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Why Some Are More Equal Than Others

Country Typologies of Food Security

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ABSTRACT

Food (in)security conditions differ across countries, and those differences affect the discussion of potential policy approaches. This paper reviews several approaches to creating country typologies of food (in)security conditions and then updates Díaz-Bonilla et al.'s 2000 IFPRI paper *Food Security and Trade Negotiations in the World Trade Organization*. The exercise uses five variables: domestic food production per capita (constant dollars per capita); a combination of calories and protein per capita; the ratio of total exports to food imports; the ratio of the nonagricultural population to total population; and a variable based on the mortality rate for children under 5. The raw values are all transformed into z-scores. The paper explains how the variables relate to the traditional dimensions of availability, access, and utilization in the definition of food security. Data for the variables correspond to the period 2009–2011 (or the latest available) and cover 155 developed and developing countries.

Two clustering methods are applied: hierarchical and k-means. The hierarchical approach is used first, to determine potential outliers and to explore what would be a reasonable number of clusters. That analysis suggests that the maximum number of relevant clusters for the analysis is 10 and identifies three countries as outliers. We then use the k-means method to classify all other countries in one of the 10 different clusters or groups.

The paper analyzes the average profile of each one of those groups and divides them into three categories of food insecure, intermediate, and food secure.

We highlight the different profiles of each of the food-insecure clusters (such as whether they were rural or urban, trade stressed or not, and so on). Limitations related to land and water availability (measured as arable land, hectares per person, and renewable internal freshwater resources in cubic meters per capita) are incorporated into the analysis as an additional dimension to be considered. The paper closes with some policy considerations for the different types of clusters of food-insecure countries.

Keywords: food security, nutrition security, typology, cluster analysis

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The title of this paper obviously owes to George Orwell, who in his classic book *Animal Farm* writes, "All animals are equal, but some animals are more equal than others."

1. INTRODUCTION

This paper examines the different approaches and methodologies for classification of countries in terms of their food and nutrition security conditions. Its objective is to identify a number of country groups and thus provide some guidance about potential policies to address food and nutrition insecurity. Defining the adequate number of groups depends in good measure on the purpose of the exercise, as discussed later. It should be recognized, however, that every country is unique, and therefore policy makers and analysts must make an effort to understand the country and its circumstances when discussing specific policies. This implies considering (1) current economic conditions, (2) the totality of the economic program where the policy in question fits, (3) structural aspects of the national economy and society, (4) the heterogeneity of economic agents, and (5) the world economic environment within which the country is inserted. Many policy and analytical mistakes result from considering policies in isolation without taking into account those five aspects (Díaz-Bonilla 2015a).

In the next section of the paper, we perform a traditional categorization based on geographically defined developing regions. For some exercises, this approach may suffice to distinguish food and nutrition (in)security conditions, looking at a variety of structural and contextual conditions. The third section discusses in greater detail some formal exercises that have tried to classify countries based on agriculture and food security variables. It makes the obvious point that the objective of the classification should guide the exercise, and that the classifications depend on the variables selected and the method (or methods) applied. A fourth section presents a specific food security typology using cluster analysis, a classification methodology. The final section concludes.

2. REGIONAL ASPECTS

An approach to categorization that has a long history is to differentiate developing countries by geographical region. That approach has received some support from econometric regressions that found that dummy variables for regions have statistical significance in relation to growth (Sala-i-Martin 1997). As a first approach, we include different developing regions using the World Bank's classification (Table 2.1), highlighting the great variety in structural characteristics in those regions' agricultural sectors. Compared with other regions, in Latin America and the Caribbean (LAC), agriculture is less important as a percentage of gross domestic product (GDP) and the share of the rural population in total population is smaller. Africa south of the Sahara (SSA) and South Asia (SA), followed closely by East Asia and the Pacific (EAP), fall on the other extreme, displaying larger incidences of agricultural production and rural population. Although agriculture is relatively smaller in terms of GDP in LAC, that region is the most dependent on agricultural exports, followed by SSA. Agriculture appears to be more productive per unit of labor and uses more capital (using tractors as a proxy) in Europe and Central Asia (ECA), LAC, and the Middle East and North Africa (MENA).

Table 2.1 Regional agricultural indicators

Agricultural indicator	Europe and Central Asia	Latin America and the Caribbean	Middle East and North Africa	Africa south of the Sahara	East Asia and the Pacific	South Asia	All developing countries
Rural population (% total population)	41.0	22.2	41.6	64.9	54.6	70.1	55.9
Agriculture, value added (% GDP)	8.9	5.6	10.6	16.8	11.4	18.8	10.8
Agriculture value added per worker (constant 2005 US\$)	4,270.2	3,728.3	2,653.8	655.5	673.2	608.8	843.9
Arable land (hectares per rural population)	1.1	1.3	0.4	0.4	0.2	0.2	0.3
Agricultural machinery, tractors per 100 sq. km of arable land	171.1	116.0	137.1	12.8	59.1	103.0	92.9
Fertilizer consumption (kilograms per hectare of arable land)	57.9	101.4	87.6	12.4	371.3	153.5	142.1
Agricultural exports (percent merchandise trade)	10.2	19.9	5.9	16.2	7.9	12.4	11.4
Road density (km of road per 100 sq. km of land area)	22.5	16.1	10.6	6.7	34.4	103.7	26.6

Source: Díaz-Bonilla (2015a) and World Bank (2015).

Note: Indicators are averages for the 2005–2011 period, except the tractor indicator, which is calculated for the period 1995–2000.

SA shows the highest road density, an important indicator of infrastructure, followed at a distant second by EAP. LAC and ECA have more available arable land per capita (counting rural population) than Asian countries, with MENA and SSA in between. Average holdings are far larger in LAC, and land appears to be distributed more unequally there than in Asia and Africa (Table 2.2). Although SSA has about double the land availability per capita of Asia, the region also shows the lowest values for the capital/technology and roads indicators (Table 2.1), and the average size of the plots actually farmed is similar to that in Asia (Table 2.2). This highlights both the opportunities in SSA for agricultural production, such as potentially more land to be incorporated into production, and the constraints the region faces, such as lack of infrastructure and low availability of productive capital.

Table 2.2 Land structure: Average size of holdings and concentration

Region/country	Average size	Gini index
Africa ^a	2.92	0.53
Asia Developing ^b	2.20	0.57
LAC w/Argentina ^c	87.09	0.82
LAC w/o Argentina	32.53	0.82
United States	186.95	0.64
European Union ^d	27.27	0.59
Japan/Korea	1.12	0.47
Canada	349.07	0.74

Source: Díaz-Bonilla and Robinson (2010) and FAO (2010).

Note: LAC = Latin America and the Caribbean. ^a Burkina Faso, Congo (Dem. Rep.), Djibouti, Egypt, Ethiopia, Guinea, Guinea Bissau, Lesotho, Libya, Malawi, Namibia, Reunion, Uganda; ^b India, Indonesia, Iran, Myanmar, Nepal, Pakistan, Philippines, Thailand, Vietnam; ^c Honduras, Panama, Puerto Rico, Argentina, Brazil, Colombia, Paraguay, Peru; ^d Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, United Kingdom.

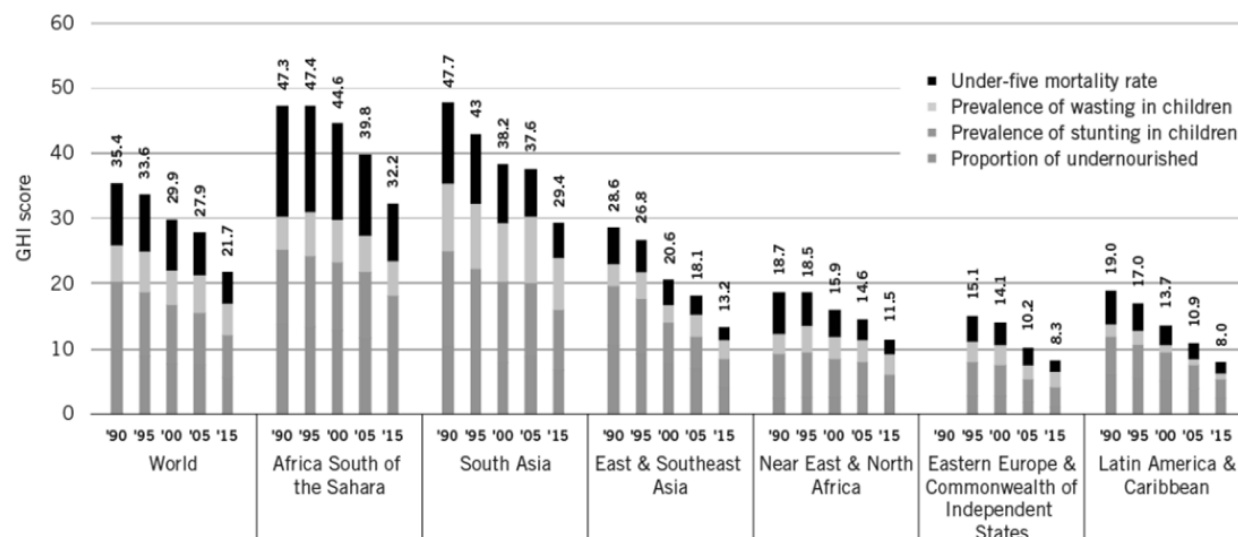
More generally, those structural factors will influence the impact of different policies. For instance, trying to improve internal terms of trade for agricultural products by a devaluation of the local currency will have a different production response in SSA, where producers face relatively more constraints in infrastructure, capital, and technology, than in Asia or LAC. As a result of the lack of internal infrastructure in SSA countries, the growing urban markets may be in several cases better linked to international food aid and imports than to domestic producers. In turn, the distributive effect (and therefore the political economy implications for policies benefiting the agricultural sector) will be different in the small-farm agricultural economies of Asia than in many LAC countries with dualistic agrarian structures and large populations of urban poor. In the latter countries, trade and macroeconomic policies that improve relative prices for agriculture may at least initially benefit large-scale farmers relatively more than small-scale farmers and have potentially negative impacts on poor urban consumers. Therefore, the political economy of different policies will differ across those regions.

