A Typology of Food Security in Developing Countries under High Food Prices

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Abstract

The recent surge in food prices around the world may reverse the gains of reducing hunger and poverty in the recent years. This paper employs factor and sequential typology analysis using data for 175 countries to identify groups of countries categorized according to four measures of food security: utilization, availability, accessibility and stability. Nine indicators are used for this study: calories intake, protein intake, fat intake, food production, the ratio of total exports to food imports, soil fertility, length of growing period, coefficient of variation of length of growing period and urbanization. The analysis first identifies 5 distinct food security groups characterized by food intake then further split these groups based on similarities and differences across the various measures of food production, trade security and agricultural potentials. The result suggests that the general category of "developing countries" is very heterogeneous and is not very useful if the focus is on issues of food security. Our food security classification is aligned with national income level and malnutrition status, but does not perfectly map to poverty headcount. The analysis provides tailored policy recommendations focusing on agricultural production for countries sharing the same typology.

Key Words
Food security, factor analysis, agricultural potential, typology, trade

JEL Code
C0, F0, O1

1. INTRODUCTION

Food security has been an ongoing concern of governments and international organizations. In 1990, the international community set an ambitious goal to reduce hunger and poverty in half by 2015. While a number of countries are currently on track, for many others, it remains a challenge.

Food price increases between 2005 and 2008 have dampened global efforts fighting poverty. High food prices pushed around 200 million more people into extreme poverty, and about half of them will remain trapped in poverty in 2009 even as food prices recede from their peaks. The sharp slowdown in economy growth resulting from the financial crisis can seriously set back progress on poverty reduction and other MDGs. According to FAO (2009), estimates of the poverty impact of the growth slowdown range from 55 million to 90 million more extreme poor in 2009 than expected before the crisis. These numbers will rise if the crisis deepens and growth in developing countries falters further.

Also, the food crisis and now the global financial crisis are reversing past gains in fighting hunger and malnutrition. Before the onset of the food crisis in 2007, there were about 850 million chronically hungry people in the developing world. This number rose to 960 million people in 2008 and is expected to climb past 1 billion in 2009, breaking the declining trend in the proportion of hungry people in the developing world and seriously jeopardizing the goal of halving this proportion by 2015.

In addition to increasing food insecurity, particularly among the poor, high food price is threatening the broader development agenda as the rise in food prices has led to many riots in countries which depend heavily upon maize, wheat and rice imports and thus are more affected by the high commodity prices. Haiti, Burkina Faso, Guinea, Mauritania, Senegal, Egypt, Cameroon, Cote d'Ivoire, Ethiopia, Somalia, and Madagascar have experienced food induced social unrest and riots. The long-run consequences of the crisis for human development outcomes may be more severe than those observed in the short run. For example, the decline in health status among children who suffer from reduced (or inferior) food consumption can be irreversible, retarding growth as well as cognitive and learning abilities. Estimates suggest that the food crisis has already caused the number of people suffering permanent damage from malnutrition to rise by 44 million. The financial crisis will exacerbate this impact as poor households respond to decreases in income by further cutting the quantity and quality of food consumption. These trends call for maintaining the momentum of recent efforts to boost agricultural investment and productivity.

While food prices have receded since mid-2008, they remain high by historical standards, and the food crisis is by no means over. At the country level. Net food exporters benefit from the high prices with favorable terms of trade, although some countries are missing out by banning exports to protect domestic consumers. On the other hand, net food importers are struggling to meet domestic demand. The high food price has especially hit many African countries as most of them are net cereal importers. But even within the net exporting countries, many poor may suffer if they are net buyers of cereals. This is particularly detrimental to the poorest poor as they often spend 60-80% o their income on food. For net food importing countries, not only does the poorest will suffer even more disproportionately, increased food importing bills may also crowd

out other imports such as energy and technology intensive equipment. Thus, it is important to understand the level of food security in countries and under what conditions.

The World Food Summit defined the multiple dimensions of food security as food accessibility, availability, food use and stability. Using factor and sequential analysis, we develop a classification of 175 countries based on their various aspects of food security. This approach stems from Adelman & Morris (1967) who argue that development is a multifaceted and nonlinear process and countries at different development stages require different strategies. Using factor analysis, they classify each country's growth according to the country's characteristics, focusing on social and political variables. This paper contributes to the typology of food security by taking a more aggregate viewpoint and by classifying countries according to the various dimensions of food security. This is an attempt by taking into account of comprehensive driving forces behind the concept of food security over time. In the long run, the only sustainable way to cope with food security issue is to boost food production through increased food supply through boosting investment in agricultural sector. Hence, the analysis considers not only the traditional perception of food production and nutritional intake, but also the potential to augment food supply by considering constraints of natural endowment. In addition, the role of nonagriculture in the economy and a country's ability to afford importing food from the international market is included in the analysis.

Previous efforts by Diaz-Bonilla et al. (2000) are a snapshot of food security situation in the middle of the 1990s. This study further extends their work and serves three objectives: to assess food security in a nutritional dimension (utilization), to investigate the sources of food insecurity in a food availability dimension, to identify potentials to achieve food security or self-sufficiency in a food stability dimension. The resulting classification allows for a broader view of the problem: which countries face similar situations and, therefore, may learn from each other's successes and failures to address food security issues? Additionally, this will allow conventional sub-national analyses to be more easily transferred across countries. Since agricultural sector is the most common and fundamental instrument to improve food security in the long haul, what kind of policy is most effective in attaining increased crop production? Are similar countries clustered at regional levels or do they vary across continents? If regions are populated by similar types of countries, then regional solutions may offer more effective solutions than a country-by-country approach. While standard measures such as per capita income levels and net food imports are useful, we find a more nuanced picture using a broader array of indicators because the more conventional measures ignore the structure of the economy, natural environment conditions, and the composition of trade. For instance, tourist destinations like Barbados may have high levels of food imports but they are not at risk of food insecurity. In general, we find that country specific measures (composition of trade and comparative advantages) provide a more accurate indication of food insecurity than broader regional characteristics.

The rest of the paper is organized as follows. The framework for food security analysis is presented in the next section, including a rationale for the selection of food security indicators considered for the typology analysis. The third section briefly describes the methodology used in this study – factor analysis and presents the results of the sequential typology analysis, ending with a classification of countries according to the food security framework defined. In the fourth section, the suggested typology of countries is discussed in greater detail considering the variety

of country situations. The evolution of food security since 2000 is discussed in the fifth section. Finally the last section concludes with some implications from the food security profiles summarized in this study for a better systematic approach to identify representative countries. Typology specific policy recommendations are also included in this section.

2. THE FRAMEWORK FOR FOOD SECURITY

2.1 Theoretical Framework

Food security can be analyzed at the global, national, regional, household, and individual levels. Concepts of food security have evolved in the last thirty years to reflect changes in official policy thinking (Clay, 2002; Heidhues et al., 2004). The history of food security definitions shows that, the focus has moved from the global and national perspectives to the household and individual levels, where the problem of food security emerges in a more concrete way (Maxwell, 1990, 1996). The term first originated in the mid-1970s, when the World Food Conference defined food security in terms of food supply to assure the availability and price stability of basic foodstuffs at the international and national level: "food security exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO, 1996a). The definition was revised by FAO to include the individual and household level, in addition to regional and national level aggregation in food security analysis (Clay, 2002). The widely accepted World Food Summit definition reinforces the multidimensional nature of food security including food accessibility, availability, utilization and stability.

This paper, acknowledging that the deeper issue of food insecurity requires analyses at the household and individual levels, takes nonetheless a national perspective and focuses mainly on food availability and utilization issues, using consumption, production, and trade measures suggested by Smith (1998). We do not intend to address sub-national income or food consumption inequalities in this paper and the results are simply an examination of food security at national level. We do recognize that there are other possible measures of the food security that may generate different conclusions.

One contribution of this study is to include indicators of long-term solutions to steady food insecurity -- to improve food availability by taking advantage of the country's agricultural potentials. Agriculture is imperative in promoting not only overall growth but also pro-poor growth given that most of the poor depends upon agriculture for their livelihood. Agriculture contributes to food security by increased food access and farming incomes allowing for better nutrition and thus higher productivity (Bliss and Stern, 1978; Strauss, 1986; Strauss and Thomas, 1995; Fogel, 1991, 1997; Williamson, 1993; Nadav, 1996). It is found that agricultural outputs per worker and per capita food production index have a large and statistically significant impact on reducing poverty (Majid, 2004). At the national level, Irz et al. (2001) argued that increase in agricultural output tends to drive down food prices which benefit the poor. Therefore it is not surprising to find that agriculture has a more substantial impact on reducing poverty and improving food security than other sectors of the economy.

Increased food production would help to restore the supply-demand balance at a lower price level. High food prices and the increased incentives they provide present an opportunity for agricultural producers to increase investment and expand production. Initial statistics indicate that the agricultural sector has responded to these greater incentives with increased planting and production (FAO, 2008a). The need to raise food production should not be limited to current status. Instead, increases in food and agricultural production and productivity will be essential to meet further increases in growing effective demand in the future. In order to meet this global food challenge, a central question relates to who participates in the short- and long-term response of agriculture to high food prices. Developing countries need to exploit their potential to increase agricultural production and productivity to achieve food security and self-sufficiency if possible, through a more conductive policy framework and increased investment in agricultural and rural development. For instance, if soil and temperature conditions are suitable for crop production but rainfall might be erratic and volatile in a country, investment in irrigation and water reservation related technologies is more effective in improving crop production and productivity. Based on climate and soil conditions, policies to exploit potentials for increasing agricultural supply can be developed accordingly.

