access efficiency is measured as a function of local food production; and utilization efficiency assesses nutrition outcomes in relation to household food access. Relying on these three efficiency types, the second typology will map and identify the most critical bottlenecks to improved nutrition outcomes for each geographical area.

[11] More details on the precise methodology for each typology can be found in Marivoet et al. (2019), and Marivoet and Ulimwengu (2018).

Information from both types of benchmarking is key to guide policies. Indeed, if an area is not producing enough food to properly nourish its population (i.e. low production adequacy), the appropriate policy response might involve strategies to remove production barriers (in case production efficiency is low compared to similar areas) or to increase market integration with areas generating agricultural surplus (in case production efficiency is relatively high). The latter combination of *low absolute* and *high relative* production efficiency may be explained by a lack of agricultural potential. Similar examples can be formulated for other food security stages and underscores the importance of distinguishing absolute and relative efficiencies. In sum, people might go undernourished due to a varying set of obstacles along the full chain from farm to fork. Policies and strategies to overcome these constraints not only require knowledge on how they add up in absolute terms, but also where relative leverage is found upstream or downstream within the same food chain or in proximate areas.

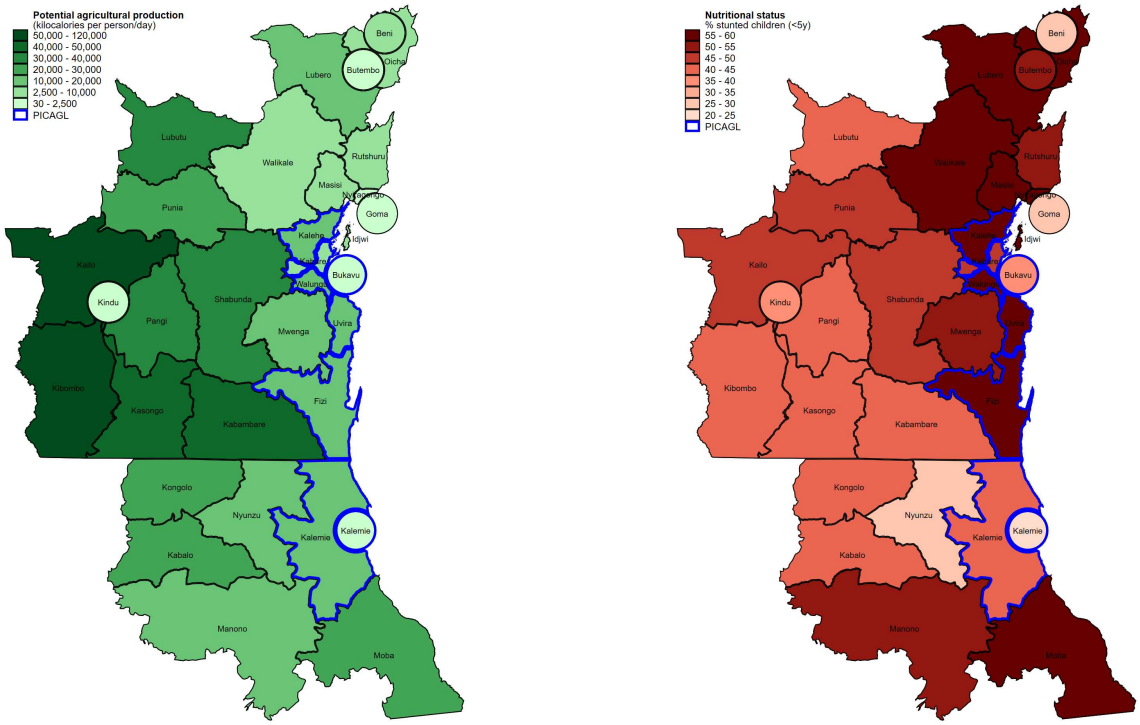
In addition to the maps generated for both typologies, we will use the market adequacy indicator from the first typology to further subdivide the level of access efficiency of the second typology into a component of market and distribution efficiency. Whereas the former evaluates the spatial link between food production and markets, the latter focuses on assessing its subsequent flow into the household food basket. Market inefficiency therefore may point to various transportation and transaction constraints, post-harvest losses or missed opportunities for increased trade or market integration. Distribution inefficiency relates to issues of food unaffordability and lack of nutrition knowledge among the population. This additional distinction allows to sketch a more complete picture of the various inefficiency types characterizing each individual area in Eastern DRC.

Technically, efficiency levels for both additional components are derived following a largely similar methodology as the one used for production, access, and utilization efficiency. This method first involves the estimation of mean expected efficiency based on data of all territories and cities before defining a 75-125% fork to distinguish low, average, and high efficiencies. Two distinctive features however should be noted with respect to market and distribution efficiency. First, the fork to define average efficiency for each component is reduced to 87.5-112.5%, which is half the original fork size set for the access dimension. Second, final levels of market and distribution efficiency are based on the lowest corresponding efficiency level observed for calorie, protein, and vitamin B12. Both adaptations result in consistent outcomes between access efficiency on the one hand and market and distribution efficiency on the other hand.

Before discussing the typology findings, Figure 7 illustrates the agricultural paradox faced by most of the 33 areas in Greater Kivu and Tanganyika. The left-hand side map displays the total amount of calories per person that *could* be produced daily. This estimate of agricultural potential is obtained using remote sensing data (to first identify immediately arable land) and by theoretically applying improved yield rates (obtained from official field stations) while accounting for prevailing food preferences. The right-hand side panel presents stunting rates of children below the age of 5 years old. Although both measures fail to grasp the full notion of agricultural potential and human nutrition, the visual opposition of their respective maps leaves little doubt as to the extent of the agricultural paradox.

Apart from the region's major cities where potential agricultural production mostly falls below 2,500 kilocalories per day, all areas in Greater Kivu and Tanganyika can easily produce the required amounts of food to properly feed their respective populations. Due to lower population densities, the in-land areas (especially those in Maniema) on average have higher agricultural potential – amounting to more than 30,000 kilocalories per person per day. In contrast, stunting rates of children below the age of five years are alarmingly high throughout the region; especially in various territories in Nord-Kivu as well as along the PICAGL corridor and in Moba, where they exceed 55%. Due to higher access to improved water sources, sanitation and health services, the major cities within this region perform relatively better in terms of chronic child malnutrition.