The Global Hunger Index (GHI)¹ (von Grebmer et al. 2015) gives another view of the heterogeneity across developing regions based on indicators of chronic malnourishment (Figure 2.1). SSA

¹ The GHI is a tool designed to comprehensively measure and track hunger globally, regionally, and by country. Each year, the International Food Policy Research Institute (IFPRI) calculates GHI scores to assess progress, or the lack thereof, in decreasing hunger. The 2015 GHI has been calculated for 117 countries and is based on four indicators related to undernourishment, child wasting, child stunting, and child mortality (von Grebmer et al. 2015). The GHI is calculated as the simple average of those four indicators. The largest (and worst) theoretical value is 100, which would represent a (largely impossible) situation in which the whole population was undernourished, all children under 5 were underweight, and all children died before 5 years of age. The best value would be zero, in the (also unlikely) situation in which all four categories have a zero value.

and SA have the worst score on the index (the higher the score the worse the indicators); East and Southeast Asia and the Near East and North Africa have intermediate values; and LAC and Eastern Europe and the Commonwealth of Independent States display the most favorable conditions.

Figure 2.1 Contribution of components to 1990, 1995, 2000, 2005, and 2015 Global Hunger Index scores, by region



Source: von Grebmer et al. (2015, Figure 2.1).

Table 2.3 summarizes the analysis based on the regional characteristics shown in Tables 2.1 and 2.2 and Figure 2.1. It illustrates that for some aggregate analyses of food and nutrition security, a geographical classification can provide a guide to the discussion of differentiated policy approaches. For more specific policy discussions, however, a finer disaggregation that considers individual countries may be needed. We discuss that in the next section.

Table 2.3 A summary of regional characteristics

Regions	GHI	Agriculture	Agrarian structure	Infrastructure	Urbanization
LAC	Better	Less incidence in GDP but more on exports	Larger farms; highly unequal	Better	Urban
SSA	Worse	More incidence in GDP but less on exports	Smaller farms; more equal agrarian structure	Worse	Rural
Asia	Worse SA, intermediate ESEA	More incidence in GDP, intermediate on exports	Smaller farms; more equal agrarian structure	Better	Rural

Source: Compiled by authors.

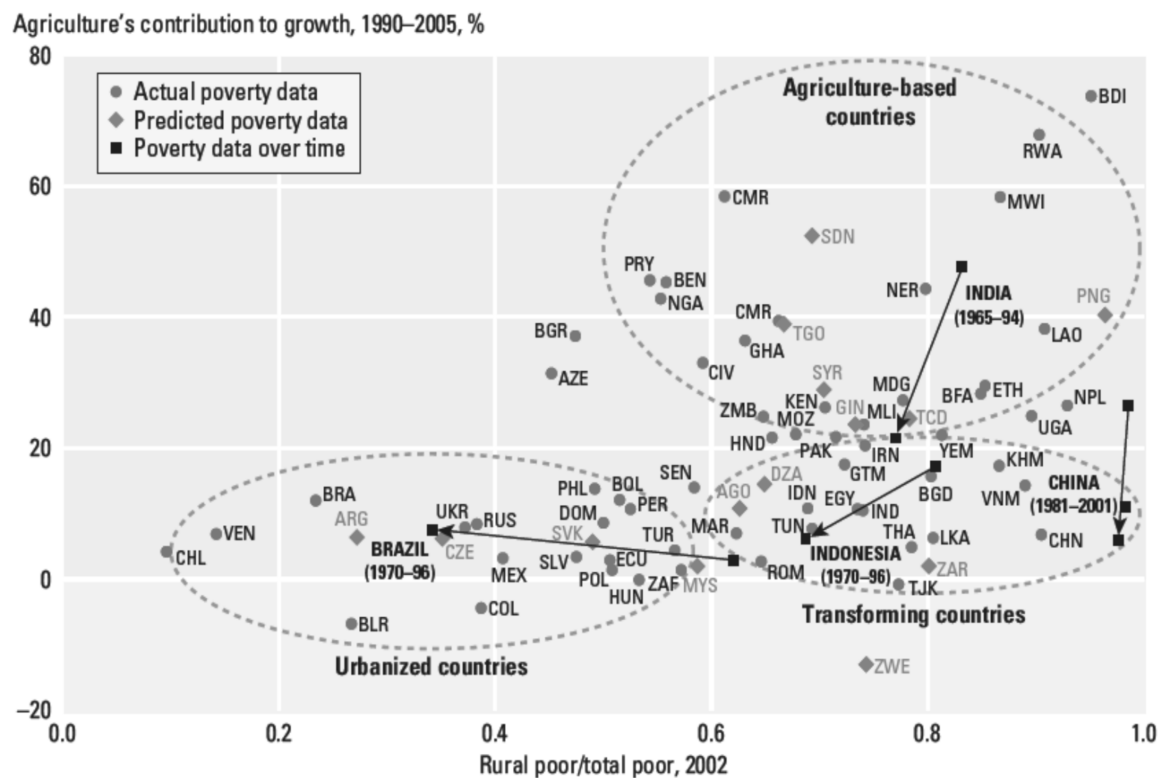
Note: GHI = Global Hunger Index; LAC = Latin America and the Caribbean; SSA = Africa south of the Sahara; SA = South Asia; ESEA = East and South-East Asia; GDP = gross domestic product.

3. DIFFERENT COUNTRY TYPOLOGIES

Agriculture

The *World Development Report 2008* (World Bank 2007), which focused on agricultural development issues, divided developing countries into three groups using a form of clustering based on two variables: the contribution of agriculture to growth and the incidence of rural poverty. This approach enabled the definition of relevant groupings of countries and at the same time kept the number of groups at a manageable level for the type of policy analysis that was intended. The groups were (1) agriculture-based countries, where agriculture contributes significantly to growth and where the poor are concentrated in rural areas; (2) transforming countries, where agriculture contributes less to growth but where poverty is still predominantly rural; and (3) urbanized countries, where agriculture is not the main contributor to growth and where poverty is mostly urban (Figure 3.1). Based on those characteristics, the analysis suggested differentiated sets of agricultural policies for the three groups of countries.

Figure 3.1 Classification of countries in the *World Development Report 2008*



Source: World Bank (2007).

This is an example of a classification exercise that based on a small set of relevant variables generates a limited number of groups that are relevant for the policy issues addressed.

Although the classification is done at the country level, the three categories can be approximately mapped into general income and geographical groupings in Table 2.1 (see previous section). Generally, for instance, low- and lower-middle-income countries, many from SSA, represent the largest percentage in the first group. Lower-middle- and middle-income countries from SA, EAP, and to a lesser extent MENA belong in the second category. Finally, middle- and upper-middle-income countries, mostly from LAC, as well as ECA, are the main income groups and geographical regions in the third category.

Therefore, although general geographical classifications provide some differentiation regarding agricultural conditions (in this case) and potential policies, country classifications add further details to the understanding of different conditions and policies.

Food Security

There are several approaches to categorize food and nutrition (in)security conditions. One approach is based on single-valued indicators that aggregate a variety of variables, such as the Global Food Security Index (GFSI) designed and constructed by the Economist Intelligence Unit and sponsored by DuPont.² They are useful toward several ends: to gather quantitative information from different sources; to summarize the situation within a single country; to allow some types of comparisons across countries; to increase public awareness about the current situation regarding some topic; to look at their evolution over time; and to help policy makers focus on some issues that may require specific attention. However, because they aggregate a series of variables in a single number, they do not capture the differing underlying “geometries” of the indicators; countries may have the same overall number due to a completely different combination of the different variables that have been averaged or aggregated (Díaz-Bonilla, Orden, and Kwieciński 2014).

Other approaches are based on classification techniques that try to capture the multidimensional geometry of food and nutrition security and allow for the differentiation of profiles. There have been several attempts to produce typologies of food and nutrition security. Those exercises differ in terms of the purposes of the typology, the number of variables considered, the methodology used, and the number of groups or types identified. Here we focus on four exercises: (1) Pieters, Gerber, and Mekonnen (2014); (2) Yu, You, and Fan (2010); (3) Matthews (2013); and (4) Díaz-Bonilla et al. (2000). Table 3.1 details some of the main characteristics of the four approaches.

Table 3.1 Summary of different typologies

Typology	Purpose	Number of variables considered	Methodology	Types identified
Matthews	Identify categories of countries for Organization for Economic Co-operation and Development case studies on trade and food security.	35 variables, plus seven variables called “helper indicators.”	Classifies countries based on thresholds defined by the author and then places them in nested tables in a sequential approach. Classifications in tables vary depending on which is the first (or root) criterion used in rows and columns.	240 cells or groups, 78 of which have countries in them.
Yu, You, and Fan	Identify “which countries face similar food security situations and therefore might be able to learn from each other’s successes and failures,” emphasizing the medium- and long-term aspects related to production.	Nine variables, of which three (calories, protein, and fat) are aggregated by principal component analysis; two of the variables related to climate appear to also be aggregated, but it is not clear. In that case, there will be six operational variables.	Uses principal component analysis to aggregate three indicators of availability. The other variables are used directly to classify countries based on thresholds defined by the authors, which are then placed in nested tables in a sequential approach.	64 cells or groups in table, 53 of which contain countries.

² The GFSI aggregates 28 variables into a single indicator. It also reports seven “background variables.”

Table 3.1 Continued

Typology	Purpose	Number of variables considered	Methodology	Types identified
Pieters, Gerber, and Mekonnen	“Help policy makers in developing the right strategy as it facilitates the interpretation and drawing of suitable conclusions from case studies and successful policies in other countries” and “will help calibrating models and interpreting results at national levels, as well as guide the selection of case studies by project partners.”	27 variables, but they are aggregated by principal component analysis into nine dimensions (see Methodology column).	Uses principal component analysis to aggregate a variety of indicators for the following dimensions: food security, nutrition security, obesity, agricultural potential, agricultural performance, economic performance, health infrastructure, political conditions, and innovation conditions. Then the values of the countries for each dimension are used to classify countries based on thresholds defined by the authors, constructing nested tables in a sequential approach.	128 different cells or groups, 40 of which contain countries using food security as criteria. There are other classification tables using nutrition security or obesity as the root criterion.
Díaz-Bonilla, Thomas, Robinson, and Cattaneo	Determine whether World Trade Organization (WTO) categories benefiting from different types of treatment under WTO legal texts (including special and differential treatment for developing countries) reflected underlying food (in)security characteristics.	Five variables.	Cluster analysis.	Four basic and 12 disaggregated groups.