The framework and theoretical logic flow of this exercise on food security typology is illustrated in Figure 1. First food utilization of the nutritional dimension is identified based on three indicators: calorie, protein and fat intake, which is driven by food availability and accessibility. Next food accessibility is proxied by the rate of urbanization, while domestic production and international trade define food availability. Both food availability and accessibility are determinants for adequate utilization of food. Agricultural potentials, including length of growing period, variation of length of growing period, and soil quality, are important preconditions for long term food supply or production. On the other hand, trade and trade policies influence both national and world food availability, as well as the cost of food imports (including food aid) at the national level. This food utilization – availability and accessibility – stability sequential approach allows us to distinguish outcome of food security (food utilization) from causes (food stability, accessibility and availability), providing more tailored policy recommendations for each food security group.

2.2. Food Security Indicators at the National Level

The indicators used in this study are considered proxies for four dimensions of food security measured at the national level: food utilization, availability, stability and accessibility. For better cross-country comparison and classification, the four dimensions are expressed in nine variables. Calories, protein and fat per capita intake are chosen to represent utilization of food through adequate diet from a nutritional point of view. For availability of sufficient quantity of food, we use food production per capita and the ratio of total exports to food imports. Food accessibility is expressed as the share of non-agricultural population to capture the inequality along rural/urban sub-groups. A population needs steady supply to be food secure in both short- and long-run, which is depicted by three agricultural potential variables: length of growing period and soil fertility for long-term stable food crop cultivation and coefficient of variation for variability or riskiness in domestic food supply.

The data for constructing the seven indicators were taken from the FAO online database (FAOSTAT, 2008b), aggregate at national level from FAO GIS database (2001), FAO (2000) and World Development Indicators by the World Bank (2008). The latest five-year average in the decades of 2000s, which for most countries is available for 2001-2005, was used for the analysis. The data set shown in Appendix Table 1 covers 175 countries for which data exist, ordered alphabetically. Those 175 countries and regions comprise 50 low, 50 lower middle, 34 upper middle, and 41 high income countries, according to the World Bank's definition. Although it would be desirable to assign more indicators to each of the dimensions defined above, data availability is limited, especially for food accessibility indicators.

Food utilization

Calories, protein and fat per capita: Three separate variables are used as indicators of average consumption levels at the national level: energy intake per capita per day measured in calories, and nutrient intake (protein and fat) per capita per day measured in grams. While national averages have limitations as indicators of household and individual food and nutrition security, Smith and Haddad (2000) show that aggregate calories (which they label food availability) is an important variable in explaining changes in malnutrition as defined by anthropometrical measures of children[1]. Yet measures based only on consumption of calories (such as the chronic malnourishment indicator used by the FAO), have been criticized, among other things, for ignoring protein and micronutrient consumption (Smith, 1998; von Braun et al., 1992, 2000). Consistent data on micronutrients at the national level are difficult to obtain, and this analysis uses time series for both calories and nutrients from FAOSTAT (2008b), thus improving upon a calories-only measure[2].

Food availability

Food production per capita is an indicator of the ability of countries to feed themselves. It tries to address both the notion of insurance and national autonomy, used mainly in some developed countries, as well as the more pressing problems of poverty and hunger in developing countries. This variable is calculated by the FAO as the vector of quantities of total food production in every year multiplied by the 1999-2001 average international commodity prices in international dollars, and then divided by total population of the corresponding year. Therefore, all values are in constant international dollars of 1999-2001. The definition of food is the one followed by FAOSTAT (2008b), which includes not only cereals, oils, and livestock products, but also other products such as fruits, pulses, roots and tubers, other vegetables, cocoa, and sugar.

[1] Aggregate calories is shown to be the second most important determinant to contribute to the decrease in child malnutrition over the period 1970 to 1996, contributing to 26 percent of the decline, while women's education, the most important factor, explained 48 percent of that decline. The impact of the first determinant, however, decreases at higher level of food availability.

[2] Bouis (2000) presents evidence showing that the animal component of food intakes is more strongly correlated with direct measures of nutrition such as weight-for-age, or blood hemoglobin, a marker of iron status. In that sense, the animal portion of proteins, instead of total proteins, could have been utilized in this exercise.

In terms of the contribution to calories, proteins, and micronutrients, the FAO category appears to be more adequate than narrower definitions of food, particularly those based only on cereals.[3]

The ratio of total exports to food imports is an indicator of the ability of different countries to finance their food imports out of total export revenues (i.e. a measure of access to world food supply by individual countries).[4] Total exports include merchandise and services, such as tourism. This indicator, which has been used in different early studies of food security (see for instance, Valdes and Konandreas, 1981), is more relevant for food security analysis than the net food trade position (i.e. food exports minus food imports). This last indicator only reflects the fact that a country is a net food importer or exporter, but not the relative cost for access to food in each individual country, and therefore how vulnerable it may be to changes in food prices and international food availability. A country that is a net food exporter but for which the total food bill takes a larger percentage of total exports (for example Bangledesh, with a food bill of about 20 percent of total exports) is likely to be more vulnerable than a country that is a substantial net food importer but whose food bill takes only a small percentage of its total exports (for example Venezuela spends about 5.7 percent of total exports, which include substantial oil sales, on imported food).

The ratio of the food import bill over total exports also presents a broader and more adequate picture of the role of trade, and the possible impact of trade policies, on food security. Focusing only on the value of the food import bill (gross or net) does not take into account the broader contribution of trade to food security, which is not only the availability of food in world markets, but also the generation of export income to finance those imports. A country whose food import bill goes up may still be less vulnerable if at the same time its total exports have gone up by a larger amount. Conversely, a country may be more vulnerable even with declining food import bills, if exports receipts have dropped even more. Therefore, in the context of trade policies the important issue is whether total exports have grew faster as a result of those policies by more than the food import bill.

Appendix Figure 1 shows the ratio of the food bill to total exports for the low, lower middle, upper middle, and high income countries in the sample. While the ratio remains high for low and lower middle income countries, there is a downward trend of relative cost of food imports. This trend is most visible among low income countries, where ratio of food bill to total exports declines from about 20 percent in the early 1990s to 12 percent in 2005. Lower middle income countries also see a drop in the food bill of about 6 percentage point over the same period. Although the magnitude of decline is smaller in upper middle and high income countries, this ratio also decreases from 9 percent in mid-1990s to 6 percent in 2005. Unlike distinctive trend for low and lower middle income countries, upper middle income countries share almost

[3] FAO data for food production does not include fish and fish products. These food items are not part of the product coverage of the Agreement on Agriculture but their importance for food security may be high, particularly for some developing countries and social groups. For example, Delgado et al. (1998) discuss the importance of fisheries in developing countries.

[4] This variable is usually measured as food imports over total exports, i.e. the inverse of the ratio used here. As calculated in this paper, higher (lower) values would indicate more (less) food security and the variable could be interpreted similarly as consumption of calories and proteins, and food production. This makes the charts used in this analysis easier to read.

identical ratio and trend. However, the recent high food prices and global recession resulted in a reversal of this downward trend.

In terms of trade and food security, a point to be noticed is that the decline in the ratio during the last decade for low and lower middle income countries has been related to the expansion of total trade, and not to a decrease in food imports, which have been growing (but at a slower rate than total exports). Appendix Figures 2a-2d show the values of the food bill and total merchandise and service exports (measured in billions of current dollars) for low, lower middle, upper middle and high income economies, respectively. Although the cost of food imports has increased over time in all income countries at all income levels, the volume and value of total merchandise exports has grown even more during those years, as a result of buoyant economic conditions at the world level. For instance, food import in low income countries in 2005 grew to 3.3 times of its 1990 level, and at the same time total exports reached nearly 5 times of 1990 level. The jump in food prices during 1995-1996, which generated widespread concern at the time (Friedberg and Thomas, 1997; FAO, 1999), is barely perceived, if at all, in the data presented. Conversely, with declining food prices after the 1997 Asian crisis (and further reverberations in Russia during 1998 and Brazil in 1999), the ratio clearly went up, especially in low and lower middle income economies, showing a deterioration of the ability to finance food imports, which was basically caused by a decline in total value of exports.

Although the ratio of food imports to total exports in low and lower middle income countries has declined in the 2000s compared to the 1990s, the burden of the food import bill is still very high in those countries. Furthermore, the increase of total exports by these countries has been slower than the expansion of aggregate world trade. Since data used in this study only reflects figures up to 2005, the ratio is expected rise dramatically for some net food importing countries during the peak of food crisis in 2007-2008. The current slowdown of world economy will certainly exacerbate trade positions of some low and lower middle income countries whose trade structure consists of raw material exports and cereal imports. In summary, these observations underscore the importance of looking at food imports in the context the evolution of trade in general. The ratio used here appears more appropriate than the net food importing measure to identify vulnerable countries and to help evaluate the impact of trade issues in general, and not just on food (which is only a part of agricultural exports).

Food accessibility

Non-agricultural population: An indicator of food accessibility is the share of non-agricultural population, which gives an idea of the extent to which countries may be affected by changes in trade and agricultural policies, and the possible distributive impact along the rural/urban dimension. There are concerns in some developing countries that certain agricultural and trade policies (like removal of fertilizer subsidy) may create problems for their large agricultural populations, where poverty is still concentrated. At the same time it is also important to notice the shift in the locus of poverty, food insecurity, and malnutrition from rural to urban areas that different developing countries are experiencing. Some of them exists for several decades now, some others as a more recent phenomenon (Ruel et al., 1998; Ruel et al., 1999; Haddad et al., 1999; Garrett and Ruel, 2000). Therefore, while for the other indicators (consumption per capita of calories, proteins and fat, food production per capita, and total

exports per unit of food import) a higher value would be associated with greater food security, the ratio of urban population may be somewhat more ambiguous in its implications.