Figure 7. Agricultural paradox, East-DRC (2017-2019)



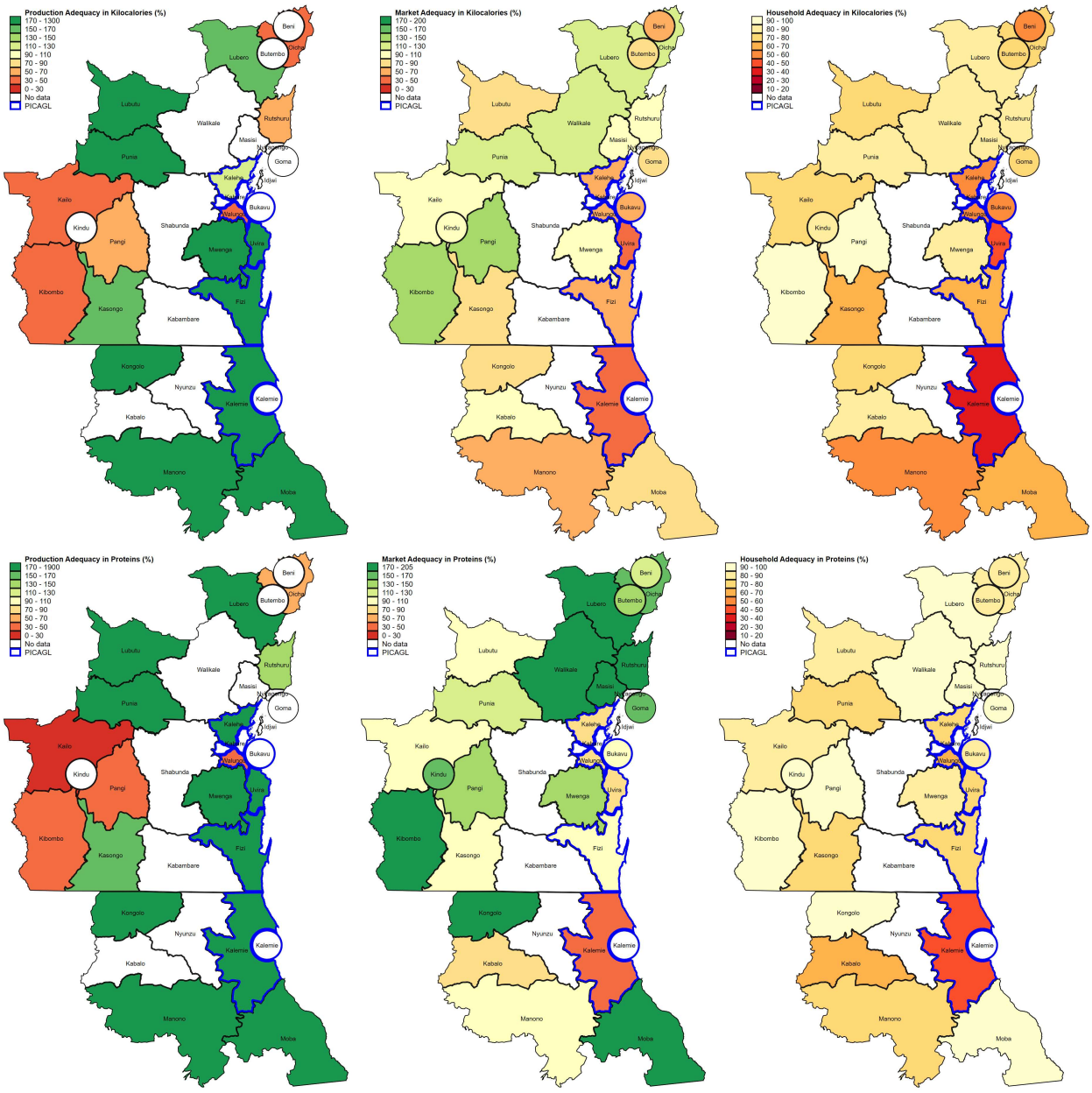
Source: Authors with data from Brown de Colstoun et al. (2017); Hansen et al. (2013); HDX (2020); INS (2019); Pekel, Cottam, Gorelick, & Belward (2016); République démocratique du Congo (2014b); Stadlmayr et al. (2012); UNEP-WCMC (2018); Xiong et al. (2017).

Figure 8 presents maps with absolute production, market and household adequacies for kilocalories and proteins. Despite significant levels of untapped agricultural potential (as can be inferred from Figure 7), most territories register production adequacy ratios (well) above 100% for both calories and proteins (see left-hand side maps). In contrast, with adequacy rates well below 70%, the territories of Kailo, Kikombo and Pangi in Maniema are far from producing enough calories and proteins – regardless of the very high levels of agricultural potential observed in that region. In addition, less than 70% of total calorie needs are covered by agricultural production in Rutshuru, Oicha and Walungu, and the same applies for protein needs in the latter two territories. Apart from Walungu, the areas covering the PICAGL corridor perform well with production adequacy rates well above 100% for both calories and proteins.

In contrast, the market performance of most PICAGL areas appears among the weakest within the entire region (see middle maps in Figure 8). This is especially the case for the territories of Uvira and Kalemie where less than 50% of total calorie needs reach the market while the same also applies to proteins in Kalemie. To some extent, this observation logically results from food being produced in rural areas to supply urban centres. However, given the underperformance of the PICAGL corridor compared to other areas in the region, low market adequacies may also stem from various types of post-harvest losses (PHL). Comparing market adequacies of calories and proteins, the assumed PHL appear to involve calorie-rich rather than protein-rich food items. In the case of Eastern DRC, this may be related to cassava, which after harvest is a highly perishable crop that requires prompt transformation into derived products such as cassava chips and flour (Ferraro et al., 2016). In contrast, food items rich in vegetal and animal proteins may be less subject to PHL; the former since they are found in beans, pulses and nuts, which can be easily dried and stored, and the latter because it involves the production of meat and animal-based food items which are processed with less constraints regarding the agricultural calendar and therefore more deliberately implemented. Contrary to their inadequate agricultural production, market adequacies are distinctly higher for Kailo, Kikombo, Pangi, Rutshuru, Oicha and Walungu, which points

to lower levels of PHL and/or improved market linkages with neighbouring territories or areas outside the Greater Kivu region and Tanganyika.