Source: Compiled by authors.

Purpose

A first point to note is that the exercises differ in their purposes: there may be different ways of classifying countries depending on the reasons for the typology. Matthews (2013) classifies countries in order to define representative case studies for a larger Organization for Economic Co-operation and Development exercise on adequate trade policies for food security. Yu, You, and Fan (2010) and Pieters, Gerber, and Mekonnen (2014) indicate that their groupings may be used for the consideration of general policies for food and nutrition security and for comparisons across countries.

On the other hand, Díaz-Bonilla et al. (2000) have more limited objectives: given that many types of countries, both developed and developing, claimed food security reasons for some type of special consideration under World Trade Organization (WTO) trade agreements, this exercise focused on whether the WTO country categories benefiting from differentiated commitments in trade negotiations

correlated with categories of countries as defined by the WTO (such as least developed countries, LDCs, net food-importing developing countries, NFIDCs, and others) and groups of countries classified on the basis of some general characteristics of food (in)security.³

Variables

The selection and measurement of variables, in part, relate to the objectives. Matthews (2013) and Pieters, Gerber, and Mekonnen (2014) use the largest number of variables. Matthews includes a very helpful database with all the variables, and an Excel file that allows the user to generate different types of classifications. Pieters, Gerber, and Mekonnen aggregate 27 variables into nine dimensions: food security, nutrition security, obesity, agricultural potential, agricultural performance, economic performance, health infrastructure, political conditions, and innovation conditions. It should be noted that this classification includes obesity indicators, which none of the other exercises does (Table 3.2).

Table 3.2 Variables in Pieters, Gerber, and Mekonnen (2014)

Food Security Profile	Economic Performance Profile
Share of animal protein in diet	Gini
Average daily calorie intake	GDP per capita
Food deficit	Women economic opportunity index
Nutrition Security Profile	Political Profile
Undernourishment	Political stability and violence
Anaemia women	Control of corruption
Child mortality	Democracy index
Obesity	Innovation Profile
Female obesity	Innovation system
Agricultural Potential Profile	Economic incentive regime
Length of growing period	Education and skills
Percentage without major soil constraints	Information infrastructure
Precipitation	Health Infrastructure Profile
Agricultural Performance Profile	Health expenditures per capita
Value added per worker in agriculture	Sanitation
Import share of agriculture	Water supply
Food production per capita	Hospital beds

Source: Pieters, Gerber, and Mekonnen (2014).

Yu, You, and Fan (2010) mention nine basic variables, but then the three measures of average availability (for calories, protein, and fat) are aggregated by principal component analysis into a single variable and two of the variables related to climate appear also to be aggregated in the analysis (Table 3.3).

³ Kasteng, Karlsson, and Lindberg (2004) and Ruffer, Jones, and Akroyd (2002) also focused on WTO categories. The first study is based on Díaz-Bonilla et al. (2000) but subdivides country groups further. The LDC category was defined by the United Nations Assembly. The NFIDC category defined during the Uruguay Round of negotiations was incorporated into the current legal system of the WTO. Both have some legal implications for economic aid and trade negotiations.

Table 3.3 Variables in Yu, You, and Fan (2010)

Variable	Definition
<i>Food consumption</i>	
Daily calorie intake per capita	Energy intake per capita per day measured in calories
Daily protein intake per capita	Protein intake per capita per day measured in grams
Daily fat intake per capita	Fat intake per capita per day measured in grams
<i>Food production</i>	
Annual food production per capita	Gross sum of all commodities weighted by 1999–2001 average international commodity prices, then divided by total population
<i>Food imports</i>	
Ratio of total exports to food imports	Value of all exported goods and market services divided by food imports
<i>Food distribution</i>	
Share of urban population	Percentage of midyear population of areas defined as urban in total population
<i>Agricultural potential</i>	
Soil without major constraints	Percentage of soil not affected by eight major fertility constraints
Length of growing period	Number of days of the year when both natural moisture and temperature conditions are suitable for crop production
Coefficient of variation of length of growing period	Coefficient of variations of length of growing period

Source: Yu, You, and Fan (2010, Table 1).

The notion that the objectives of the typology drive the indicators is exemplified by Díaz-Bonilla et al.: they acknowledge “that the deeper issue of nutrition insecurity requires analyses at the household and individual levels,” but the study “takes nonetheless a national perspective (the level at which the negotiating categories are defined) and focuses mainly on food availability issues, utilizing consumption, production, and trade measures.” (2000, 5). The five indicators of food security used are calories per day per capita; protein per day per capita (grams); food production per capita (measured in constant U.S. dollars as the average of the three years 1989–1991); the ratio of total exports (merchandise and services) to food imports; and the share of nonagricultural population over total population.⁴

Other indicators, potentially very important for a different type of exercise (such as those used in the papers previously mentioned), were consciously excluded: this is the case for the FAO measure of undernourishment (which is a measure of calorie availability doubly corrected by age/gender and by income distribution); measures related to health infrastructure or women’s education; and indicators of anthropometric outcomes at the individual level (such as wasting or stunting in children). The reasons for the exclusions included that such indicators reflect issues that are related to policies other than trade measures (such as public investments in health or in women’s education) and that it would be inadequate that such indicators be used to claim special trade treatment (for instance, no country would attempt to request special trade considerations because it has a very unjust income distribution that worsens FAO’s undernourishment measure or because women are discriminated against). However, many of the variables not included in Díaz-Bonilla et al. (2000) must be considered if the issue is to identify general policies to address food and nutrition security problems, as in Yu, You, and Fan (2010) and Pieters, Gerber, and Mekonnen (2014).

⁴ The last two variables have been inverted from the more common representations (that is, food imports over total exports and percentage of rural population) so that for all the variables a larger number is considered to be associated with better food security (this also makes charts and tables easier to read).

Methods

The four analyses differ also in the way the groups or types are constructed. While Díaz-Bonilla et al. (2000) use cluster analysis, the other three exercises (Matthews 2013; Yu, You, and Fan 2010; and Pieters, Gerber, and Mekonnen 2014) use some form of hierarchical and sequential construction to generate tables with different cells that represent the country groups of food and nutrition security. To construct those groups, the exercises define, in different ways, cutoff values to separate groups by single variable or groups of variables. The thresholds between categories may be expressed in the original values of the variables, or the latter may be converted into z-scores.⁵ The three exercises other than Matthews use at some points z-scores to define thresholds or perform calculations, or both. For the cluster analysis in Díaz-Bonilla et al., this conversion is necessary to avoid giving more weight to any one variable because of its unit of measure.

In the three cases that use a hierarchical and sequential construction of tables, there are two key issues to consider (as noted by Matthews 2013). First, how many levels/dimensions will be used to generate the classification? Too many levels/dimensions would create a large number of types or categories; Matthews suggests that not more than four or five levels would be reasonable. Second, which dimension/variable will serve as the “root” to start the classification? Both Matthews and Pieters, Gerber and Mekonnen (2014) present different tables depending on which dimension/variable acts as the root of the classification (for instance, Pieters, Gerber, and Mekonnen present three different tables, using food security, nutrition security, and obesity indicators as the initial classificatory dimension). While groups would differ depending on the root dimension used, once the mutually exclusive roots or starting points have been selected, then the sequence in which the additional levels/dimensions are added should not matter for the definition of the final groups, provided that those levels/dimensions are the same (in other words, for a given root dimension and the same additional classifying levels, the final groups would be the same, even though the tables would be visually different with each sequence).

The three exercises that use tables built in a hierarchical and sequential fashion differ in the way the individual variables are aggregated or used. Matthews (2013) uses the raw data for the individual variables; Yu, You, and Fan (2010) apply principal component analysis to aggregate the average level of daily availability of calories, protein, and fat per capita, but then the other variables are used individually (that is, they are not aggregated, except perhaps for some of the variables related to climate) and the thresholds are defined using z-scores. Pieters, Gerber, and Mekonnen (2014), in turn, use principal component analysis to aggregate a larger number of variables in each of the nine dimensions mentioned before (except for obesity, which has only one variable, each dimension has three or four variables, and therefore principal component analysis helps to reduce the dimensionality).

As noted, Díaz-Bonilla et al. (2000) use cluster analysis, which places all the dimensions/levels on the same footing. As in the other approaches, which variables are considered still matters for the typology.⁶

Groups Identified

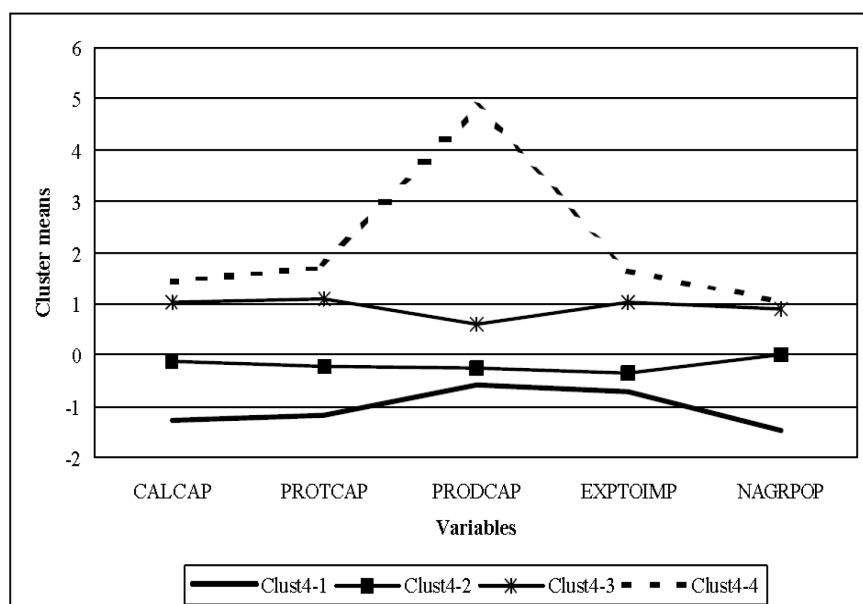
The types, classes, or groups identified differ significantly in number. Matthews (2013) shows 240 cells (or groups) in the classifying table, with a total of 78 groups containing countries and the rest of the cells remaining empty. Yu, You, and Fan (2010) have 64 groups in the table and 53 have countries. Pieters, Gerber, and Mekonnen (2014) present a table with 128 different groups, but only 40 of them include specific countries within them.