Urbanization in developing countries is posing new questions regarding economic and social policies. The world's urban population has grown more than the rural population. Sixty-one percent of the world' populace will be in urban areas in the next three decades (Cohen, 2006). However, three quarters of the poor remain in rural areas and poverty will continue to be more prevalent in rural areas (Ravallion, Chen and Sangraula, 2007). Ideally, ratio of agriculture investment in agricultural GDP will capture the supply side of food security. However, since data for the 175 countries is scarce we look at the demand side of food security equation. The share of non agricultural population indicates impact of net food buyers, which is becoming a larger share of people affected by rising food prices.

Food stability

Length of growing period (LGP): LGP is defined as the number of days in a year when sufficient water is available in the soil profile to support plant growth. The concept of the growing period provides a way of including seasonality in land resource appraisal. In many tropical areas, conditions are too dry during part of the year for crop growth to occur without irrigation, while in temperate climatic regimes crop production in winter is limited by cold temperatures. The growing period defines the number of days of the year when both natural moisture and temperature conditions are suitable for crop production (FAO, 1996b). It provides a framework for summarizing temporally variable elements of climate, which can be compared with the requirements and estimated responses of a plant. Such parameters as temperature regime, total rainfall, soil properties and potential evapotranspiration are more relevant when calculated for the growing period, when they may influence crop growth, rather than averaged over the whole year. Length of growing period is calculated and mapped globally at a scale of 30 minutes based on spatially interpolated 40-year average climatic data of temperature, humidity and elevation (Fischer, et al. 2001). A map of length of growing period overlaid with country border is presented in Figure 2, which highlights countries with favorable (long) growing period are clustered around equator and west Europe.

Coefficient of variation of length of growing period: While length of growing period may be acceptable for broad scale national studies, it fails to capture the temporal year-to-year variation in length of growing period and the incidence of climatic hazards. The coefficient of variations of length of growing period is introduced to fill the gap. It is calculated as the ratio of standard deviation to the mean of length of growing period, allowing us to compare the scatter of rainfall and temperature variations on a year-to-year basis. A map of length of growing period overlaid with country border is presented in Figure 3. Countries with more erratic or irregular rainfall patterns (a CV of LGP greater than 1) include some Middle East and North African countries like Djibouti, Egypt, Jordan, Kuwait, Saudi Arabia, United Arab Emirates, Yemen, as well as Namibia and Pakistan.

Soils without major constraints: This indicator reflects the percentage of soils without major constraints in the total areas. In order to translate soil characteristics into agronomic constraints, one of the best known methods, the fertility capability classification (FCC) is used

(Sanchez et al., 1982). This characterizes soils by means of a set of fertility constraints, that is, inherent features which offer problems to soil management. The FCC criteria were linked with the mapping units of the Soil Map of the World to derive country level soil constraints. All data reported on inherent soil constraints apply to the total areas of regions or countries, not to their arable land, or agricultural land. Thus, for example, the areas showed as having erosion hazard and shallowness include mountainous regions in which little or no attempt at agricultural use is made. For the world's land area as a whole, there are four major constraints (erosion hazard, aluminum toxicity, shallowness and hydromorphy), each occupying 13-16% of the global area. Four other constraints (salinity and sodicity, low cation exchange capacity, high phosphorus fixation and vertic properties) each cover 2-6% of the area. Soil quality analysis can be used for preliminary assessment of potential development strategies, or potential for soil management technology transfer (Nachtergaele and Brinkman, 1996).

A range of soils exists which are not affected by any of the eight major constraints covered above. Some are in dryland and others possess constraints within the soil fertility capability classification, because they are either less severe or of relatively low extent[5]. Based on the method by which these have been identified, they may be referred to simply as soils without major constraints. In terms of the classes shown on the Soil Map of the World, just under a quarter of the world's land area has soils which lack the major constraints of the fertility capability classification (FAO, 2000). North Asia (east of the Urals) has the largest total and relative extent with 40 percent of total area without any major soil fertility constraints. Europe and North America follow at 31 and 27 percent, respectively. Twenty-three percent of total area is fertile in the Asia-Pacific region. Less than 20 percent of land area contains soil without any major constraints in Sub-Saharan Africa and South and Central America. The figure in North Africa and the Near East is only 9%, to which the constraint of dryness must be added due to widespread desert and low rainfall.

A map of soil fertility by country is presented in Figure 4. A notable feature of the country-level soil fertility results is that 22 of the 36 countries with over 40% soils without major constraints lie in Europe. This includes the extension of the Ukraine and adjacent countries. Among non-European countries, the greatest total extent by far is found in the Russian Federation. Next in order of absolute area are the United States, Canada, China, Australia, India and Argentina. There is a striking coincidence between countries with high total areas of soils without major constraints and the world's leading grain-producing and exporting countries. It is worth pointing out that although some countries have vast fertile land measured in absolute area, the share of fertile soil in total area might not follow the suit. For example, only 20 percent of land area is fertile in China, even though it is one of the top countries when measured in the area of high quality soil.

Table 1 summarizes definitions and sources of the 9 indicators, and descriptive statistics are included in Table 2.

[5] These additional constraints are: acidity; dominance of allophane in the clay fraction (Andosols); potassium-deficiency; free calcium carbonate; acid sulphate soils (cat clays). Dryness (an ustic or xeric soil moisture regime) is also recognized by the fertility capability classification as a soil limitation.

3. FACTOR ANALYSIS OF FOOD SECURITY

Factor analysis is a statistical method used to describe variability among observed inter-correlated variables in terms of fewer unobservable (latent) variables called factors. The observed variables are modeled as linear combinations of the factors, plus "error" terms. It is a form of data dimensionality reduction, and the information gained about the interdependencies can be used later to condense variables into fewer dimensions with a minimum loss of information.

Factor analysis is based on the correlation matrix of the variables involved. Suppose we have a set of p observable random variables $x_1, \dots, x_p$ with means $\mu_1, \dots, \mu_p$. Assume for some unknown constants l_{ij} and k unobserved random variables F_{ij}, where $i, j = 1, \dots p$. For $k<p$ we have $x_i - \mu_i = l_{i1}F_1 + \cdots + l_{ip}F_p + \varepsilon_i$.

Here ε_i is independently distributed error terms with zero mean and finite variance, which may vary for different *i*.

Let $V(\varepsilon_i) = \psi_i$, so that we have $COV(\varepsilon_{p\times 1}) = Diag(\psi_1, \dots \psi_p) = \Psi$ and $E(\varepsilon) = 0$. In matrix terms, we have $x - \mu = LF + \epsilon$.

Also we will impose the following assumptions on *F*:

1. *F* and ϵ are independent;
2. $E(F) = 0$;
3. Cov(F)=I(k).

Any solution for the above set of equations following the constraints for *F* is defined as the *factors*, and *L* as the *loading matrix*. Suppose $COV(x_{p\times 1}) = \Sigma_{p\times p}$, then we have $COV(x - \mu = COVLF + \epsilon$, or $\Sigma = LCOVFL' + COV\epsilon = LL' + \Psi$.

Factor analysis is used to isolate the underlying "factors" that explain the variance of a group of variables. It is an interdependence technique and the complete set of interdependent relationships is examined. It allows us to reduce the number of variables by combining two or more variables into a single factor. It also assists in the identification of groups of interrelated variables and to see how they are related to each other. Factor Analysis can be used to identify the hidden dimensions or constructs which may or may not be apparent from direct analysis. However, the usefulness of factor analysis depends on the researchers' ability to develop a complete and accurate set of product attributes. The selection of the variables is crucial because the derived factors would only reflect the structure of the data set as defined by those variables. If important attributes are missed the value of the procedure is reduced accordingly. Interpreting factor analysis is based on using a heuristic approach, and more than one interpretation can be made of the same data factored the same way. It is not possible to know what the "factors" actually represent without theory or a prior knowledge. Also there is no specification of dependent variables, independent variables, or causality.

There are several ways to conduct factor analysis and the choice of method depends on many things (Hair et al., 1998). Although there have been heated debates over the merits of the methods, a number of leading statisticians have concluded that in practice there is little difference (Velicer and Jackson, 1990), since the computations are quite similar despite the differing conceptual bases, especially for datasets where communalities are high and/or there are many variables. For our purpose we will apply principal component analysis, which seeks values of the loadings that bring the estimate of the total commonality as close as possible to the total of the observed variance. The factors produced by principal component analysis are conceptualized as being linear combinations of the variables, and results produced by principal component analysis are not dependent on the method of computation.

Correlation coefficients are presented in Table 3, and high correlations are observed among three nutritional indicators: calorie, protein and fat intake per capita per day. It is suspected that there exist one or more common factors among the three variables and factor analysis is applied to the three measures of nutrition intake. Generally speaking, calorie intake in high correlated with protein and fat intake, with correlation coefficient ranging between 0.82-0.91. To avoid giving more weight to any one variable because of its unit of measure, variables are standardized to z-scores (subtracting the mean and dividing by the standard deviation). One common factor is extracted from the three variables and it explains 90 percent of total variance of the three variables. We name this factor as "food security" and it is expressed as the product of factor loading and variables:

$$F = 0.961 * calorie + 0.959 * protein + 0.929 * fat.$$

Factor scores are the scores of each country based on the caloric and nutrient intake factors, which are widely used to portray the concept of food security. To compute the food security factor score for a given country, one takes the country's standardized score on each of the three variables, multiplies by the corresponding factor loading of the variable for the given factor, and sums these products. Computing factor scores allows us to rank countries for the widely used nutritional or food utilization aspect of food security. In addition, factor scores can be incorporated in subsequent analysis.