Figure 8. Absolute food energy and protein adequacies, East-DRC (2012-2018)

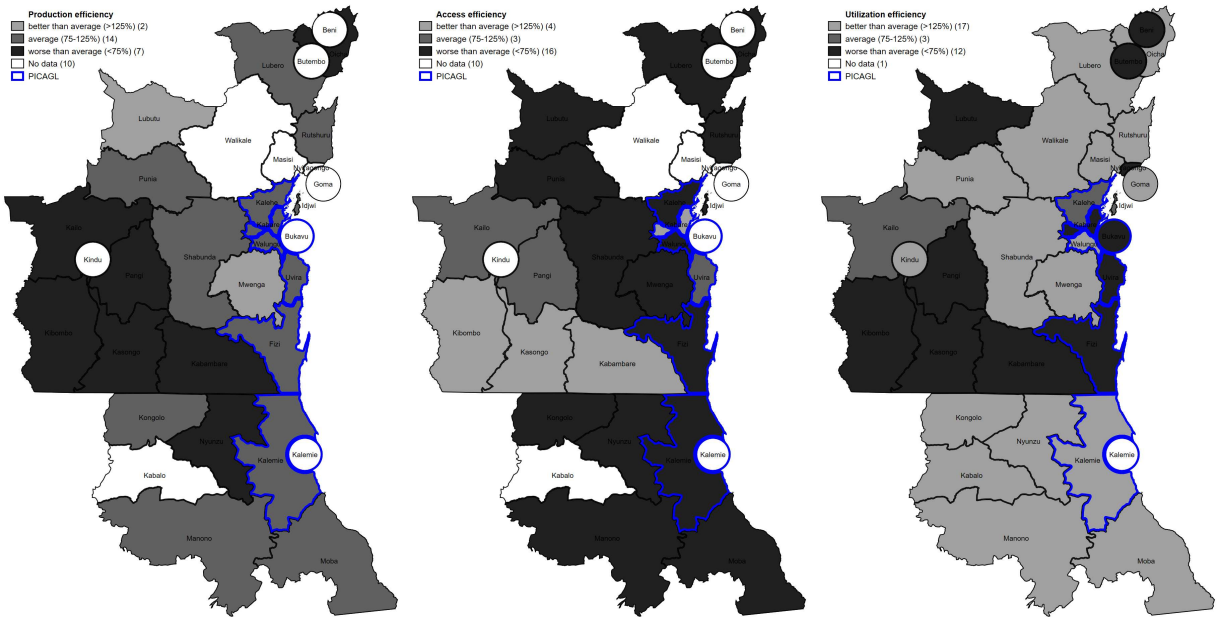


Source: Authors with data from Bacigale, Manyawu, Nabahungu, Okafor, & Duncan (n.d.); Batumike Banywesize (2018); Bisimwa Ntagereka, (n.d.-b), (n.d.-a); FAO (2005, 2012); MINAGRI (2018); Ndomba Katokolo W'Owanga (2015); Otte & Chilonda (2002); République démocratique du Congo (2014b); Stadlmayr et al. (2012).

Finally, household adequacies for both calories and proteins largely mimic those of the market, with populations in various PICAGL territories on average recording the lowest rates (see right-hand side maps of Figure 8). Again, the same territories perform worst in this respect, that is Kalemie and Uvira where households on average reach less than 50% of their required calories, and the same also applies to proteins in Kalemie.

Figure 9 presents the typology results using relative benchmarking. Consistent with previous observations, low production efficiencies are found in various territories of Maniema as well as in Oicha and Nyunzu (see left-hand side map). In contrast, Mwenga and Lubutu record better-than-average production efficiencies. In terms of access efficiency (see middle map) and equally in line with the discussion above, we observe that the same areas in Maniema perform better while most other territories (including those in the PICAGL corridor) do worse compared to what is on average expected in the region. Sufficient access to a diverse set of food items however does not necessarily translate into decent levels of nutrition, which is affected by utilization constraints such as cooking habits, intra-household food allocations and the broader sanitary and health conditions in which this consumption takes place. The right-hand side map sketches a very unequal distribution of utilization efficiencies with only three territories (Kalehe, Kailo and Idjwi) recording an average performance while all other territories either perform significantly better or worse. Areas with low utilization efficiency involve most rural territories of Maniema (except Kailo and Punia), various territories of the PICAL corridor in South Kivu as well as the cities of Bukavu, Beni and Butembo.

Figure 9. Relative FNS efficiencies, East-DRC (2017-2019)



Source: Authors with data from Bacigale, Manyawu, Nabahungu, Okafor, & Duncan (n.d.); Batumike Banywesize (2018); Bisimwa Ntagereka, (n.d.-b), (n.d.-a); Brown de Colstoun et al. (2017); CAID (2020); FAO (2005, 2012); Hansen et al. (2013); HDX (2020); INS (2019); MINAGRI (2018); Ndomba Katokolo W'Owanga (2015); Otte & Chilonda (2002); Pekel, Cottam, Gorelick, & Belward (2016); République démocratique du Congo (2014b); Stadlmayr et al. (2012); UNEP-WCMC (2018); WFP (various years); Xiong et al. (2017).

By subdividing access efficiency into its components as explained above, Table 3 presents an overview of each area's stunting level and corresponding FNS efficiency profile. These profiles are defined based on observed combinations of low efficiencies. The first four profiles involve areas with only one type of inefficiency, that is either a low production, market, distribution or utilization efficiency. Profiles 5-9 include various combinations of low efficiencies. For example, Kailo's and Oicha's high stunting rates could best be reduced by focusing on the removal of production and distribution constraints. In contrast, the territories of Uvira, Fizi and Lubutu will mostly benefit from improving market and utilization efficiencies since their performance in these domains is significantly lower than what is on average observed in the region.