⁵ Z-score values are calculated by subtracting the mean and dividing by the standard deviation of the population of a specific variable, which transforms the original data into a new variable with a zero mean and one (1) standard deviation.

⁶ A common and mistaken criticism of typologies of any entity (countries in this case) is that the groups formed combine elements that are very “different.” But usually the difference is caused by variables other than the ones used in the classification. Obviously, the types, groups, or classes defined are only comparable in terms of the variables considered, and selecting different variables will produce different typologies.

On the other hand, Díaz-Bonilla et al. (2000) used three methods of cluster analysis (hierarchical, k-means, and fuzzy) to classify 167 countries, both developed and developing and encompassing all income levels, into clusters. Using the z-scores for variables considered, those clusters were then labeled as food insecure (those clusters for which the average z-score value of the variables considered fell below -0.5⁷), food neutral (approximately between -0.5 and +0.5), and food secure (approximately above +0.5). That exercise first identified four clusters (whose profiles for each variable are shown in Figure 3.2), labeled as food insecure (cluster 4-1), food neutral (4-2), food secure (4-3), and very food secure (4-4).⁸

Figure 3.2 Profile of the four clusters



Source: Díaz-Bonilla et al. (2000).

Those four groups were further subdivided into 12 groups, which were classified again depending on whether the average value for the variables in the groups fell below -0.5, between -0.5 and +0.5, or above +0.5. Figure 3.3 shows the categorization of the 12 clusters using the combined value of average availability of calories and protein per capita (avcalpro) on one axis and the ratio of total exports over food imports (exptoimp) in the other.⁹ The -0.5 line is emphasized with a solid line, and the +0.5 is indicated with a dotted line.

In Figure 3.3, the food-insecure clusters are 1 to 4, the food-neutral clusters are 5 to 8, and the food-secure clusters are 9 to 12. As mentioned, the use of the classification method, such as cluster analysis, allows the differentiation of the shape or geometry of the components of food (in)security when compared to single indicators. If all variables had been combined in a single number, different values in the five dimensions may have resulted in the same overall single index, but that would have obscured the existing differences. For instance, cluster 4 has average availability of calories and protein (it is placed at the 0 value for the z-score of the 167 countries), but it is below the -0.5 standard deviation for the trade variable, while cluster 3 is clearly below the average for availability of calories and protein but is at the

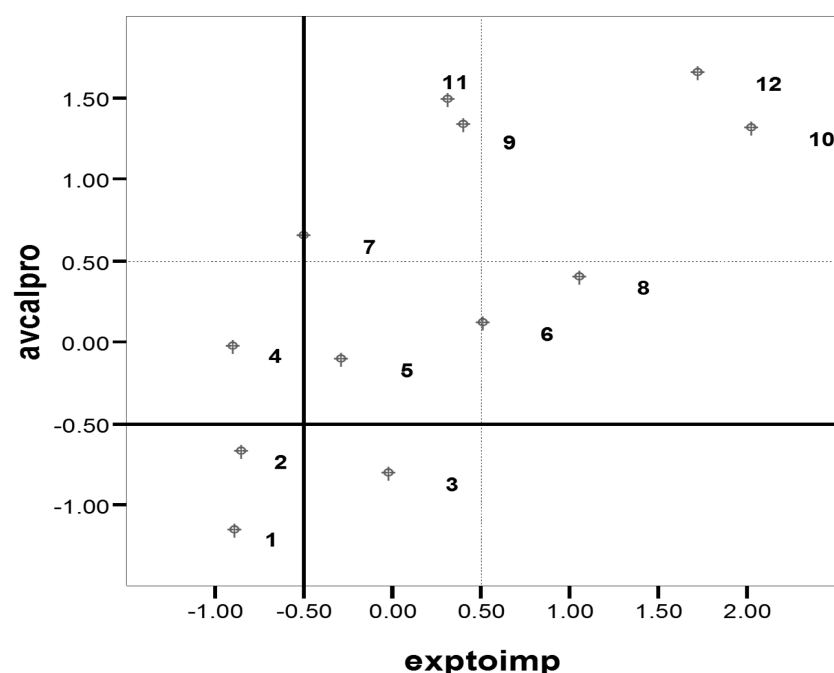
⁷ Remember that all the variables have been normalized to z-scores with a mean of zero and a standard deviation of 1. A negative (positive) value means that the cluster is below (above) the mean. Considering that the standard deviation is 1, the classification could have been based on plus or minus 1, but this would have led to a more restrictive definition of food insecurity. Alternatively, anything below the mean could have been called food insecure, but this would have led to a broader definition. In the end, it was considered better to use -0.5 as an intermediate cutoff value between both options to label groups.

⁸ Cluster 4-4 was called very food secure because the average values for the variables were above one standard deviation.

⁹ The other two variables used for the clustering cannot be shown in a two-dimensional figure.

average of the trade variable (the 0 value on the horizontal axis, meaning that these countries are at the world average when considering the percentage of their exports needed to buy food). Therefore, in the terminology of Díaz-Bonilla et al. (2000), cluster 3 appears “consumption vulnerable” but not “trade stressed,” while cluster 4 appears to be a mirror image: countries in that group are trade stressed (that is, they use a large percentage of their exports to buy food) but less consumption vulnerable (their current levels of calories and protein per capita are close to the average for all countries considered). The policy options for these two types of countries may be different: for instance, although both would be helped by producing more, the first group may also increase imports to improve availability of calories and protein, whereas the second group may be more constrained in that regard.

Figure 3.3 Classification with 12 clusters



Source: Díaz-Bonilla et al. (2000).

Díaz-Bonilla et al. (2000) used the cluster analysis to draw some general implications for WTO categories. They argued that

1. the category of LDCs did a better job at identifying food insecurity;
2. the category of NFIDCs did not seem as good an indicator of food insecurity to the extent that one-third of the countries covered in the analysis fell within the food-neutral band;
3. there were several countries in the food-insecure groups that were not included in either of the two previous categories;
4. the countries in the WTO category of developing ones appeared spread over all clusters, except the most food secure, so that category seemed an inadequate guide to define special and differential treatment in the negotiations; and
5. developed countries were in the food-secure category (with some minor exceptions that appeared in the food-neutral category)—therefore claims of food security as a trade concern in developed countries seemed to refer to something very different from what was happening in really food-insecure countries, and mixing completely different notions did not help poor countries.

Some Closing Comments for this Section

First, there are no “general” typologies; rather, they are specific to the objectives of the exercise, which must be clear from the start. Second, the objectives of the analysis drive the variables considered as well. For instance, if the objective is to analyze trade policies and food and nutrition security, the variables considered may be different than other exercises focused on more general policy issues. Third, in terms of policy implications, the typology is more useful if it does not exceed a reasonably low number of categories, and the distinctions help clarify differential policy and structural issues.

The next section presents an exercise to develop a country typology that extends and updates Díaz-Bonilla et al. (2000).

4. CLUSTER ANALYSIS OF FOOD SECURITY CONDITIONS

Objective

The objective of this exercise is to contribute to the analysis of general food security policies with an emphasis on trade issues, using a limited number of groups in order to outline a manageable quantity of differentiated policy packages. It must be remembered though, as noted earlier, that any specific policy advice must reflect the unique characteristics of each country.

Variables and Country Coverage

We employ five variables, three of which are similar to those in the Díaz-Bonilla et al. (2000) study: food production per capita (constant U.S. dollars per capita), the ratio of total exports to food imports, and the ratio of the nonagricultural population to total population. As before, we transform all raw values into z-scores.

The first variable (food production per capita) reflects the availability of domestically produced food, the first component of food security. The second (the ratio of total exports to food imports) reflects access, the second component of food security, but at the country level. The ratio of nonrural population was retained because, as Díaz-Bonilla et al. (2000) argue, food security challenges and related policies differ in mostly urban or mostly rural countries, reflecting the old policy dilemma of sustaining high food prices for producers (to ensure availability) or maintaining affordable prices for consumers (to facilitate access) (Timmer, Falcon, and Pearson 1983; Díaz-Bonilla 2015a).

The variables related to calories per capita (kcal/caput/day) and protein per capita (gr/caput/day), which were separated in Díaz-Bonilla et al. (2000), are combined in this analysis in a single variable called “calories and protein per capita”; the raw values are transformed into z-scores and then averaged for the composite variable. They reflect overall availability, coming from both domestic production and trade.

The fifth variable is based on the mortality rate for children under 5 years of age and is used to construct what can be called the “nonmortality” rate. For instance, if the under-5 mortality rate in a country is 3 percent, the variable utilized is 97 percent (that is, the complement to 100 percent showing the percentage of under-5 children that survived).¹⁰ In this way, the convention that larger numbers indicate better conditions is maintained. The infant-mortality variable is also transformed into a z-variable with zero mean and one standard deviation. Given the more general policy nature of this exercise (it considers trade but is not exclusively a WTO-focused analysis), we thought it important to include a variable with anthropometric measures. The latter reflects (albeit along with other factors) the impact of food insecurity at the individual level, particularly regarding aspects related to food access and utilization (the second and third components of food insecurity).

There are other potential indicators reflecting poverty and access issues related to food security, such as the rates of children stunting and wasting. The smaller number of countries for which stunting and wasting data are available compared with child mortality data led to the decision to use the latter indicator.