The food security score follows a standard normal distribution with mean equals to 0 and variance equals to 1. The score ranges from -2.17 in Democratic Republic of Congo to 2.14 in United States (Appendix Table 1). We first split the countries into 5 groups based on their food security factor scores. Countries with food security factor scores falling below -1 are defined as "Lowest Food Security". The Low Food Security group has factor scores in the -1 and -0.5 ranges. Countries with factor score between -0.5 and 0 are considered to be in the "Middle Food Security" category. Factor scores of nutrition consumption lie between 0 and 1 are labeled as "Upper Middle Food Security". Finally, Countries with food security factor scores above 1 are considered "High Food Security". The means of all nine indicators as well as GNI values, are summarized for each food security group in Table 4. The map of the food security factor score is included in Figure 5.

Since this study emphasis the food insecurity issue among countries, we will discuss the former three groups in great detail while only briefly remark Upper Middle and High food security countries.

4. TYPOLOGY ANALYSIS

We will employ a sequential method to generate a food security profile for the 175 countries included in this study, following the sample structure outlined in Figure 6 for each food security group. First, countries of each food security group are separated according to the trade security level, countries with a food imports accounts for more than 10 percent of total export earnings on food imports are categorized as trade insecure, while countries spent less than 10 percent of total export on importing food from world market are trade secure. Second, countries are further organized according to their food production level. If a country's food production per capita is below sample mean of 232 1999-2001 International dollars, it is classified as a low food production country; otherwise, the country is a high food production country. At last, we will arrange countries within each trade and production sub-groups into 4 sets, based on their agronomical conditions: countries with high soil fertility and favorable climate, countries with high soil fertility and unfavorable climate, countries with low soil fertility and favorable climate, countries with low soil fertility and unfavorable climate. It is possible that not all sub-groups exist within each food security group. For example, there are no trade insecure countries in the High Food Security group, or no high food production countries in the Lowest Food Security group.

Table 5 lists the countries based on their food security status and conditions of climate and soil fertility. The level of food security is defined as Lowest, Low, Middle, Upper Middle and High, and it increases as we move down the table. For example, the first panel includes countries of lowest food security, classified in 2 sub-groups: trade secure and low production sub-group and trade insecure and low production group. These countries are first grouped based on their soil fertility conditions, using the sign of z-scores of percentage of soil without major fertility constraints. "High soil fertility" refers to positive z-scores of percentage of soil fertility and "low soil fertility" negative z-scores. Within each soil group, countries are further disaggregated based on their climate conditions. We define "favorable climate" as positive z-scores of temperature and rainfall conditions and "unfavorable climate" as negative z-scores. Countries of the Low Food Security group are listed in the next panel of two rows, followed by panels of the Middle and Upper Middle Food Security countries. The last panel of four rows includes High Food Security countries.

Table 6 lists countries based on food security status and geographic location. The Lowest and Low Food Security countries are overwhelmingly clustered in sub-Saharan Africa. Most Latin American countries fall in the group of Middle and Upper Middle Food Security groups, and the majority of West European and North American countries belong to the High Food Security group.

The next section will analyze in greater detail these Food Security groups and their composition. It provides an indicator of the degree of membership, thus allowing a deeper understanding of the composition of groups and the differences between countries.

4.1 Lowest Food Security Group

The Lowest Food security group contains 31 countries. Countries in this group all have food security factor scores below -1, and they suffer from the lowest levels of food intake measured in calories (2,026), protein (50.3 grams) and fat (36.9 grams) per capita. These countries have nutrition indicators that are all below the -0.5 threshold of their standardized z-score values. They show the lowest levels of food production per capita ($94.4 in 1999-2001 International dollars) and have the lowest per capita income (GNI per capita only $395). The food import bill for the group on average amounts to more than 15 percent of total exports, and countries are predominately rural (only 31 percent of the population is urban). All but one (Swaziland) countries are classified as low-income economies by World Bank.

The sequential typology analysis for the Lowest Food Security group is presented in Figure 7. Of the 31 countries in this group, only 7 countries spend less than 10 percent of foreign exchange earnings on food import: Cambodia, Laos, Tajikistan, Angola, Republic of Congo, Swaziland and Zimbabwe.

Twenty-two countries in this group are located in sub-Saharan Africa: Burundi, Central Africa Republic, Comoros, Democratic Republic of Congo, Eritrea, Ethiopia, Guinea, Kenya, Liberia, Madagascar, Malawi, Mozambique, Niger, Rwanda, Sierra Leone, Tanzania, Uganda and Zambia. Four countries located in East Asia and Pacific Rim are also classified as most food insecure: Cambodia, Laos, Democratic Republic of Korea and Solomon Islands. In addition, Bangladesh in South Asia, Yemen in Middle East and Haiti in Latin America and the Caribbean are also in the Lowest Food Security group. Historically, a major source of food insecurity is conflict, which happened in the majority of countries in this group in spite of long growing periods.

Soil fertility is low in 19 countries but climate is favorable for crop cultivation in 11 of them. Eight countries are endowed with low soil fertility and unfavorable climate, as indicated in Table 5. More than half of countries in the Lowest Food Security group (17 countries) enjoy favorable climate, and climate is favorable for agricultural production in 6 countries. However, countries in this group do not generate enough food supply and average food production is below $170, despite helpful weather and soil condition,.

4.2 Low Food Security Group

This group has low nutrition consumption but is better off than the Lowest Food Security group, with consumption of 2,368 calories, 64.6 grams of protein and 55.6 grams of fat. Food imports still account for a significant part (near 12 percent) of total export earnings, indicating heavy reliance on international market and food aid. About one-third of the countries are trade secure. Urbanization rate is significantly above the Lowest Food Security group, and about half of its population lives in rural area. Countries in the Low Food Security group generally are all

low food producing countries, and food production per capita averages about 140 International dollars.

This group includes 31 countries, 18 of which are low-income economies. There are 14 sub-Saharan countries in this group, of which 12 are low-income countries except for Botswana and Namibia: Benin, Cameroon, Chad, Cote d'Ivoire, Gambia, Ghana, Guinea-Bissau, Lesotho, Mali, Senegal, Sudan and Togo. Nine countries in Latin America and the Caribbean fall in this group as well: Bolivia, Colombia, Dominican Republic, Guatemala, Honduras, Nicaragua, Panama, Peru and Venezuela. Nepal, Pakistan, Sri Lanka and India are also Low Food Security countries. This group also includes Philippine and Vietnam in East Asia, Armenia in East Europe, Djibouti and Palestine in Middle East and North Africa.

One thing to notice is that most Latin America and the Caribbean countries in this group are far less rural than other food vulnerable countries in this group. In fact, on average more than 68 percent of the population in Latin America and the Caribbean countries in the Low Food Security group is classified as urban. This raises the issue of urban food insecurity, which has its own special characteristics. While countries in the previous Lowest Food Security group, being mostly rural, may be more concerned about food insecurity in the countryside and the impact of agricultural imports on poor agricultural producers, in countries with larger urban populations, where a large part of poor and food insecure groups may be urban dwellers, there is clear trade-off for policies aimed at agricultural sector promotion: they may maintain higher incomes for poor rural producers but they may also act as a tax on poor urban consumers (both effects depending on other policies the interactions of market and institutions).

Similar to the Lowest Food Security group, countries in this group are presented in all four climate and soil condition combination (Figure 8). Climate and soil fertility conditions are detrimental for food production in 11 countries: Bolivia, Botswana, Chad, Djibouti, Guinea-Bissau, Namibia, Pakistan, Palestine, Peru, Mali and Sudan, where deserts account for a substantial part of land area. On the other hand, 8 countries enjoy high fertile soil and favorable climate. They are located in tropical areas, including 5 countries in Latin America and the Caribbean (Dominican Republic, Guatemala, Honduras, Nicaragua and Panama), 1 in sub-Saharan Africa (Togo), 1 in East Asia and Pacific (Philippines) and 1 in South Asia (Sri Lanka).

4.3 Middle Food Security Group

The Middle Food Security group countries have their food utilization indicator z-scores in the -0.5 to 0 range, although there are some deviations mostly towards the values above +0.5 or below -0.5. All of them show levels of food consumptions and production per capita above the Low Food Security groups. An average person consumes 2,636 calories, 75.8 grams of protein, and 66.9 grams of fat. Per capita food production increases by $52 to $192. Countries tend to be more trade secure and spend less than 10 percent of total export on food import. More than 56 percent of the population is urban residents. Among the 29 members of this group, 12 members are from Latin American and the Caribbean, 5 from sub-Saharan Africa, 6 from East Asia and Pacific, 5 from East Europe and Central Asia, and 1 from Middle East.