Based on these low efficiency types, Figure 10 maps all possible combinations for each of the territories and cities in Greater Kivu and Tanganyika. Despite pronounced diversity throughout the region, some spatial clustering of challenges can be observed, which might be helpful while technically and logistically implementing interventions. For example, the territories of Pangi, Kasongo and Kabambare all suffer from low production and utilization constraints. If the first constraint is due to lack of knowledge about good agronomic practices and the second because of poor sanitary conditions, agricultural extension services could be complemented with a training on improving hygiene practices within farming households, all targeting the three mentioned areas at once. A similar observation applies to the clustered territories of Walikale, Masisi and Rutshuru, which all three suffer from low distribution efficiency.

Likewise, all areas along the PICAGL corridor most critically suffer from only two forms of inefficiencies, resulting in three separate profiles. Whereas the populations of Bukavu and Kabare will mostly benefit from the removal of utilization constraints, nutritional status of children in Kalehe, Walungu and Kalemie could best be improved by addressing market constraints. The remaining territories of the PICAGL axis, that is Uvira and Fizi, suffer from a combination of market and utilization constraints. Given observed market inefficiencies within the corridor stretching from Kalehe to Kalemie, interventions and policies which aim to upgrade food value chains could be an effective strategy to improve FNS among the population.

As pointed out by Badibanga & Ulimwengu (2020), the agricultural sector in the DRC in general and the eastern part in particular also faces a number of cross-cutting challenges including: i) a deficit in public governance that affects the private sector and significantly increases transaction costs; ii) a weak organization of financial services, reducing options for smallholder farmers to access improved inputs and equipment; iii) inadequate infrastructures (such as roads, electricity grids, collection centers, warehouses), and iv) a dualistic land tenure system torn between customary practice and administrative management which results in land insecurity and prevents essential productive investments. These institutional, infrastructure, and organizational constraints must be addressed to unlock agricultural potential. This will require the involvement of various stakeholders including the government and private sector.

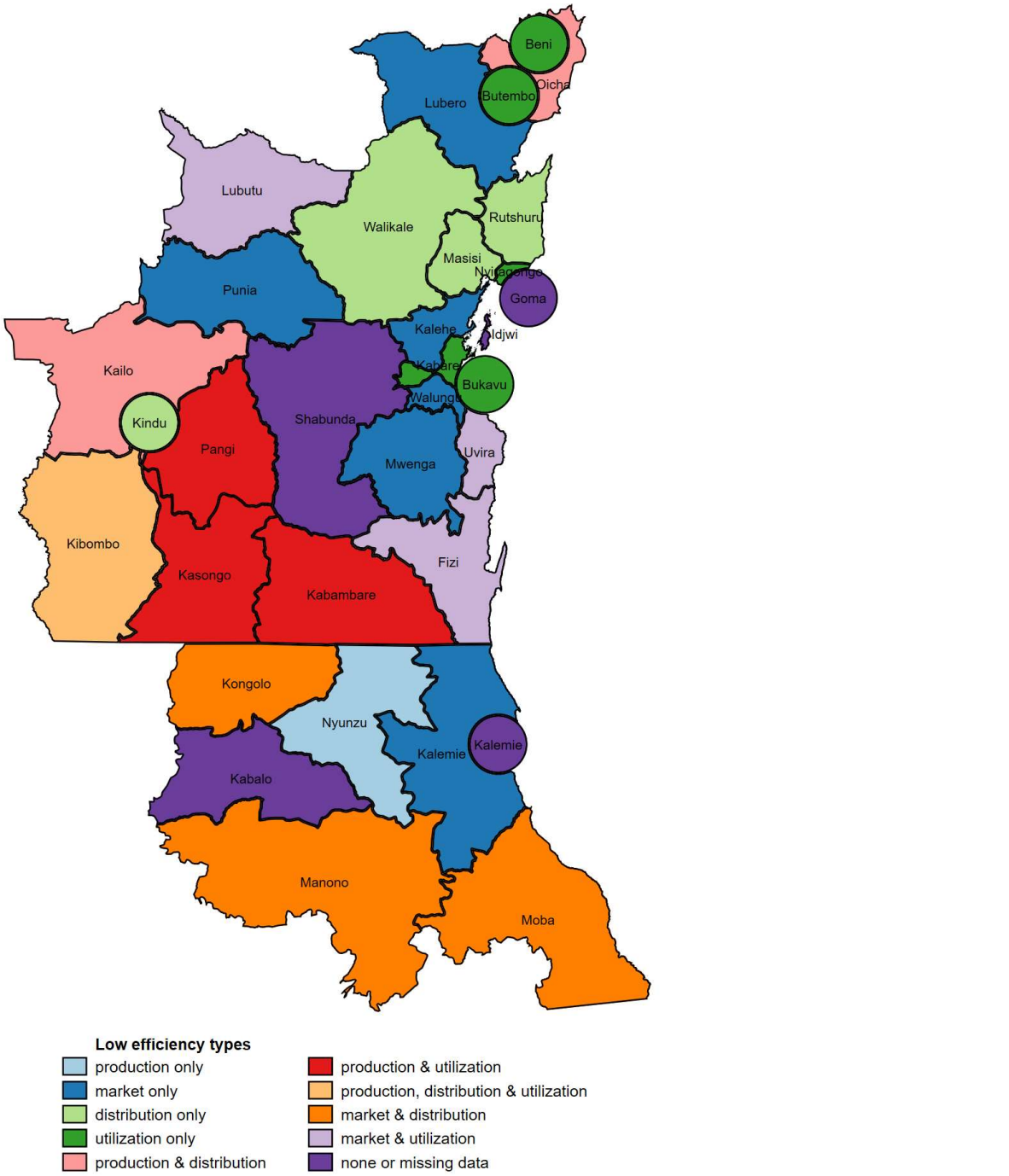
Table 3. FNS efficiency profile, East-DRC (2017-2019)