Data for the variables correspond to the period 2009–2011 (or the latest available) and are from the FAOSTAT database (FAO 2015) and the World Bank database (World Bank 2015). Data cover 155 countries, both developed and developing, but Argentina, Iceland, and New Zealand were dropped as outliers (as discussed below), and therefore 152 countries are included in the final clusters.

¹⁰ The expression in percentage terms is used only for explanatory purposes. Mortality rates are usually computed in per thousands of born children.

Method

Two clustering methods are applied: hierarchical and k-means.¹¹ The agglomerative hierarchical method starts by assigning one country per cluster (that is, the process starts with as many clusters as countries). Clustering begins by combining the two countries that are the most similar; after the first step, the combination may be a country and a cluster, and with further steps clusters may be eventually combined. To measure the changes in similarity within clusters resulting from the agglomeration process, an agglomeration coefficient is computed using the within-cluster minimum variance, or Ward's method. The clusters are joined together so as to minimize the variance at each step (Díaz-Bonilla et al. 2000).

We used the hierarchical approach first to get a sense of potential outliers and to explore what would be a reasonable number of clusters. It must be noted that the number of groups depends on the objective of the typology and requires the analyst's judgment as to how many clusters are adequate for a particular analysis.¹² Here, as in Díaz-Bonilla et al. (2000), we use the hierarchical method to decide on the number of groups by running a sequential classification starting with two clusters (the minimum for policy analysis) and going up to 15 clusters. A greater number would not have been manageable for a differentiated analysis and would not have had clear policy implications for food insecurity, as discussed below.

We analyzed the country composition of the 2 to 15 clusters looking for (1) stable groupings, (2) the number of clusters before some groups were formed, and (3) the presence of outliers. The existence of outliers may be attributed to extreme values of single variables or to a particular combination of variables. It was clear that New Zealand, Argentina, and Iceland were outliers classified consistently in single-country clusters by the hierarchical method after generating a reasonable number of groups, and they were dropped from the final sample. Also, further differentiation beyond a 10-cluster classification happened only among the groups with clearly better food security indicators. Therefore, for the analysis of food *insecurity*, those differentiations did not add relevant information. In the end, it was considered that 10 clusters would suffice to capture the variations in food security conditions that suggested differentiated policy approaches.¹³

Next, we used k-means clustering to refine the country classification process. The hierarchical method, although very useful to define the number of clusters, does not allow for reallocation of countries when new groups are formed. K-means, on the other hand, requires that the number of clusters be defined from the outset but has the advantage of allowing reallocation of countries as the classification proceeds and different groups are being formed. This method allocates objects to clusters so as to minimize an expression that includes the sum of Euclidean distances over all objects and clusters; countries are reclassified as the cluster centers are recalculated as new members are added. But, as noted above, the k-means approach depends on the hierarchical method to define the number of clusters and to specify the starting average value for the variables in each cluster (also called cluster seeds or centroids).

¹¹ Díaz-Bonilla et al. (2000) employed a third method, called fuzzy cluster analysis (developed by Sherman Robinson and Andrea Cattaneo). In some regards it is similar to k-means, but whereas the latter is categorical in its cluster partition (that is, the objects being classified, countries in this case, are either in a group or they are not), the fuzzy algorithm allows degrees of membership in different groups. While k-means indicates how similar or dissimilar from the center of a cluster a member in that cluster may be, the fuzzy cluster analysis incorporates information about what is the dominant degree of membership in a particular cluster, but also the degree of belonging to other clusters. In terms of the final classification (that is, to what cluster a country belongs), the k-means method and the dominant cluster in the fuzzy method generated similar allocation of countries to clusters (that is, there were no divergences in the country composition of the clusters analyzed).

¹² The exercises discussed in the previous sections that did not use cluster analysis also had to make decisions regarding the number of dimensions needed for their analyses, which defined the final number of country groups.

¹³ The number of clusters selected is partly a function of the desired level of similarity among members of the same cluster. A useful device for that analysis is the dendrogram, a chart that provides a graphical view of the agglomeration process and shows the increase of the agglomeration coefficient, at each level of agglomeration. At the start, when every country is in its own cluster, the value of the coefficient is zero, and it increases as the number of cluster is reduced by joining them together. Díaz-Bonilla et al. (2000) found that the agglomeration coefficients were small (higher similarity within clusters) until the number of clusters was reduced to less than 10; if the number of clusters was further reduced, the agglomeration coefficient started to increase by larger jumps. This indicated that the clusters were becoming less similar internally if their number was reduced to less than 10, and particularly when moving to less than four clusters.

All objects that are closest to a particular profile of centroids are assigned to the corresponding cluster. In a first iteration, all countries are assigned to the number of clusters defined, but given that the countries now in that cluster may be different from the ones used by the hierarchical method to calculate the starting values of the centers, the latter may have changed. The new centers are then recomputed, and in subsequent iterations the countries are reassigned, changing again the cluster membership and the cluster centers. The procedure stops when successive iterations do not change the centers more than a minimum threshold value such as 0.0001. In this exercise, the k-means method converged rapidly (see Appendix I of Díaz-Bonilla et al. 2000 for more details on the methodology).

Results

Tables 4.1, 4.3, and 4.4 show the results of the typology, divided into food-insecure, food-neutral, and food-secure groups, respectively. The groups are ordered considering the values of the variables. The tables present the average z-scores for the five variables explained before and for each cluster. Values smaller than -0.5 are shown in dark grey; those between -0.5 and 0 are in intermediate grey; those between 0 and +0.5 are in light grey; and those above +0.5 are in white. Each table also shows the simple average of the z-scores for the five variables, and the number of countries in the cluster. The list of developing countries in each cluster is included in footnotes.¹⁴ Table 4.1 shows the clusters of countries considered food insecure in this typology.

Table 4.1 Food-insecure clusters

Variable	Food-insecure clusters			
	1	2	3	4
Under-5 mortality	-1.45	-2.44	-0.5	-0.03
Food production pc	-0.58	-0.62	-0.14	-0.35
Calories and protein pc	-0.78	-0.86	-0.16	-0.47
Total exports per food imports	-0.76	1.02	4.2	-0.49
Nonagricultural population	-1.03	-0.68	-0.78	-1.42
Average value of indicators	-0.92	-0.72	0.52	-0.55
Number of countries in cluster	32 ^a	4 ^b	2 ^c	13 ^d

Source: Compiled by authors.

Note: pc = per capita. ^a The countries included in this cluster are Afghanistan, Benin, Burkina Faso, Cameroon, Central African Republic, Côte d'Ivoire, Ethiopia, Gambia, Ghana, Guinea, Guinea-Bissau, Haiti, Kenya, Lao PDR, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Niger, Pakistan, Rwanda, Senegal, Sierra Leone, Swaziland, Timor-Leste, Togo, Uganda, United Republic of Tanzania, and Zimbabwe. ^b The countries included are Angola, Chad, Nigeria, and Zambia. ^c The countries included are India and Turkmenistan. ^d The countries included are Bangladesh, Cambodia, Guyana, Kyrgyzstan, Myanmar, Nepal, Solomon Islands, Sri Lanka, Tajikistan, Trinidad and Tobago, Uzbekistan, Vietnam, and Yemen.

Cluster 1 has average values for each of the five variables that are clearly below -0.5. It should be emphasized that the average is for the cluster, not for each of the individual countries. However, the cluster algorithm calculates that the 32 countries included in cluster 1 are closer to the average profile indicated in Table 4.1 than countries in other clusters. They are rural countries that have worrisome indicators for under-5 mortality, production per capita, availability of calories and protein per capita, and the burden of food imports over total exports.

¹⁴ Developed countries, defined as all those with an income per capita according to the World Bank Atlas method that was higher than Saudi Arabia, are not shown in the footnotes, even though they were part of the cluster exercise. They include the following 27 countries: Australia, Austria, Belgium, Brunei Darussalam, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Israel, Italy, Japan, Republic of Korea, Kuwait, Luxembourg, Netherlands, Norway, Portugal, Slovenia, Spain, Sweden, Switzerland, United Arab Emirates, United Kingdom, and United States of America.

Cluster 2 is similar to cluster 1 in most regards but differs in that its countries do not suffer a burden of food imports. While cluster 1, using the terminology in Díaz-Bonilla et al. (2000), is very trade stressed (among other problems), cluster 2 shows a large margin within which to increase food imports if the countries in that group decide to use that approach to improve availability.

Table 4.2 details the individual profiles of the only two countries, India and Turkmenistan, in cluster 3, and compares them to the average for the group.

Table 4.2 Analysis of cluster 3

Variable	India	Turkmenistan	Cluster 3
Under-5 mortality	-0.53	-0.47	-0.5
Food production pc	-0.52	0.24	-0.14
Calories and protein pc	-0.76	0.44	-0.16
Total exports per food imports	4.15	4.25	4.2
Nonagricultural population	-1.18	-0.38	-0.78

Source: Compiled by authors.

Note: pc = per capita.

The two countries appear to have been clustered together because they have very small food import bills, which results in a large value to total exports per unit of imported food (a value of more than 4). The strong similarity in large values for that variable,¹⁵ plus convergence in the levels of infant mortality, dominated potential differences in other variables and led to their classification in the same cluster. However, India appears closer to cluster 2, while Turkmenistan is more similar to food-neutral clusters in variables other than the ratio of total exports to food imports. When discussing final types of food insecurity and potential policies later on, we will eliminate this cluster, allocating India to cluster 2 and Turkmenistan to a food-neutral group.

Cluster 4 includes 13 countries. It is as rural or more than clusters 1 and 2 but shows better indicators for food production and availability of calories and protein. It also is closer to cluster 1 in showing a heavy trade burden. On the other hand, the cluster's average displays a more neutral value for infant mortality, close to the global average (zero). However, considering the rest of the variables, it seems appropriate to consider this cluster within the food-insecure ones.

Table 4.3 shows clusters 5 and 6, considered here to be in more neutral territory. The profiles, however, are very different.