Figure 9 indicates that higher than average food production is associated with benign climate and fertile soil in this group. Favorable climate is registered in 8 out of 9 high food

production countries, including Paraguay, Thailand, Costa Rica and Ecuador. In addition to some small islands, several large countries (in terms of land area) come out with low food production under unfavorable climate: Azerbaijan, Burkina Faso, Jordan, Mongolia, Nigeria and Uzbekistan. There are also countries under favorable climate but produce less than average food: Indonesia, Myanmar, Bosnia and Herzegovina, El Salvador, Gabon, Georgia and Jamaica,

4.4 Upper Middle Food Security Group

The Upper Middle Food Security group countries have their food security z-score indicators in the 0 to 1 range. The levels of nutrition consumption are higher than their counterparts in the Middle Food Security group, with average calorie, protein and fat intake per capita 2,977 calories, 93.1 grams and 86.5 grams. Per capita food production in the Upper Middle Food Security group is higher than that of the Middle Food Security groups, but countries in this group exhibit higher food production per capita at $445 despite lower soil fertility and unfavorable growing conditions.

This group stands out for high soil quality – some of the world's most fertile soil without any major fertility constraints is located in countries within this group. Many countries under this classification have great potential to significantly increase food production and provide a resilient supply for the world market. Among the countries enjoying favorable weather and good soil conditions, many are located in East Europe and Central Asia or are tropical islands. There is no country falling in the combination of favorable weather and low soil fertility for trade secure groups (Figure 10). Among 17 countries with barren soil and inclement climate, food production is higher than average in 8 countries: Chile, China, Estonia, Iran, Kazakhstan, Kyrgyzstan, Lebanon and Turkmenistan. Additionally, 4 more countries with low soil fertility but favorable climate are high food production countries: Brazil, Malaysia, New Zealand and Slovakia. Of the 14 high food production countries where soil is generally rich, adverse climate exists in 9 countries: Argentina, Belarus, Bulgaria, Latvia, Macedonia, Russia, Turkey, Syria and Ukraine. Only 5 high food production countries are blessed with both favorable climate and high soil fertility: Albania, Croatia, Serbia and Montenegro, Slovenia and Uruguay. Many countries of high food production in this group indicates that difficult natural endowment for crop cultivation can not necessarily the single or predominant determinant of agricultural production or food security status, and investment in agricultural sector could improve and overcome the agronomical constraints in countries without beneficial natural conditions.

In the Upper Middle Food Security group, major players of food production are concentrated in East Europe and Central Asia (16 countries) and Latin America and the Caribbean (5 countries), in addition to China, Malaysia and New Zealand in East Asia and Pacific Rim. South Africa is the solo significant food producer in sub-Saharan Africa in this group.

Many small islands are classified in this group, scattering in the Caribbean and the Pacific Ocean, which requires some further analysis because the levels of trade stress are the highest in some individual countries. The level of trade stress is an issue for some of the countries in this group, such as Suriname, Dominica, Antigua and Barbuda, Vanuatu, Moldova, Jamaica, Belize, Guyana. In these island countries, food import is 20-30 percent of total exports, as most of them have little arable land and thus have to depend heavily on imported food

shipment. Although these countries have a high to very high food import bill, they should not be classified as food insecure even with such high levels of trade stress. Although in terms of trade stress, the countries mentioned above are vulnerable or worse than some lower food security countries, they also have far higher levels of consumption of calories and nutrition. In addition, these countries are far less rural than most food insecure countries, and most of them are classified as upper middle or high income countries by World Bank,. Therefore, these trade stressed countries are classified by the factor analysis algorithm in the Upper Middle Food Security group.

4.5 High Food Security Group

The last panel of Table 5 and 6 includes countries with food security factor scores above the +1 value, which translates into average consumption of calories, proteins and fat in excess of 3,486, 117.4 grams and 131.8 grams. Food production per capita hovers far above any other groups (above $445), and food import bill less than 6 percent of total exports (i.e., these countries are mostly trade secure). Most countries are very urban (above 82 percent of total population). There are 5 trade insecure countries but the levels of food consumption and high domestic production, as well as a trade ratio for food imports, have provided enough buffers to achieve food security under any likely event, domestic or international (Figure 11).

Almost all industrialized countries (considered in the category of high-income OECD countries by the World Bank) fall into the High Food Secure group, but they also include some developing countries and transition economies (which fall under the upper middle-income label of the World Bank). All European Union members are in the High Food Secure group, except for transition economies of Bulgaria, Estonia, Latvia, Slovakia and Slovenia (which are in the Upper Middle Food Secure group with high food production). All of the 33 countries in high food security groups are classified as high income by World Bank, with the exception of 3 upper middle income countries (Poland, Lithuania and Romania).

5. EVOLUTION OF FOOD SECURITY

This section compares the five food security indicators: calorie intake per capita, protein intake per capita, food production per capita, ratio of total export to food import, and share of nonagricultural population, which are available for both Diaz-Bonilla et al.'s (2000) and this study. Table 7 presents the growth of these variables over an 8-year period, from 1993-97 to 2001-05 (5-year average) in percentage, and a positive growth means improved food security. On average, the five indicators all grow at various rates, with food production and protein intake the fastest and calorie intake the slowest.

In terms of calorie intake, all groups registered a positive growth, but the High Food Security group grew especially faster than the Lowest and Low Food Security groups. Protein intake grows healthily across all groups, and generally growth rate of protein intake is higher than that of energy intake. But protein intake grew the slowest in the Lowest Food Security group at 0.6 percent per year but at a robust 1.5 percent or higher in other groups. There is a

trend of urbanization, which is more manifest in the Lowest and Middle Food Security countries, witnessing share of urban population increasing by 1.1-1.2 percent annually.

Food production increases universally, especially in the Upper Middle Food Security countries. Several countries with favorable weather or fertilizer soil register dramatic increase in per capita food production by more than 50 percent within a decade, including Armenia, Azerbaijan, Belarus, Laos, Malaysia, Vietnam Ghana, Rwanda, and Cuba (Appendix Table 2). On the other hand, food production per capita dropped more than 20 percent in some countries with unfavorable agricultural environment (Namibia, Botswana) or tropical islands (Saint Lucia, Vanuatu, Antigua and Barbuda, Saint Vincent and Grenadines), as well as three sub-Saharan African countries: Democratic Republic of Congo, Eritrea and Senegal. In fact, among the countries experienced negative growth in per capita food production, 23 out of 41 are located in sub-Saharan Africa, and 9 in Latin America and the Caribbean.

Trade variable has the biggest volatility, annual growth rate ranging from -20.6 percent in The Bahamas to more than 31.8 percent in Uzbekistan. Average share of food import in total export decreases in all groups except for the Lowest Food Security group, indicating a deteriorating trade balance in the most vulnerable countries. Combined with slow growth rate of per capita food production and high urbanization, it implies that the trade stressed Lowest Food Security countries have observed an increased burden of imported food bill while facing a quickly urbanizing population. Compare to Appendix Figure 2a - Figure2d, it is important to note that aggregate by income level could mask vast difference among countries within the same income level.

Next let's examine the food insecure countries in the Lowest Food Security group closely in Appendix Table 2. During the mid-1990s to early 2000s, most countries exhibited some improvement in at least one of the five temporal indicators. Of the 30 least food secure countries, 3 countries have improved all 5 indicators: Cambodia, Malawi and Mozambique. Additionally 11 countries have gained in 4 out 5 indicators. Two countries show the complete opposite trend: food consumption and production per capita level declined, trade position deteriorated, and urbanization reversed, indicating the utilization, accessibility and availability of food have plummeted. Both countries are in sub-Saharan Africa, including Democratic Republic of Congo and Zimbabwe.

Seventeen out of 30 countries in the Lowest Food Security group observed higher per capita food production, with more than 4 percent per annum registered in Laos, Malawi, Rwanda and Uganda. Additionally, food production net of population growth grew at more than 2.4 percent per year took place in 7 countries: Angola, Bangladesh, Cambodia, Central African Republic, Guinea, Kenya and Mozambique, and grew at 1-2 percent annually in Haiti, Liberia, Niger and Tajikistan. In spite of the encouraging progress in these countries, per capita food production decreases in a dozen of low food security countries. Annual per capita food production falls by more than 1 percent in Burundi, Comoros, Democratic Republic of Congo, Eritrea, Ethiopia, Madagascar, Republic of Congo, Togo, Zambia and Zimbabwe. It is alerting to recognize that millions of people are facing dwindling domestic food supply, which could be attributed to adverse weather, conflicts, and poor-designed agricultural policies.

6. CONCLUSIONS AND ISSUES FOR FURTHER RESEARCH

6.1. Discussion and Conclusions

This exercise has been an intermediate step between the analysis of aggregate categories and the study of individual sub-national country cases. By highlighting groups of countries with similarities in their food security profiles, as measured by the variables considered here, it allows a more differentiated analysis of possible situations of food (in)security. This classificatory exercise is also relevant for the grouping of countries in terms of their possible investment, policy interventions and trade positions.

The results have implications for the two issues identified in the introduction: first, the usefulness of the categories currently used by international development community to discuss food security concerns, and, second, the appropriate policies tailored for each food security group. The answer to the first issue is positive as this study shows that some of the commonly used categories by the development economists appear inadequate to capture food security concerns. The most obvious case is the category of "developing countries". Concerns about the wide variety of countries labeled as developing countries, have existed for some time in development literature. Those concerns are highlighted by this analysis, where developing countries appear scattered across all levels of food (in)security, except for the High Food Security group.

The categories by income level, however, more aligned with our definition of food secure groups: low income economies dominantly falling into the Lowest Food Security group with the lowest food consumption indicators. Of the 50 low income countries included in this study, all fall into the Lowest or Low Food Security groups except for Burkina Faso, Kyrgyzstan, Mauritania, Myanmar, Nigeria, San Tome and Principe, Vietnam, and Uzbekistan. But, at the same time, there are some countries that have a somewhat better food security profile are included in the low food security categories, which are middle income countries, such as Angola, Republic of Congo and Swaziland.