	Area	Stunting (%)	Efficiency type			
			production	market	distribution	utilization
1	Nyunzu	30	**low**	na	na	high
2	Lubero	57	average/high	**low**	average/high	average/high
	Walungu	**57**				
	Kalehe	**57**				
	Kalemie (terr.)	**42**				
	Mwenga	53				
	Punia	47				
3	Walikale	57	average/na	high/na	**low**	average
	Kindu	37				
	Masisi	57				
	Rutshuru	55				
4	Butembo	53	average/na	na	average/high/na	**low**
	Beni	28				
	Bukavu	**36**				
	Kabare	**47**				
	Nyiragongo	57				
5	Kailo	47	**low**	high	**low**	average/high
	Oicha	57				
6	Kabambare	45	**low**	high/na	average/na	**low**
	Pangi	45				
	Kasongo	45				
7	Kibombo	45	**low**	high	**low**	**low**
8	Kongolo	43	average	**low**	**low**	high
	Manono	54				
	Moba	56				
9	**Uvira**	**57**	average/high	**low**	high	**low**
	Fizi	**57**				
	Lubutu	45				
10	Kabalo	41	average/na	na	average/na	average/high/na
	Idjwi	57				
	Shabunda	45				
	Goma	28				
	Kalemie (city)	**22**				

Note: Territories/cities are grouped under the same profile if they share the same combination of low efficiencies, which is indicated in bold. Areas covering the PICAGL corridor are equally indicated in bold. "na" means that data were missing to estimate the corresponding efficiency type.

Source: Authors with data from Bacigale, Manyawu, Nabahungu, Okafor, & Duncan (n.d.); Batumike Banywesize (2018); Bisimwa Ntagereka, (n.d.-b), (n.d.-a); Brown de Colstoun et al. (2017); CAID (2020); FAO (2005, 2012); Hansen et al. (2013); HDX (2020); INS (2019); MINAGRI (2018); Ndomba Katokolo W'Owanga (2015); Otte & Chilonda (2002); Pekel, Cottam, Gorelick, & Belward (2016); République démocratique du Congo (2014b); Stadlmayr et al. (2012); UNEP-WCMC (2018); WFP (various years); Xiong et al. (2017).

Figure 10. Low efficiency combinations, East-DRC (2017-2019)



Source: Authors with data from Bacigale, Manyawu, Nabahungu, Okafor, & Duncan (n.d.); Batumike Banywesize (2018); Bisimwa Ntagereka, (n.d.-b), (n.d.-a); Brown de Colstoun et al. (2017); CAID (2020); FAO (2005, 2012); Hansen et al. (2013); HDX (2020); INS (2019); MINAGRI (2018); Ndomba Katokolo W'Owanga (2015); Otte & Chilonda (2002); Pekel, Cottam, Gorelick, & Belward (2016); République démocratique du Congo (2014b); Stadlmayr et al. (2012); UNEP-WCMC (2018); WFP (various years); Xiong et al. (2017).

5. CONCLUSIONS, POLICY RECOMMENDATIONS AND KNOWLEDGE GAPS

In a country where poverty is widespread and development challenges ubiquitous, it is difficult to prioritize among mutually exclusive policies and intervention areas. By combining two spatial typologies, this paper presents a series of maps to help identify and locate key bottlenecks to improved nutrition security at territorial level in Eastern DRC. Using absolute and relative benchmarking techniques and despite their reductionist nature, each of the typology maps point to a different type of inefficiency. Most conceptual innovation resides in subdividing the access dimension in two separate components, that is market and distribution efficiency. Whereas market efficiency evaluates the supply of food markets, distribution efficiency focuses on the subsequent flow of food into the household basket. In addition to conceptual improvements, this paper relies on the most recent and most spatially disaggregated agricultural production data collected in 2017/18 while providing indirect estimates of meat, milk and egg production based on livestock populations and corresponding offtake rates. Although data quality concerns remain, the latest agricultural statistics constitute a huge advance compared to past attempts of estimating the size of the agriculture sector in the DRC.

The typology results and value chain review discussed in this paper both corroborate with the generally accepted view of a country endowed with huge agricultural potential but failing to lift millions of its population out of poverty and food insecurity. This general incongruity is explained by various combinations of inefficiencies along the entire FNS chain. For the Greater Kivu region and Tanganyika, nine unique relative inefficiency profiles were identified. Despite significant spatial variation across the region, territories along the PICAGL corridor suffer from only two basic forms of inefficiencies, that is market and/or utilization constraints. Most affected in terms of market inefficiency are the territories of Uvira and Kalemie, where less than 50% of total calorie needs reach the market while food is more than abundantly produced in both territories. This observation combined with lower market inefficiencies for protein, may point to significant PHL of cassava and other highly perishable tubers. To a lesser extent, Kalehe, Walungu and Fizi could also benefit from the removal of market constraints. In addition, the populations of Bukavu, Kabare, Uvira and Fizi are suffering from high utilization inefficiencies, which may involve intra-household allocations inadequacies, imperfect cooking habits and various health-related constraints.

With the NAIP expiring in 2020 and all individual provinces being asked to develop their own investment plan based on newly developed national guidelines, the typology profiles presented in this paper could be useful to guide the design and implementation of future provincial policies on agricultural and food value chains development. Indeed, despite being reductionist by construction, the typology results provide for more spatial precision than what is currently available in South Kivu's Provincial Development Plan (PDP) and Tanganyika's Integrated Agricultural Project (TIAP). Both policy documents and corresponding priority actions make perfect sense in general, though they either lack clear identification of target zones or the selected areas do not neatly match the issues highlighted in the typology profiles. For example, South Kivu's PDP does not specify where production capacity and agro-pastoral skills should be improved, nor where crop value chains and animal-based processing should be developed (RDC/Province du Sud-Kivu, 2019). Similarly, TIAP aims to revive food production and processing activities in *all* six territories of Tanganyika. Furthermore, given its significantly lower household adequacy for protein, most attention to revive the livestock sub-sector could be devoted to Kalemie as opposed to other territories mentioned in TIAP where protein intake is higher (RDC/Province du Tanganyika, 2017). With expected impact spanning beyond the agriculture sector, both key policy documents also discuss the need to implement or rehabilitate basic infrastructure; however, without much needed geographical targeting.