Table 4.3 Food-neutral clusters

Variable	Food-neutral clusters	
	5	6
Under-5 mortality (inverse)	0.39	-0.42
Food production pc	-0.32	-0.4
Calories and protein pc	-0.25	-0.41
Total exports per food imports	-0.6	0.72
Nonagricultural population	0.1	0.21
Average value of indicators	-0.14	-0.06
Number of countries in cluster	37 ^a	6 ^b

Source: Compiled by authors.

Note: pc = per capita. ^a The countries included are Albania, Algeria, Armenia, Barbados, Belize, Bosnia and Herzegovina, Botswana, Cabo Verde, Colombia, Croatia, Cuba, Cyprus, Korea (Dem. Rep.), Djibouti, Dominican Republic, Egypt, El Salvador, Fiji, Georgia, Guatemala, Honduras, Indonesia, Iraq, Jamaica, Jordan, Lebanon, Maldives, Mauritius, Mongolia, Morocco, Nicaragua, Philippines, Republic of Moldova, Sao Tome and Principe, Slovakia, Suriname, and Macedonia, FYR. ^b The countries included are Azerbaijan, Bolivia, Congo, Gabon, Namibia, and South Africa.

¹⁵ This shows that even using z-scores to standardize the values of the variables, some of those variables may display large z-score values, which will give them a stronger influence on the allocation of countries than other variables with smaller z-score values.

The average value for under-5 mortality in cluster 5 is clearly better than the world average (remember that this is reversed so that larger numbers of the variable indicate lower mortality rates), but in cluster 6 it is closer to -0.5, the cutoff for food insecurity. On the other hand, whereas cluster 5 is trade stressed, cluster 6 is clearly not. The average values for the other variables are broadly similar. Both clusters 5 and 6 are more urban than the previous clusters. Cluster 6 in particular, being more urban and having a smaller food trade bill than cluster 5, may use trade imports to improve levels of calorie and protein availability, which appear close to the cutoff value for food insecurity.

Clusters 7 to 10 are considered food secure. They include both developed and developing countries, whereas clusters 1 to 6 have only developing countries as members. As was noted earlier, the profile for each cluster does not mean that all countries in that cluster have that average profile, only that they are closer to that profile than countries in other clusters. This is an important point when considering the average profile in the food-secure clusters, which include developed and developing countries, especially in the case of cluster 8.

Basically all clusters in Table 4.4 have better indicators related to under-5 mortality, with averages above the +0.5 value. Cluster 7 is more constrained in food production per capita (closer to the -0.5 value) and has an average availability of calories and protein that is around the global mean. Cluster 8 has average indicators for food production, and it has availability of calories and protein of between 0 and +0.5. It is also the less urban cluster and shows the lowest incidence of the food bill among the food-secure clusters (that is, least trade stressed). For cluster 9, the main difference is that the food import bill is around the global mean. Cluster 10 has all variables above the +0.5 value. The only developing countries in this cluster are Brazil and Uruguay (Argentina would have been in a food-secure cluster but was excluded because it was an outlier).

Table 4.4 Food-secure clusters

Variable	Food-secure clusters			
	7	8	9	10
Under-5 mortality (inverse)	0.71	0.77	0.74	0.82
Food production pc	-0.43	0.1	0.51	2.02
Calories and protein pc	0.08	0.4	0.68	1.62
Total exports per food imports	0.59	2.37	0.19	0.57
Nonagricultural population	1.2	0.34	0.56	1.16
Average value of indicators	0.43	0.80	0.54	1.24
Number of countries in cluster	14 ^a	5 ^b	29 ^c	10 ^d

Source: Compiled by authors.

Note: pc = per capita. ^a The developing countries included are Iran (Islamic Republic of), Malta, Mexico, Panama, Peru, Saudi Arabia, and Venezuela, RB. ^b The developing countries included are China and Thailand. ^c The developing countries included are Belarus, Bulgaria, Chile, Costa Rica, Czech Republic, Ecuador, Estonia, Hungary, Kazakhstan, Latvia, Lithuania, Malaysia, Paraguay, Poland, Romania, Russian Federation, Serbia, Tunisia, Turkey, and Ukraine. ^d The developing countries included are Brazil and Uruguay.

Cluster 8 merits closer consideration because of the peculiar combination of China and Thailand on the one hand and developed countries (such as Norway and Switzerland) on the other (it should be emphasized again that the countries clustered together are only “similar” in regard to the variables considered and may well be very different in other dimensions, as is the case here). Table 4.5 shows the profiles of China and Thailand, respectively and combined, compared with the cluster average.

Table 4.5 Analysis of cluster 8

Variable	China	Thailand	Average of China and Thailand	Cluster average
Under-5 mortality	0.5	0.62	0.56	0.77
Food production pc	0.14	0.32	0.23	0.1
Calories and protein pc	0.44	-0.34	0.05	0.4
Total exports per food imports	2.74	1.95	2.35	2.37
Nonagricultural population	-0.32	-1.05	-0.69	0.34

Source: Compiled by authors.

Note: pc = per capita.

The clustering is dominated by similarities in the ratio of total exports per food imports, rates of under-5 mortality, and food production per capita; but Thailand is different in terms of availability of calories and protein per capita (lower than that of the other countries in the cluster), and both Thailand and China are more rural. In Díaz-Bonilla et al. (2000), Thailand appeared as an outlier because of the special combination of a very high ratio of total exports to food imports (very trade secure) with average to low availability of calories and protein and an important rural population. This may reflect that an important part of the food produced is exported, but there may also be some under-recording of domestic food crops and products for self-consumption in farms with export crops.

Policy Implications

Using clusters 1 to 6, Table 4.6 synthesizes the types or categories of food (in)security for the different dimensions. To simplify, food production and calories and protein availability have been combined. The categories are labeled depending on whether the values are less than -0.5, between -0.5 and +0.5, or more than +0.5. In the case of under-5 mortality within the intermediate range of -0.5 and +0.5, we distinguish between the range between -0.5 and 0 (which indicates an intermediate to high mortality rate) and between 0 and +0.5 (which represents an intermediate to low mortality rate). Table 4.6 also includes an overall ranking for food (in)security based on the simple average of the values of all variables. It shows also some representative countries in each group based on their distance from the respective group average. Types I, II, and III are considered food insecure (corresponding to clusters 1, 2, and 4, respectively),¹⁶ while types IV and V are intermediate groups (clusters 5 and 6, respectively), or “food neutral” following Díaz-Bonilla et al. (2000).

Table 4.6 Typology of food security conditions

Type	Under-5 mortality	Production/availability	Rural/urban	Food trade condition	Overall ranking for food security	Clusters and examples of representative countries
I	High	Low	Rural	Stressed	Food insecure	Cluster 1. Togo, Guinea, Lesotho
II	High	Low	Rural	Not stressed	Food insecure	Cluster 2. Nigeria, Zambia, India
III	Intermediate to high	Intermediate	Rural	Intermediate stress	Food insecure	Cluster 4. Nepal, Cambodia, Vietnam
IV	Intermediate to high	Intermediate	Intermediate rural/urban	Not stressed	Intermediate	Cluster 5. South Africa, Bolivia, Azerbaijan
V	Intermediate to low	Intermediate	Intermediate rural/urban	Stressed	Intermediate	Cluster 6. Nicaragua, Honduras, Georgia

Source: Compiled by authors.

¹⁶ It should be remembered that cluster 3 was eliminated, allocating its members to other clusters.

Table 4.7 includes another dimension of the analysis, using a variable to determine the potential constraints related to land and water availability. The index used for Table 4.7 was constructed using the last data available on arable land (hectares per person) and renewable internal freshwater resources per capita (cubic meters) from the World Development Indicators of the World Bank.¹⁷ Both variables have been transformed into z-scores and then averaged for every one of the countries considered in this exercise. We employ the following cutoff values for the categories presented in Table 4.7: less than -0.5 (“land and water constrained”), between -0.5 and 0 (“intermediate to constrained”), between 0 and +0.5 (“intermediate to abundant”), and more than +0.5 (“land and water abundant”).

Table 4.7 Classification of countries according to land and water constraints

Land and water constraints	Type I		Type II		Type III		Type IV		Type V	
		%		%		%		%		%
Constrained	0	0%	0	0%	4	31%	0	0%	8	22%
Intermediate to constrained	22	69%	4	80%	7	54%	2	33%	23	62%
Intermediate to abundant	8	25%	1	20%	1	8%	3	50%	5	14%
Abundant	2	6%	0	0%	1	8%	1	17%	1	3%
Total	32		5		13		6		37	

Source: Compiled by authors.

The following analysis combines results shown in both Tables 4.6 and 4.7.

As noted, type I (which corresponds to cluster 1) presents the worst indicators in under-5 mortality, has low production and availability in general, is rural, is composed of rural countries, and suffers a high food import bill (trade stressed). Many of those countries are in SSA and are LDCs. Using an index of land and water availability, about 69 percent of the countries in this group were in the category of “intermediate to constrained,” about 25 percent were in the “intermediate to abundant” category, and 6 percent were in the “abundant” category. No countries were constrained regarding land and water.

For type I countries, the policy approach should be based on the expansion of agriculture and food production. It has been noted that agriculture-led growth strategies appear to have larger dynamic multipliers for the rest of the economy than other alternatives in low-income developing countries (Haggblade and Hazell 1989; Delgado et al. 1998; Haggblade, Hazell, and Dorosh 2007). Additionally, agricultural growth is not only pro-poor in reducing poverty or increasing more the income of the lower quintiles of the income distribution, but it also seems to have larger effects on poverty reduction than growth in other sectors (Lipton and Ravallion 1995; Eastwood and Lipton 2000; Christiaensen, Demery, and Kuhl 2011 on the pro-poor nature of agricultural growth).¹⁸

¹⁷ Originally, we used this variable as a sixth dimension in a first exercise of the cluster analysis. However, because of the amplitude of the range between the maximum and minimum values in this variable (even after being converted into z-scores), it tended to dominate the rest of the indicators in the construction of clusters. This generated outliers and/or very uneven clusters (for instance, a food-insecure country in most dimensions that was also extremely land and water constrained clustered with a far more food-secure country just because the latter was equally constrained in those natural resources). To a far smaller degree, we discussed this type of problem before: the variable of total exports over food imports (which has more amplitude between maximum and minimum values than the other dimensions, but clearly less so than the land and water availability) also exercised strong pull in the formation of some of the clusters. However, because the trade variable was directly relevant for the policy exercise and the potentially dominant effect was far smaller than in the case of the index of availability of land and water, the former was retained, while the natural resource dimension, although not used in the clustering exercise, is introduced in the text as part of the analysis of policy implications.