Figure 5 presents the regional distribution by the Lowest, Low, Middle, Upper Middle and High Food Security groups. Sub-Saharan Africa dominates the low food security groups, especially the Lowest group. This is consistent with the FAO (2008a) report that among 39 countries experienced serious food emergencies and required external assistance for dealing with critical food insecurity, 25 of them are in Africa. One South Asian country is in the Lowest Food Security group (Bangladesh) and 4 countries are in the Low Food Security group: Nepal, Pakistan, Sri Lanka and India). Central American and the Caribbean countries are mostly clustered in the Low and Middle Food Security groups, while several big South American economies fall into the Upper Middle Food Security group (Argentina, Brazil, Chile and Uruguay). Countries in Middle East and North Africa are concentrated in the Upper Middle Food Security group, except for Yemen and Jordan in lower security groups. East Europe and Central Asia congregates mostly in the Middle and Upper Middle Food Security groups, while all countries in West Europe and North America are in the High Food Security group. The resulting groups from this study allows countries within the same food security category to learn from the successes and failures of each other for a solution to food security by further exploring the

synergy of cross-country study. It also encourages conventional sub-national analyses to be more integrated into regional based on food security related issues.

The Global Hunger Index 2003 (Wiesmann, 2006) ranks 119 countries in the world, based on three equally weighted indicators: the proportion of people who are food energy deficient (share of the population with inadequate dietary energy intake) as estimated by the FAO, the prevalence of underweight in children under the age of five as compiled by the World Health Organization (the proportion of children suffering from weight loss and/or reduced growth), and the under-five mortality rate as reported by the United Nations Children's Fund. The results show that most of the countries ranking low in hunger are in sub-Saharan Africa and South Asia regions. There are a few exceptions to this regional pattern and several countries have high hunger scores (at alarming or extremely alarming level): Haiti in the Caribbean, Yemen in Middle East, Tajikistan in Central Asia, and Cambodia, Laos, Timor-Leste in Southeast Asia, Nepal in South Asia. The findings based on Global Hunger Index are consistent with the Lowest and Low Food Security groups defined in this study.

A recent IFPRI study report rate of ultra-poverty (the poorest poor) using appropriate cut-off values applied to households' total expenditure per capita in 20 countries, based on national household surveys (Akhter et al., 2007). Five countries exhibit high ultra-poverty incidence (more than 10 percent of the population is ultra poor) and high food insecurity, of which 4 countries are in sub-Saharan Africa (Burundi, Mozambique, Rwanda, and Zambia) and 1 in Latin America (Nicaragua). The 5 countries are all classified as low food security countries in this typology analysis.

Being a net food importer appears to be only a weak indicator of food vulnerability. Some countries may be net food exporters but still have a larger percentage of their total exports allocated to buy food, and vice-versa, as the contrasting examples of Mali and Venezuela have shown. Additionally, some countries may be net food importers just because of a dominant tourist industry (like Barbados, which also has a high income per capita at about US$7,000). Other net food importing countries have important levels of oil exports (such as the case of Venezuela, and Trinidad and Tobago) and therefore imports of food only reflect the comparative advantages of their economy structure. It is important to note that some events can alter the landscape of food security quite quickly: changes in terms of trade, occurrence of conflicts, etc.

The second issue of policy design is also very relevant. The classification presented here of food insecure countries would help accomplish defining more precisely the group of countries that appear vulnerable to food security problems, and thus providing more targeted policies in representative countries. Stakeholders could design country- and region-specific policy to target the constricting factor in promoting agriculture production. In order to achieve food security and self-sufficiency if possible, developing countries need to exploit their potential to increase agricultural production and productivity through a more conductive policy framework and increased investment in agricultural and rural development. This approach allows decision makers to mobilize and utilize resources more effectively and efficiently in order to achieve development and food security goals. For instance, in the Lowest Food Security group, benign weather is beneficial for crop production but soil is plagued by major constraints such as aluminum toxicity in many sub-Saharan African countries. For most crops and cultivars, fertilizer response will be poor so long as the soil remains strongly acid from aluminum toxicity. This could

be corrected by choosing the correct technology of soil management (like liming), which is technically feasible. On the other hand, if soil and temperature conditions are suitable for crop production but rainfall might be erratic and volatile in a country (like Kenya and Pakistan), investment in irrigation and water reservation related technologies is shown to be more effective in improving crop output and yield. In countries with supreme soil and moderate temperature conditions, such as East European and Central Asian countries, policies to promoting cereal production are one way to exploit the countries' comparative advantages in food production in global market. Some of the broad policy recommendations are summarized in Table 8, based on FAO's approaches for fighting hunger (Pingali et al., 2005).

Not only does there need to be an increase in investment in agriculture but the right focus for this investment has to be found. A coordinated response to deliver aid in agriculture most effectively is essential. Donors need to scale up aid to the sector and to consider investing through comprehensive plans, formulated by the developing countries.

It is also relevant to ask about the food security situation of the developed countries. Our typology, however, shows that developed countries are unanimously concentrated in the food secure groups, according to the variables utilized here. There appears to be a very different meaning of the term "food security" in developed and developing countries. In terms of policy implications and economy development, maintaining the same label for two altogether different situations only obscures the issues being negotiated. The discussion of food security should be limited to the vulnerability of developing countries, using a different terminology for developed countries.

6.2. Issues for Further Research

Our analysis raises several issues that may require additional research. First, the calculations presented here used level variables as an average of the last five years. It may be important to include indicators of time trends and variations over time, to have a better idea of types of food vulnerability (Valdes and Konandreas, 1981). A related matter is the possibility and actual occurrence of extreme events that disrupt agricultural production in a country and that compromise its food security, such as conflicts and weather shocks such as floods and droughts.

Second, following Bouis (2000), the food security typology analysis can be recalculated with animal proteins instead of total proteins, to try to focus more precisely on malnutrition issues. A related aspect is that the definitions of food production and trade used here could be expanded to include fisheries. This may be important for several developing countries, in particular small-island economies, and countries like Peru which is a net food importer under the definition utilized here, but is a net food exporter if fisheries are included (Quirós, 2000).

Third, after classifying countries in different types of food (in)secure groups, the relevant issue is why they ended up where they are. Different statistical techniques can be applied to analyze other characteristics and determinants for the grouping patterns. It seems important to identify countries that have been changing, either moving to more secure or more insecure groups, and then analyze the reasons for those transitions, considering both policy variables and exogenous events. Based on this interventions can be developed for different groups of countries.

Lastly, this study does not take into account the distributional effects of inequality in income or dietary energy consumption, which prevents the less privileged and hungry people from accessing food. Countries with food inequality might grow enough food to support themselves but divide it unequally, for instance exporting it without ensuring that benefits of increased production to domestic consumers. Especially in remote or conflict-affected areas, irregular or unreliable harvests have a devastating effect on family nutrition. Gender inequality may also exacerbate food inequality among the population. Women who have never been to school have limited information on nutrition for themselves and their children. Maternal and child health program providing life-saving supplements and knowledge are often under-prioritized by the government. The distribution of food is a profoundly matter, and achieving food security means creating a food system that is sustainable, secure, safe, sufficient, nutritious, and equitable (Tansey and Worsley, 1995). This involves issues of economic and social justice and forging alliances between sectors such as agriculture, food policy, and health and social welfare and between various levels of the state and civil society.

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Figures and Tables

Figure 1. Structural framework for food security typology.