With respect to the PICAGL project and its main intervention zone stretching from Bukavu to Kalemie, all activities related to upgrading of food value chains and development of agribusinesses are warranted given the lower-than-average market efficiencies observed in most areas. This involves among other things the improvement of agricultural infrastructure, such as post-harvest facilities and agricultural service roads. On the contrary, activities aimed at increasing agricultural productivity appear less critical

in these areas as production efficiency is not significantly lower compared to what is on average observed in other territories in Eastern DRC.

Although the present analysis generates the first essential layer of information on what sort of intervention would be most promising in each location, important knowledge gaps remain. First, apart from a crude indication of the types of inefficiency, the typology profiles remain silent on the precise bottlenecks – let alone the exact factors behind the constraints. For example, we may be confident that the most crucial constraint in the PICAGL corridor is market-related, but more information is required to know whether the crux of the matter lies in transportation infrastructure, lack of storage facilities causing substantial PHL, informal taxation or any other constraint operating between production sites and markets. In addition, it is important to understand how actors in the value chain (upstream, downstream and at the same stage) currently collaborate or counteract each other in addressing prevailing constraints. To shed more light on these issues, a comprehensive value chain analysis is highly commendable, which could also provide for a much-needed quality check of current agricultural production statistics.

Given the wide range of issues facing agricultural value chains in Eastern DRC, our findings call for a comprehensive approach involving all actors at every stage of the food system. Critical to such inclusive process is the role of the DRC government. First, the government must create an enabling business environment for farming and agribusiness, which involves a stable political, legal and conducive financial environment. Second, the DRC government has the responsibility to put in place efficient institutional and legal frameworks that govern the entire agricultural sector, including input and output markets, finance and insurance, machinery and farm equipment supply, marketing, and trade. Third, the government must also initiate institutional reform in supporting facilities, including R&D, agricultural training and education, technical service delivery, and multisectoral planning. The DRC government however does not have the resources and capacities to lift all the constraints identified in the study by itself. Therefore, we encourage the development of partnerships between the public sector, the private sector, international organizations, and NGOs. As pointed out by Poulton and Macartney (2012), Public-Private Partnerships in many African countries do help leverage private investment in poorly functioning agricultural value chain parts and enable agro-dealers to expand their operations.

REFERENCES

Bacigale, S. B., Manyawu, G. J., Nabahungu, L. N., Okafor, C. C., & Duncan, A. (n.d.). Assessing the livestock herd dynamics along the 'Solidarity Chain' structure in Sud-Kivu province, Eastern DR Congo. Crop-Livestock integration Project (CLiP).

Badibanga, T., & Ulimwengu, J. (2020). Optimal investment for agricultural growth and poverty reduction in the Democratic Republic of Congo a two-sector economic growth model. Applied Economics, 52(2), 135–155.

Batumike Banywesize, F. (2018). Evaluation du rendement à l'abattage des bovins selon leurs lieux de provenance : cas de l'abattoir central de Bukavu (ELEKAT). International Journal of Innovation and Scientific Research, 36(2), 110–118.

Birachi, E., Karume, K., Kyamuhangire, W., Chiuri, W., Mugabo, J., Tumwesigye, K. S., Kasenge, V., Bonabana-Wabbi, J., Tenywa, M. M., Nyamwaro, S. O., Bikuba, G., Habumugisha, P., Lubanga, L., Byamukama, J., Nyamurinda, B., Mandefu, P., Gafaranga, J., & Kamugisha, R. (2013). Expanding market access and value addition in selected agricultural value chains: the role of IAR4D in the Lake Kivu Pilot Learning Site. African Journal of Agricultural and Resource Economics, 8(3), 135–144. http://www.afjare.org/resources/issues/vol_8_no3/4. Karumi Birachi et al Expanded_market_value_addition (edited).pdf

Bisimwa Ntagereka, P. (n.d.-a). Caractérisation morphométrique des chèvres abattues dans les principaux abatoirs de la ville de Bukavu.

Bisimwa Ntagereka, P. (n.d.-b). Caractérisation morphométrique des porcs abattus dans les principaux abatoirs de la ville de Bukavu.

Brown de Colstoun, E. C., Huang, C., Wang, P., Tilton, J. C., Tan, B., Phillips, J., Niemczura, S., Ling, P.-Y., & Wolfe., R. E. (2017). Global Man-made Impervious Surface (GMIS) Dataset From Landsat. NASA Socioeconomic Data and Applications Center (SEDAC). https://doi.org/https://doi.org/10.7927/H4P55KKF

C. Soderlund, W., DonaldBriggs, E., PierreNajem, T., & C. Roberts, B. (2013). Africa's Deadliest Conflict: Media Coverage of the Humanitarian Disaster in the Congo and the United Nations Response, 1997–2008. Wilfrid Laurier University Press.

CAID. (2020). Cellule d'Analyses des Indicateurs de Développement. https://www.caid.cd/

Carletto, C., Jolliffe, D., & Banerjee, R. (2015). From Tragedy to Renaissance: Improving Agricultural Data for Better Policies. The Journal of Development Studies, 51(2), 133–148. https://doi.org/10.1080/00220388.2014.968140

Coghlan, B., Brennan, R. J., Ngoy, P., Dofara, D., Otto, B., Clements, M., & Stewart, T. (2006). Mortality in the Democratic Republic of Congo: A nationwide survey. Lancet, 367(9504), 44–51. https://doi.org/10.1016/S0140-6736(06)67923-3

Devaux, A., Torero, M., Donovan, J., & Horton, D. (2018). Agricultural innovation and inclusive value-chain development: a review. Journal of Agribusiness in Developing and Emerging Economies, 8(1), 99–123. https://doi.org/10.1108/JADEE-06-2017-0065

Ericksen, P. J. (2008). Conceptualizing food systems for global environmental change research. Global Environmental Change, 18, 234–245. https://doi.org/10.1016/j.gloenvcha.2007.09.002

FAO. (2005). Livestock sector brief, Democratic Republic of Congo (Issue June). Food and Agricultural Organization of the United Nations.