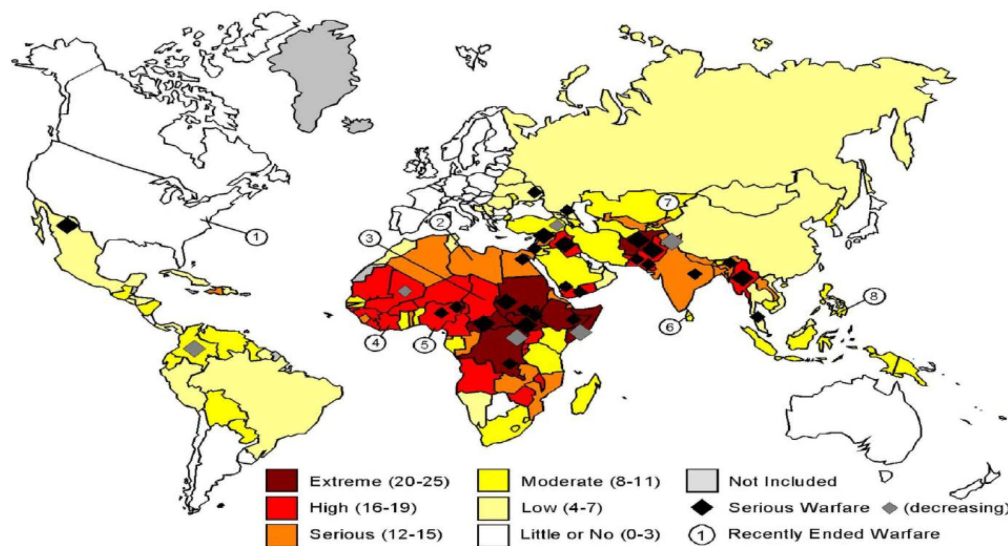
¹⁸ The exceptions to these results appeared in developing countries with large inequalities in landholdings where agricultural growth appeared uncorrelated with poverty reduction (Eastwood and Lipton 2000). Also, the correlation weakens in higher-income countries (that is, in richer countries, agricultural growth does not have stronger effects on poverty reduction when

These countries should be able to utilize to the full extent the special and differential provisions under the Agreement on Agriculture of the World Trade Organization. Investments in rural infrastructure, agricultural research and development (R&D), well-designed programs of input subsidies, some margin of trade preference, and public programs buying from small farmers to support social safety nets (such as nutritional programs for women and children, school lunches, and so on) may help to jump-start production.

In designing the program, several points must be considered. First, although these countries are rural, it does not mean that all farmers are net sellers of food. If the concern centers on poverty and food security problems, a more granular analysis of poor and vulnerable households, which spend significant percentages of their income on food, is called for.¹⁹ Those that are net sellers tend to be a small percentage. For instance, the World Bank (2005) presents the following estimates of the percentages of rural households that are net sellers: for maize, Zambia (24 percent), Mozambique (25 percent), Kenya (27 percent), and Ethiopia (maize and teff, 25 percent);²⁰ for rice, Indonesia (29 percent) and Vietnam (43 percent) (Poulton et al. 2006 illustrate this point by presenting a general typology of households for Africa based on their net food position). As such, large trade protection margins that keep domestic prices high would hurt consumers, many of them poor, and the net effect on welfare and poverty depends on a complex operation of product and labor markets, in the context of unemployment (as discussed in Díaz-Bonilla 2015a and 2015b). Also, high support prices to aid producers and subsidized food to help consumers would most likely create fiscal imbalances that can lead to macroeconomic crises, with very damaging effects on the poor and food insecure (Díaz-Bonilla 2015a).

Furthermore, it is important to consider the restrictions in the operational capabilities of the governments involved and their lack of financial resources. Many of these food-insecure countries appear prominently also on the list of fragile states, affected by war and violence (Figure 4.1; Marshall and Cole 2014). Food security is affected by and in turn affects those conditions.

Figure 4.1 State fragility and warfare in the global system



Source: Marshall and Cole (2014, Figure 6).

compared with other sectors).

¹⁹ According to the World Bank (2008, ch. 3, table 3.6), food consumption in developing countries represents 66 percent of income for rural poor households and 60 percent for urban poor households, with the highest value at 71 percent for rural population in EAP and the lowest at 44 percent for urban population in LAC.

²⁰ All those numbers include farmers who are net buyers at some point during the year.

These countries would benefit from a globally financed cash transfer program supporting both poor producers and consumers, coupled with health programs, water and sanitation investments, nutrition programs for mothers and infants, and expanded school lunches. This cash transfer program would be an expansion of the type of global “food stamp” program advocated in Josling (2011). More fundamentally, most of these countries need to be supported by strong diplomatic and security efforts at the global level to end war and violence.

Type II is similar to the previous group on most accounts except for the trade dimension, having a food import bill being a very small fraction of total exports. These countries, with the exception of India, are oil or mineral exporters from SSA. Using the same index as before, they appear somewhat more constrained in land and water availability compared with the previous group. Theoretically, these countries could expand food imports to increase availability, and consumers would benefit from that. However, at the same time, they have a large rural population that depends on agriculture, and therefore a strong effort to expand agricultural and food production seems warranted. A specific policy challenge for the SSA countries in this group is how to manage the oil and mineral production and revenues to avoid “Dutch disease” effects on other tradable sectors such as agriculture. These countries should be more able to structure cash transfer programs and safety nets for poor producers and consumers using internal resources. They also need to strengthen health programs, water and sanitation investment, nutrition programs for mothers and infants, and the coverage of school lunches. Some of them also suffer from war and civil conflict, which need to be addressed.

Type III displays somewhat better indicators regarding under-5 mortality, has an intermediate level of food production and availability, is less trade stressed than type I (but more than type II), and has a rural profile. Most of the countries are in Asia (Central, South, and East). They have more limitations in land and water availability than the other two groups: 31 percent are in the “constrained” category and 54 percent appear in the “intermediate to constrained” group (Table 4.7). These countries have moved on from the “Mosher stage,” when programs are needed to jump-start agricultural production (Timmer 1988; Mosher 1966), to the stage of investment programs designed to improve human capital, productivity, and sustainability. While productive subsidies necessary to jump-start production may still be needed in the type I countries, other studies for Asia are showing that such programs have clearly diminishing returns over time (Mogues et al. 2012; Fan 2008). In LAC, some estimations suggest negative effects of the subsidies (Allcott, Lederman, and López 2006). Still, all of the type III countries need a balanced pattern of expenditures with investments in human capital, infrastructure, R&D, and safety nets for poor consumers but also for poor and vulnerable agricultural producers that can provide income support when harvests fail or when prices take a sharp downturn.

Type IV is similar to type III in under-5 mortality and food production and availability, but differs significantly in that it is more urban and it is not trade stressed. Also, it has a better endowment of land and water than the other groups, with more than two-thirds of the countries in the intermediate to abundant and abundant categories (Table 4.7). This group is considered to be in the intermediate food security category, or labeled “food neutral” using the terminology in Díaz-Bonilla et al. (2000).

The food policy dilemma of high prices for producers and low prices for consumers is particularly relevant in type IV given that countries in this group are more urban. However, some of these countries with less land and water constraints could pursue a policy of investments designed to expand the frontier for food production and productivity, and sidestep the food policy dilemma mentioned (although other dilemmas may emerge in terms of adequate use of natural resources for future sustainability).

Type V is in the intermediate category of food security (“food neutral”). It has the lowest under-5 mortality rate of the five types, and is similar to type IV in terms of food production and availability and in being more urban (Table 4.6). In contrast to type IV, however, it has a relatively high food import bill (it is trade stressed). It shows the largest dispersion in terms of land and water availability, with 22 percent of countries in the “constrained” category, 62 percent “intermediate to constrained,” 14 percent “intermediate to abundant,” and even 3 percent in the “abundant” category (Table 4.7).

The good news is obviously the relatively lower under-5 mortality rate. Given that this type is trade stressed, policy makers may be tempted to employ protectionist policies to reduce the food import bill (perhaps aiming for self-sufficiency), but the fact that it is more urban immediately brings the food policy dilemma between producers and consumers to the fore. Furthermore, the countries in the “constrained” land and water category may not have the material base of natural resources to expand production further, except perhaps through a strong investment effort in R&D and irrigation. On the other hand, the countries in the “intermediate to abundant” and “abundant” categories may sidestep the food policy dilemma as in the case of type IV. Finally, the more than 60 percent of the countries in the “intermediate to constrained” category will have to carefully design policies that expand production without using instruments that penalize food consumers or generate fiscal crises, or both.

A final topic is the mapping of the food (in)security categories in this exercise to the WTO categories used in the negotiations (Table 4.8).

Table 4.8 Food (in)security types and WTO categories

Type	LDCs	NFIDCs	Neither	Total
Types I to III (food insecure)	34	6	11	51
Types IV and V (intermediate or neutral)	2	18	23	43
Total	36	24	34	94

Source: Compiled by authors.

Note: LDC = least developed country; NFIDC = net food-importing developing country.

In general, this exercise confirms the findings in Díaz-Bonilla et al. (2000) that while the category of LDCs is a relatively better indicator of food insecurity, the category of NFIDCs is far less so. Another finding is that a nontrivial number of developing countries that appear food insecure using the metrics applied here are not included in either of the two categories.