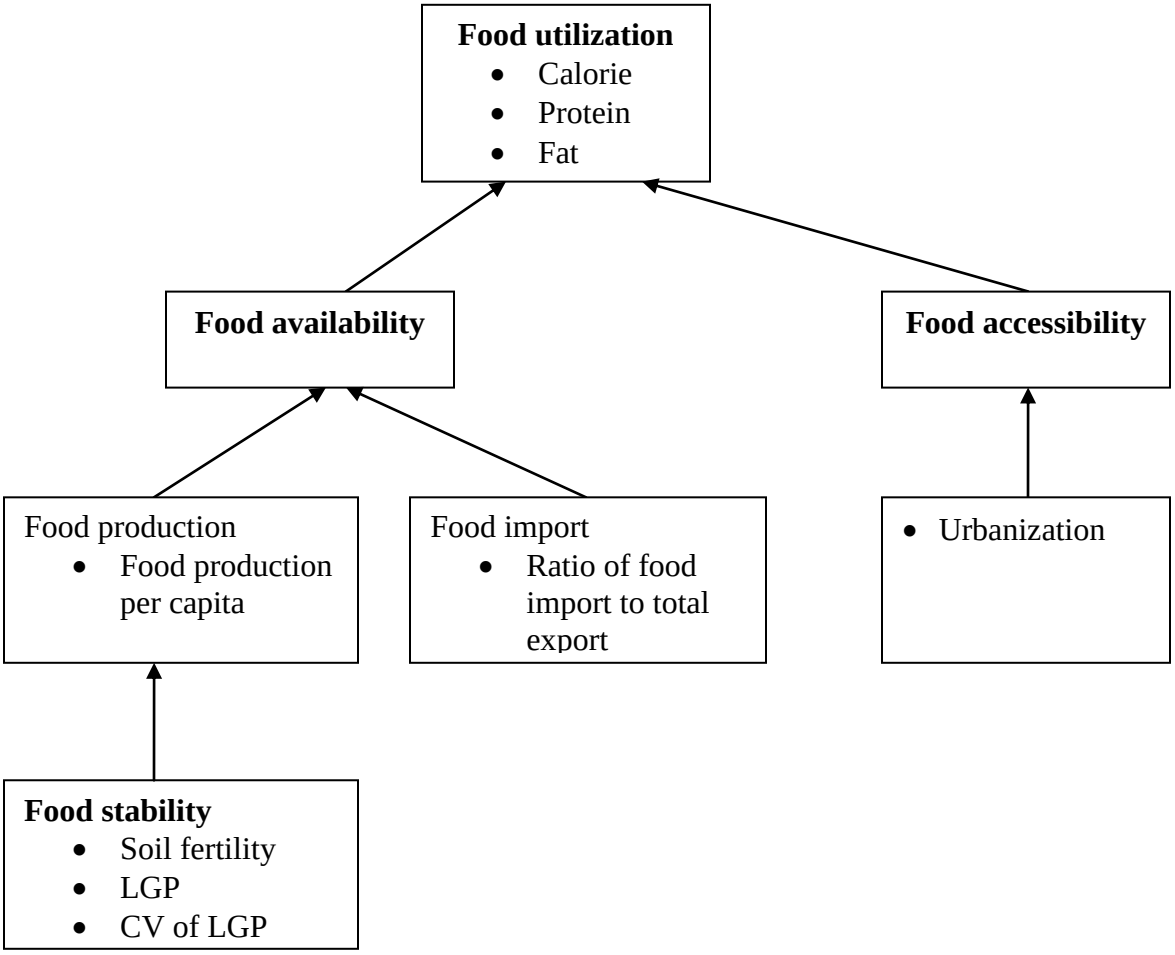
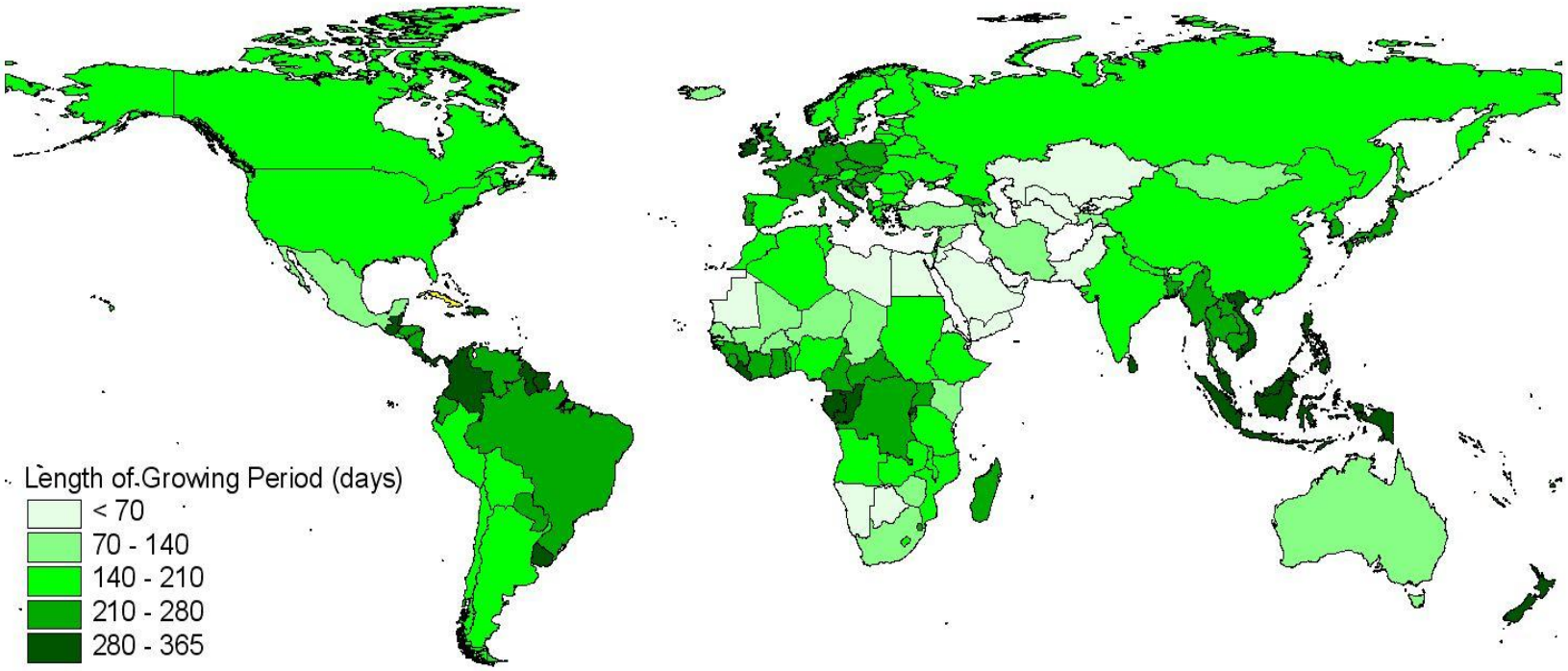
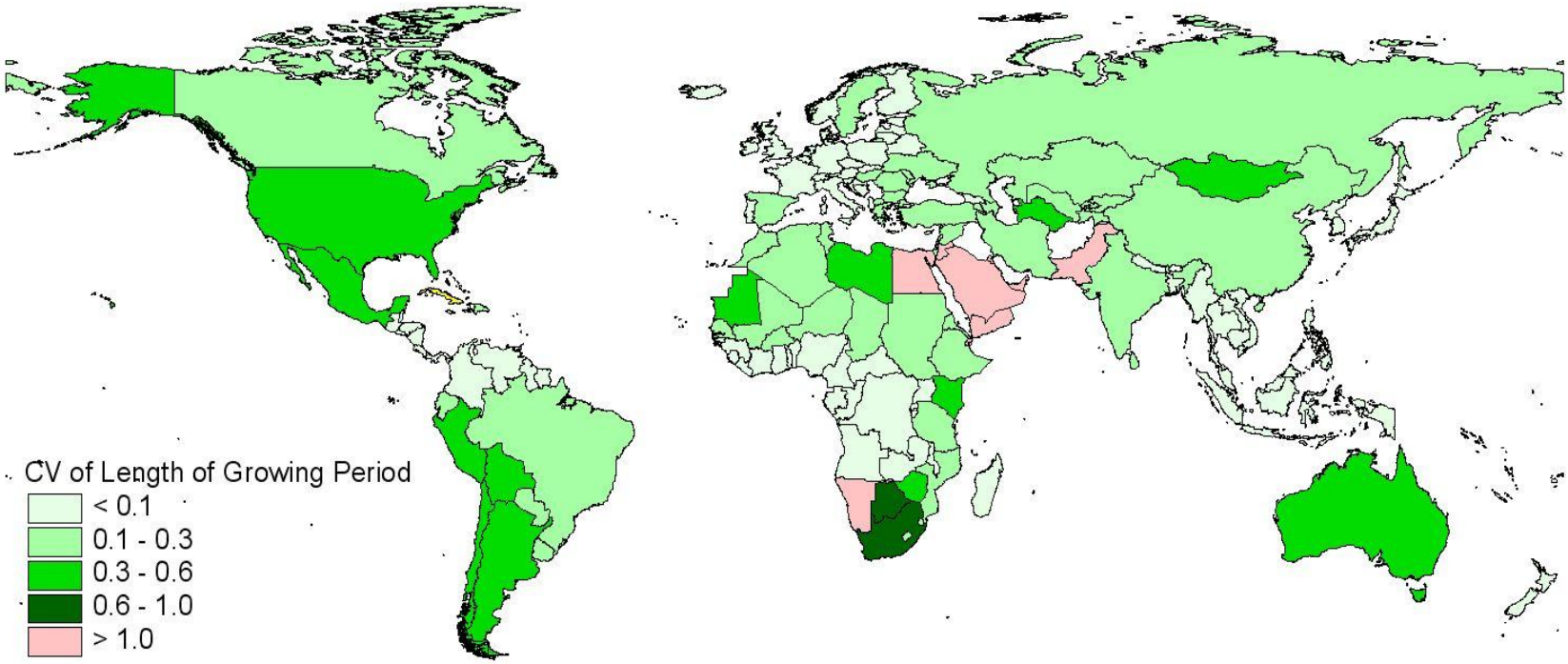


Figure 2. Map of length of growing period by country.