FAO. (2011). Guidelines for the preparation of livestock sector reviews. In Animal Production and Health Guidelines. No. 5. Food and Agriculture Organization of the United Nations.

FAO. (2012). Secteur porcin, République Démocratique du Congo. Revues nationales de l'élevage de la division de la production et de la santé animales. Food and Agricultural Organization of the United Nations.

FAO, WFP, & IFAD. (2011). The State of Food Insecurity in the World: How does international price volatility affect domestic economies and food security? Food and Agriculture Organization of the United Nations.

Ferraro, V., Piccirillo, C., Tomlins, K., & Pintado, M. E. (2016). Cassava (Manihot esculenta Crantz) and Yam (Dioscorea spp.) Crops and Their Derived Foodstuffs: Safety, Security and Nutritional Value. Critical Reviews in Food Science and Nutrition, 56(16), 2714–2727. https://doi.org/10.1080/10408398.2014.922045

Gillespie, S., & van den Bold, M. (2017). Agriculture, Food Systems, and Nutrition: Meeting the Challenge. Global Challenges, 1(3), 1–12. https://doi.org/10.1002/gch2.201600002

Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S. A., Tyukavina, A., Thau, D., Stehman, S. V., Goetz, S. J., Loveland, T. R., Kommareddy, A., Egorov, A., Chini, L., Justice, C. O., & Townshend, J. R. G. (2013). High-Resolution Global Maps of 21st-Century Forest Cover Change. Science, 342(November), 850–853. https://doi.org/10.1126/science.1244693

HDX. (2020). OCHA DR Congo. https://data.humdata.org/organization/ocha-dr-congo

Herforth, A., & Ahmed, S. (2015). The food environment, its effects on dietary consumption, and potential for measurement within agriculture-nutrition interventions. Food Security, 7(3), 505–520. https://doi.org/10.1007/s12571-015-0455-8

IDEA Consult International. (2014a). Elaboration de la Strategie de Relance de l'Agro-Industrie en RDC, Rapport A1: Elaboration des Ebauches de Strategie par Province. Ministere de l'Agriculture et du Developpement Rural de la RDC.

IDEA Consult International. (2014b). Elaboration de la Strategie de Relance de l'Agro-Industrie en RDC, Rapport A2: Elaboration des Ebauches de Strategie par Province. Ministere de l'Agriculture et du Developpement Rural de la RDC.

IDEA Consult International. (2014c). Elaboration de la Strategie de Relance de l'Agro-Industrie en RDC, Rapport B1: Ameliorations de l'Environnement des Affaires. Ministere de l'Agriculture et du Developpement Rural de la RDC.

IDEA Consult International. (2014d). Elaboration de la Strategie de Relance de l'Agro-Industrie en RDC, Rapport B2: Ameliorations de l'Environnement des Affaires. Ministere de l'Agriculture et du Developpement Rural de la RDC.

INS. (2019). République Démocratique du Congo, Enquête par grappes à indicateurs multiples avec volet paludisme (MICS-Palu 2017-2018). Institut National de la Statistique de la République Démocratique du Congo.

Jones, A. D., & Ejeta, G. (2015). A new global agenda for nutrition and health: the importance of agriculture and food systems. Bulletin World Health Organization, 94(December), 228–229. https://doi.org/10.2471/BLT.15.164509

Marivoet, W. (2016). Food Markets and Nutrition in the Democratic Republic of the Congo (2004–2005) (No. 01566; IFPRI Discussion Paper, Issue 01566). http://www.ifpri.org/cdmref/p15738coll2/id/130836/filename/131047.pdf

Marivoet, W., & De Herdt, T. (2017). From figures to facts: making sense of socioeconomic surveys in the Democratic Republic of the Congo (DRC) (No. 23; Analysis and Policy Brief, Issue May). http://ebrary.ifpri.org/utils/getfile/collection/p15738coll5/id/5832/filename/5833.pdf

Marivoet, W., Ulimwengu, J., & El Vilaly, M. A. S. (2018). Understanding The Democratic Republic Of The Congo's Agricultural Paradox: Based on the eAtlas Data Platform. ReSAKSS.

Marivoet, W., & Ulimwengu, J. M. (2018). Mapping Nutrient Adequacy for Targeted Policy Interventions, with application to Uganda (2013/14) (No. 01764). IFPRI Discussion Paper. http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/132901

Marivoet, W., Ulimwengu, J., & Sedano, F. (2019). Spatial typology for targeted food and nutrition security interventions. World Development, 120, 62–75. https://doi.org/10.1016/j.worlddev.2019.04.003

Maystadt, J.-F., De Luca, G., Sekeris, P. G., & Ulimwengu, J. (2014). Mineral resources and conflicts in DRC: a case of ecological fallacy? Oxford Economic Papers, 66(3), 721–749. https://doi.org/10.1093/oep/gpt037

MINAGRI. (2018). Sécurité alimentaire, niveau de production agricole et animale, Évaluation de la campagne agricole 2017-2018 et bilan alimentaire du pays. Ministère de l'Agriculture de la République Démocratique du Congo. https://reliefweb.int/sites/reliefweb.int/files/resources/WFP-0000098937.pdf

MINAGRIDER. (2013). Plan National d'Investissement Agricole (PNIA) 2013-2020. Ministère de l'Agriculture et du Développement Rural de la République Démocratique du Congo.

Mumbeya, N. P. (2011). A value chain and market integration analysis of the cassava market in the Democratic Republic of Congo (Issue November) [University of Pretoria]. http://hdl.handle.net/2263/26621

Ndomba Katokolo W'Owanga, N. (2015). Caractérisation morpho-productive et parasitologique de la poule locale (Gallus domesticus) élevée à Kibombo dans la province du Maniema/RD Congo. Université de Kisangani.

Njingulula, P., Wimba, P., Musakamba, M., Masuki, K. F., Katafiire, M., Ugen, M., & Birachi, E. (2014). Strengthening local seed systems within the bean value chain: Experience of agricultural innovation platforms in the Democratic Republic of Congo. African Crop Science Journal, 22(S4), 1003–1012.