Also, as Díaz-Bonilla et al. pointed out, we find that developing countries are scattered in all categories of food security and that developed countries are all in food-secure categories. The first finding questions the eligibility for special and differential treatment based only on being a developing country; and the second finding casts doubt on claims by developed countries that they need to subsidize and protect their agriculture based on food security concerns.

5. CONCLUSION

This paper reviews several approaches to the creation of typologies of food (in)secure conditions. We note that different typologies have different objectives and that those objectives influence the variables and methods selected and the number of groups formed. To be policy relevant, the number of groups should be small. We also underscore the obvious point that groups are formed depending on variables selected, addressing the simplistic criticism that a typology is classifying together “different countries.”

The paper presents a cluster exercise using five dimensions to group more than 150 countries into 10 clusters. Then three types of food-insecure countries and two other types of intermediate food security are analyzed in greater detail. We highlight the dichotomies of rural/urban configurations and trade stressed/not trade stressed and discuss different policies. Limitations related to land and water availability are incorporated into the analysis. The paper also compares a geographical approach with a food-security-based categorization of countries. It can be noted that countries in SSA and Asia have a larger percentage of food-insecure countries according to this classification, and they are predominantly rural, while LAC and Eastern Europe have more countries in the neutral food security category and are basically urban countries. The same policy—such as maintaining domestic prices high to help producers or the opposite of keeping those prices low to help consumers—will have different impacts in these two types of countries.

Our analysis raises several issues for additional research. First, it would be useful to identify countries that have been changing, either moving to more secure or more insecure clusters, and then analyze the reasons for those transitions, taking into account both policy variables and exogenous events. Second, it is important to consider the fourth component of the definition of food security related to instability of availability and access in a future exercise. A third issue concerns how one defines food production and trade: that definition could be expanded to include fisheries. This may be important for several developing countries, in particular small-island economies, and some countries that may be net food importers under a definition that excludes fisheries but net food exporters if fisheries were included. Fourth, the range of variables considered may be expanded while still keeping the cluster analysis manageable. To that end, two options may be considered: as in the case of Pieters, Gerber, and Mekonnen (2014), a smaller number of dimensions may be defined a priori, and the principal component method can be applied to calculate values for each dimension using a larger number of variables for each dimension; with the values of those dimensions applied to countries, these can then be classified using cluster analysis to limit the number of types or categories, as has been done in this paper. Alternatively, it would be methodologically interesting to (1) apply factor analysis to a larger group of variables, (2) define a reduced number of dimensions or factors (probably not more than five or six), (3) use the factor loadings to define the country values for those dimensions, and (4) use cluster analysis to classify countries into a manageable number of groups. This will be left for a future exercise.

REFERENCES

- Allcott, H., D. Lederman, and R. López. 2006. "Political Institutions, Inequality, and Agricultural Growth: The Public Expenditure Linkage." Unpublished, World Bank, Washington, DC.
- Christiaensen, L., L. Demery, and J. Kuhl. 2011. "The (Evolving) Role of Agriculture in Poverty Reduction—An Empirical Perspective." *Journal of Development Economics* 96 (2): 239–254.
- Delgado, C., J. Hopkins, and V. Kelly with P. Hazell, A. McKenna, P. Gruhn, B. Hojjati, J. Sil, and C. Courbois. 1998. *Agricultural Growth Linkages in Sub-Saharan Africa*. IFPRI Research Report 107. Washington, DC: International Food Policy Research Institute.
- Díaz-Bonilla, E. 2015a. *Macroeconomics, Agriculture, and Food Security: A Guide to Policy Analysis in Developing Countries*. Washington, DC: International Food Policy Research Institute.
<http://dx.doi.org/10.2499/9780896298590>.
- . 2015b. "Lost in Translation: The Fractured Conversation about Trade and Food Security." Background paper prepared for *The State of Agricultural Commodity Markets 2015–16*. Rome: Food and Agriculture Organization of the United Nations.
- Díaz-Bonilla, E., D. Orden, and A. Kwieciński. 2014. *Enabling Environment for Agricultural Growth and Competitiveness: Evaluation, Indicators, and Indices*. OECD Food, Agriculture, and Fisheries Paper 67. Paris: Organisation for Economic Co-operation and Development Publishing.
<http://dx.doi.org/10.1787/5jz48305h4vd-en>.
- Díaz-Bonilla, E., and S. Robinson. 2010. "Macroeconomics, Macrosectoral Policies, and Agriculture in Developing Countries." In *Handbook of Agricultural Economics*, Vol. 4, edited by R. E. Evensen and P. Pingali, 3033–3211. Amsterdam: North-Holland.
- Díaz-Bonilla, E., M. Thomas, S. Robinson, and A. Cattaneo. 2000. *Food Security and Trade Negotiations in the World Trade Organization: A Cluster Analysis of Country Groups*. IFPRI Discussion Paper 59. Washington, DC: International Food Policy Research Institute.
- Eastwood, R., and M. Lipton. 2000. "Pro-Poor Growth and Pro-Growth Poverty Reduction: Meaning, Evidence, and Policy Implications." *Asian Development Review* 18 (2): 22–58.
- FAO (Food and Agriculture Organization of the United Nations). 2010. *2000 World Census of Agriculture: Main Results and Metadata by Country (1996–2005)*. FAO Statistical Development. Series 12. Rome.
- . 2015. FAOSTAT database. Accessed January 22, 2015. <http://faostat3.fao.org/home/E>.
- Fan, S., ed. 2008. *Public Expenditures, Growth, and Poverty: Lessons from Developing Countries*. Baltimore: Johns Hopkins University Press.
- Haggblade, S., and P. Hazell. 1989. "Agricultural Technology and Farm-Nonfarm Growth Linkages." *Agricultural Economics, Blackwell* 3 (4): 345–364.
- Haggblade, S., P. Hazell, and P. Dorosh. 2007. "Sectoral Growth Linkages between Agriculture and the Rural Non-farm Economy." In *Transforming the Rural Non-farm Economy*, edited by S. Haggblade, P. Hazell, and T. Reardon, 141–182. Baltimore: Johns Hopkins University Press.
- Josling, T. 2011. *Global Food Stamps: An Idea Worth Considering?* ICTSD Programme on Agricultural Trade and Sustainable Development. Geneva: International Centre for Trade and Sustainable Development.
www.ictsd.org/downloads/2011/12/global-food-stamps-an-idea-worth-considering.pdf.
- Kasteng, J., A. Karlsson, and C. Lindberg. 2004. *Differentiation between Developing Countries in the WTO*. Jönköping, Sweden: International Affairs Division, Swedish Board of Agriculture.
- Lipton, M., and M. Ravallion. 1995. "Poverty and Policy." In *Handbook of Development Economics*, Vol. 3B, edited by J. Behrman and T. N. Srinivasan, 2551–2657. Amsterdam: North-Holland.
- Marshall, G., and B. R. Cole. 2014. *Global Report 2014: Conflict, Governance, and State Fragility*. Vienna, VA, US: Center for Systemic Peace. www.systemicpeace.org/vlibrary/GlobalReport2014.pdf.

- Matthews, A. 2013. "Food Security Typologies of Developing Countries." Unpublished, Organisation for Economic Co-operation and Development, Washington, DC.
- Mogues, T., B. Yu, S. Fan, and L. McBride. 2012. *The Impacts of Public Investment in and for Agriculture: Synthesis of the Existing Evidence*. IFPRI Discussion Paper 01217. Washington, DC: International Food Policy Research Institute.
- Mosher, A. T. 1966. *Getting Agriculture Moving: Essentials for Development and Modernization*. New York: Praeger.
- Pieters, H., N. Gerber, and D. Mekonnen. 2014. *A Typology of Countries Based on FNS Outcomes and Their Agricultural, Economic, Political, Innovation, and Infrastructure National Profiles*. The Hague: FOODSECURE Working Paper 24. FoodSecure. www3.lei.wur.nl/FoodSecurePublications/T02_Pieters_CountryTypologyFNS.pdf.
- Poulton, C. D., J. G. Kydd, S. Wiggins, and A. R. Dorward. 2006. "State Intervention for Food Price Stabilisation in Africa: Can It Work?" *Food Policy* 31 (4): 342–356.
- Ruffer, T., S. Jones, and S. Akroyd. 2002. *Development Box Proposals and Their Potential Effect on Developing Countries*. Oxford, UK: Oxford Policy Management.
- Sala-i-Martin, X. 1997. *I Just Ran 4 Million Regressions*. NBER Working Paper 6252. Cambridge, MA, US: National Bureau of Economic Research.
- Timmer, C. P. 1988. "The Agricultural Transformation." In *Handbook of Development Economics*, Vol. 1, edited by H. Chenery and T. N. Srinivasan, 275–331. Amsterdam: North-Holland.
- Timmer, C. P., W. P. Falcon, and S. R. Pearson. 1983. *Food Policy Analysis*. Baltimore: Johns Hopkins University Press.
- von Grebmer, K., J. Bernstein, A. de Waal, N. Prasai, S. Yin, and Y. Yohannes. 2015. *2015 Global Hunger Index: Armed Conflict and the Challenge of Hunger*. Bonn; Washington, DC; and Dublin: Welthungerhilfe; International Food Policy Research Institute; and Concern Worldwide. <http://dx.doi.org/10.2499/9780896299641>.
- World Bank. 2005. *Managing Food Price Risks and Instability in an Environment of Market Liberalization*. Washington, DC: World Bank.
- . 2007. *World Development Report 2008: Agriculture for Development*. Washington, DC: World Bank. <http://go.worldbank.org/2DNNMCBG10>.
- . 2008. *Global Economic Prospects 2009: Commodities at the Crossroads*. Washington, DC: International Bank for Reconstruction and Development/World Bank. <http://documents.worldbank.org/curated/en/2009/01/10158584/global-economic-prospects-commodities-crossroads-2009>.
- . 2015. World Development Indicators. Accessed January 2015. <http://data.worldbank.org/indicator/all>.
- Yu, B., L. You, and S. Fan. 2010. *Toward a Typology of Food Security in Developing Countries*. Development Strategy and Governance Division. IFPRI Discussion Paper 00945. Washington, DC: International Food Policy Research Institute. <http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/305>.

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