Otte, M. J., & Chilonda, P. (2002). Cattle and small ruminant production systems in sub-Saharan Africa: a systematic review. Food and Agricultural Organization of the United Nations. http://www.fao.org/3/a-y4176e.pdf

Pangaribowo, E. H., Gerber, N., & Torero, M. (2013). Food and nutrition security indicators: A review (No. 108; ZEF Working Paper, Issue 108). https://doi.org/ISSN 1864-6638

Pekel, J.-F., Cottam, A., Gorelick, N., & Belward, A. S. (2016). High-resolution mapping of global surface water and its long-term changes. Nature, 540(418–422). https://doi.org/https://doi.org/10.1038/nature20584

Pinstrup-Andersen, P. (2013). Nutrition-sensitive food systems: From rhetoric to action. The Lancet, 382, 375–376. https://doi.org/10.1016/S0140-6736(13)61053-3

Poulton, C., & Macartney, J. (2012). Can Public-Private Partnerships Leverage Private Investment in Agricultural Value Chains in Africa? A Preliminary Review. World Development, 40(1), 96–109. https://doi.org/10.1016/j.worlddev.2011.05.017

RDC/Province du Sud-Kivu. (2019). Plan de Développement de la Province du Sud-Kivu 2019-2023. République démocratique du Congo.

RDC/Province du Tanganyika. (2017). Projet Agricole Intégré du Tanganyika. République démocratique du Congo.

République démocratique du Congo. (2014a). Deuxième Enquête Démographique et de Santé (EDS-RDC II 2013–2014). Ministère du Plan et Suivi de la Mise en œuvre de la Révolution de la Modernité, Ministère de la Santé Publique, ICF International.

République démocratique du Congo. (2014b). Enquête 1–2–3 (Phase I: Emploi, Phase II: Secteur Informel et Phase III: Consommation des Ménages) 2012–13. Institut National de la Statistique.

République démocratique du Congo. (2015). Annuaire statistique 2014. Ministère du Plan et Révolution de la Modernité, Institut National de la Statistique, PNUD.

Reyntjens, F. (2009). The Great African War: Congo and Regional Geopolitics, 1996–2006. Cambridge University Press.

Stadlmayr, B., Charrondiere, R. U., Enujiugha, V. N., Bayili, R. G., Fagbohoun, E. G., Samb, B., Addy, P., Barikmo, I., Ouattara, F., Oshaug, A., Akinyele, I., Amponsah Annor, G., Bomfeh, K., Ene-Obong, H., Smith, I. F., Thiam, I., & Burlingame, B. (2012). West African Food Composition Table. Food and Agricultural Organization of the United Nations. http://www.fao.org/docrep/015/i2698b/i2698b00.pdf

Stearns, J. K. (2014). Causality and conflict: Tracing the origins of armed groups in the eastern Congo. Peacebuilding, 2(2), 157–171.

Stoian, D., Donovan, J., Fisk, J., & Muldoon, M. F. (2012). Value chain development for rural poverty reduction: A reality check and a warning. Enterprise Development and Microfinance, 23(1), 54–69. https://doi.org/10.3362/1755-1986.2012.006

Tendall, D. M., Joerin, J., Kopainsky, B., Edwards, P., Shreck, A., Le, Q. B., Kruetli, P., Grant, M., & Six, J. (2015). Food system resilience: Defining the concept. Global Food Security, 6(October), 17–23. https://doi.org/10.1016/j.gfs.2015.08.001

Tollens, E., & Biloso, A. (2006). République Démocratique du Congo: Profil des marchés pour les évaluations d'urgence de la sécurité alimentaire. Programme Alimentaire Mondial, Service de l'Evaluation des besoins d'urgence (ODAN).

Trefon, T. (2016). Congo's Environmental Paradox, Potential and Predation in a Land of Plenty. ZED Books.

Ulimwengu, J., Roberts, C., & Randriamamonjy, J. (2012). Resource-rich yet malnourished, Analysis of the demand for food nutrients in the Democratic Republic of Congo. In IFPRI Discussion Paper (No. 01154; IFPRI Discussion Paper). International Food Policy Research Institute (IFPRI). http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/126768

UNEP-WCMC. (2018). Protected Area Profile for the DRC from the World Database of Protected Areas. www.protectedplanet.net

USAID. (2015). Assessment of the DRC's Agricultural Market Systems: Value Chains in the North & South Kivu and Katanga provinces (Issue April). United States Agency for International Development.

Vlassenroot, K., Perrot, S., & Cuvelier, J. (2012). Doing business out of war. An analysis of the UPDF's presence in the Democratic Republic of Congo. Journal of Eastern African Studies, 6(1), 2–21. https://doi.org/10.1080/17531055.2012.664701

Webber, C. M., & Labaste, P. (2010). Building Competitiveness in Africa's Agriculture, a Guide to Value Chain Concepts and Applications. International Bank for Reconstruction and Development/The World Bank.

WFP. (n.d.). Emergency Food Security Assessments in South-Kivu (2017), North-Kivu (2016/18/19), Province Orientale (2015), Kasai (2019) and Kasai Central (2019). World Food Programme, Vulnerability Analysis and Mapping (VAM).

Xiong, J., Thenkabail, P. S., Tilton, J. C., Gumma, M. K., Teluguntla, P., Oliphant, A., Congalton, R. G., Yadav, K., & Gorelick, N. (2017). Nominal 30-m cropland extent map of continental Africa by integrating pixel-based and object-based algorithms using Sentinel-2 and Landsat-8 data on Google Earth Engine. Remote Sensing, 9(10), 1–27. https://doi.org/10.3390/rs9101065

ALL IFPRI DISCUSSION PAPERS

All discussion papers are available **here**

They can be downloaded free of charge

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
www.ifpri.org

IFPRI HEADQUARTERS
1201 Eye Street, NW
Washington, DC 20005 USA
Tel.: +1-202-862-5600
Fax: +1-202-862-5606
Email: ifpri@cgiar.org

AFRICA REGIONAL OFFICE
Titre 3396, Lot #2
BP 24063
Dakar - Almadies
Senegal
Phone: +221-33-869-9800
Email: ifpri-dakar@cgiar.org