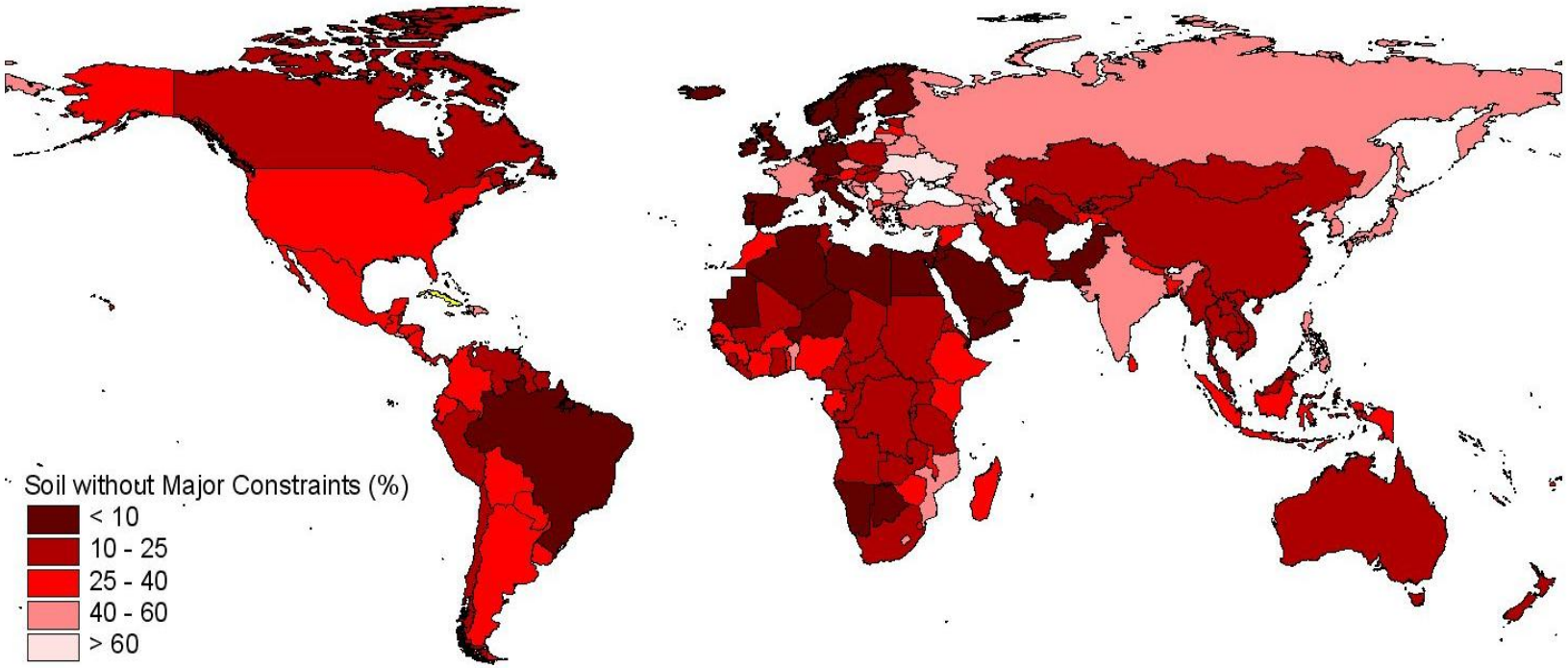
Source: Authors' calculation based on Fischer et al. (2001).

Figure 3. Map of coefficient of variation of length of growing period by country.



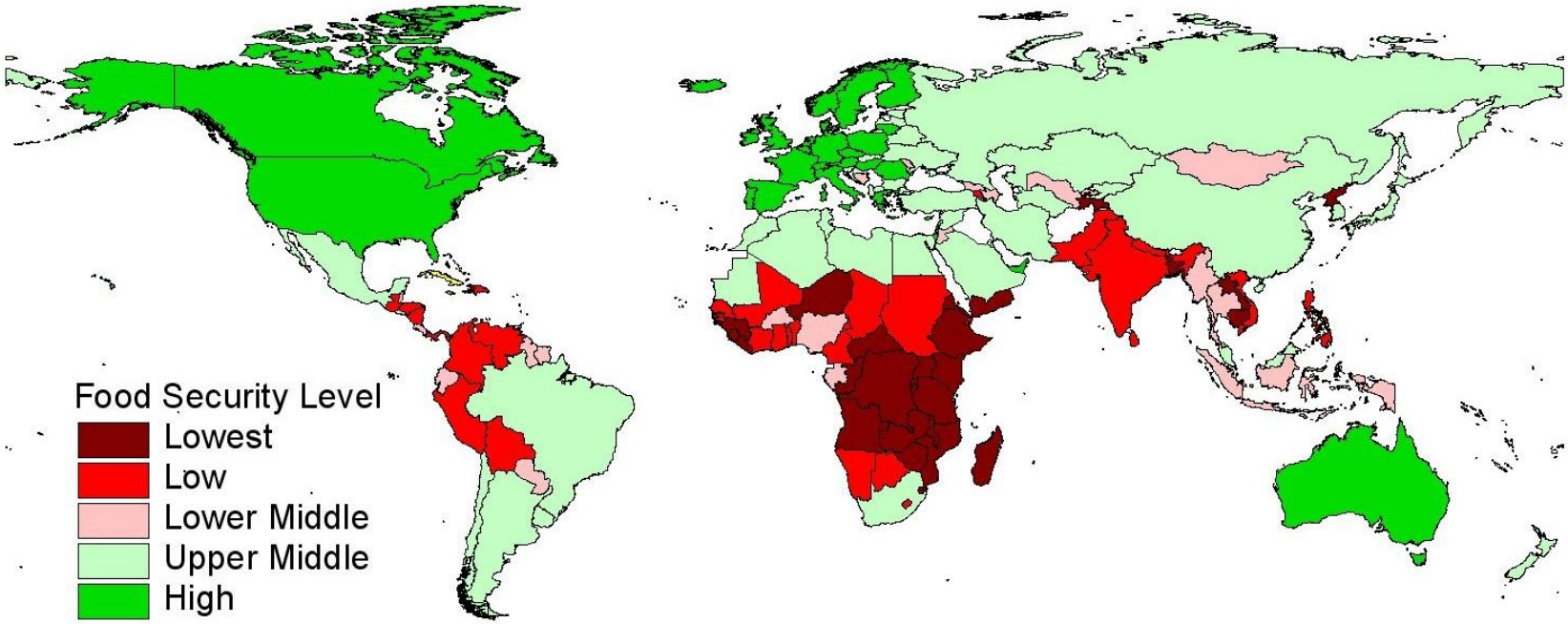
Source: Authors' calculation based on Fischer et al. (2001).

Figure 4. Map of percentage of soil without major constraints by country.



Source: FAO (2000).

Figure 5. World food security level.



Source: Authors' calculation of FAO(2006).

Figure 6. Sample structure of food security typology.

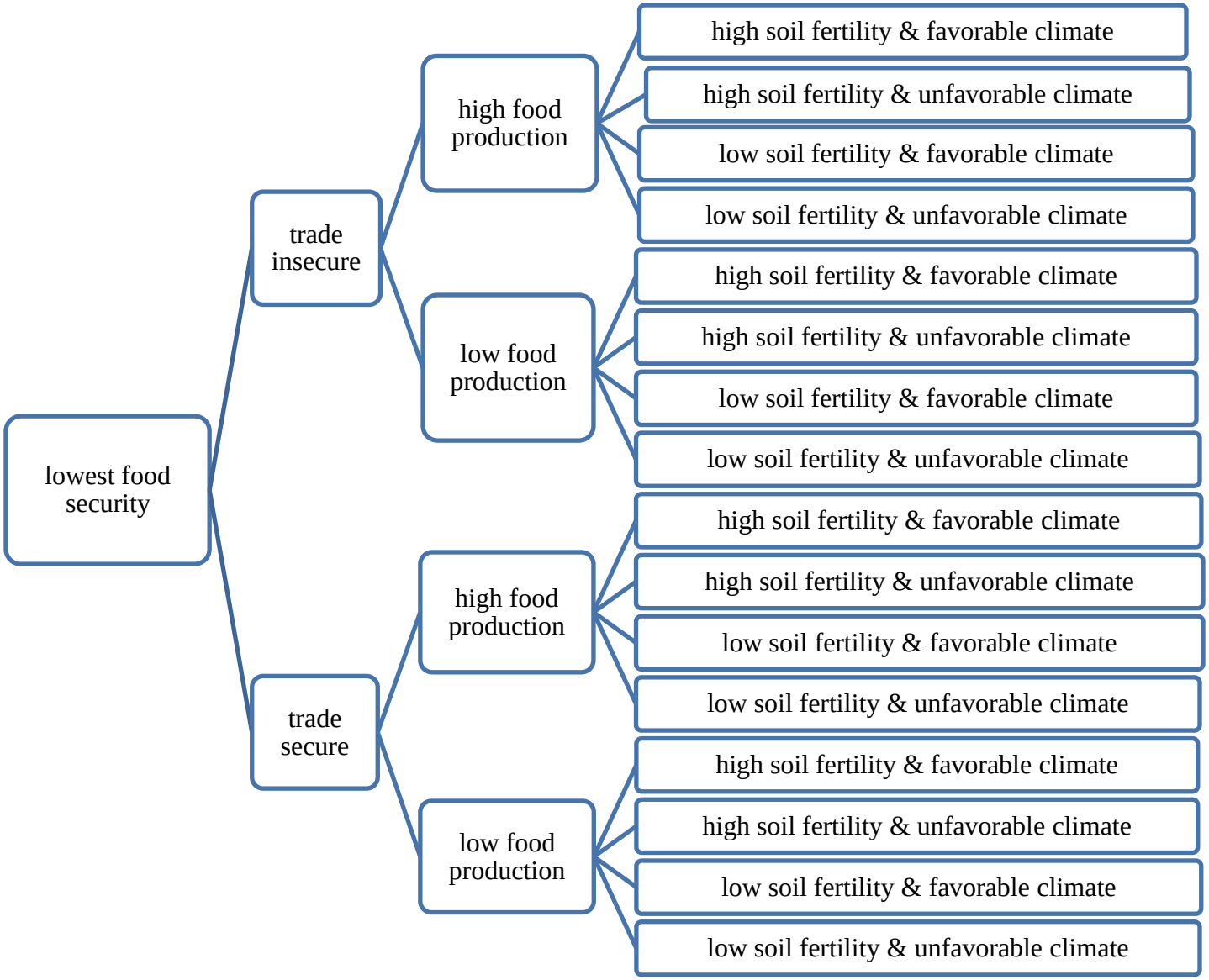


Figure 7. Food security typology for Lowest Food Security group.

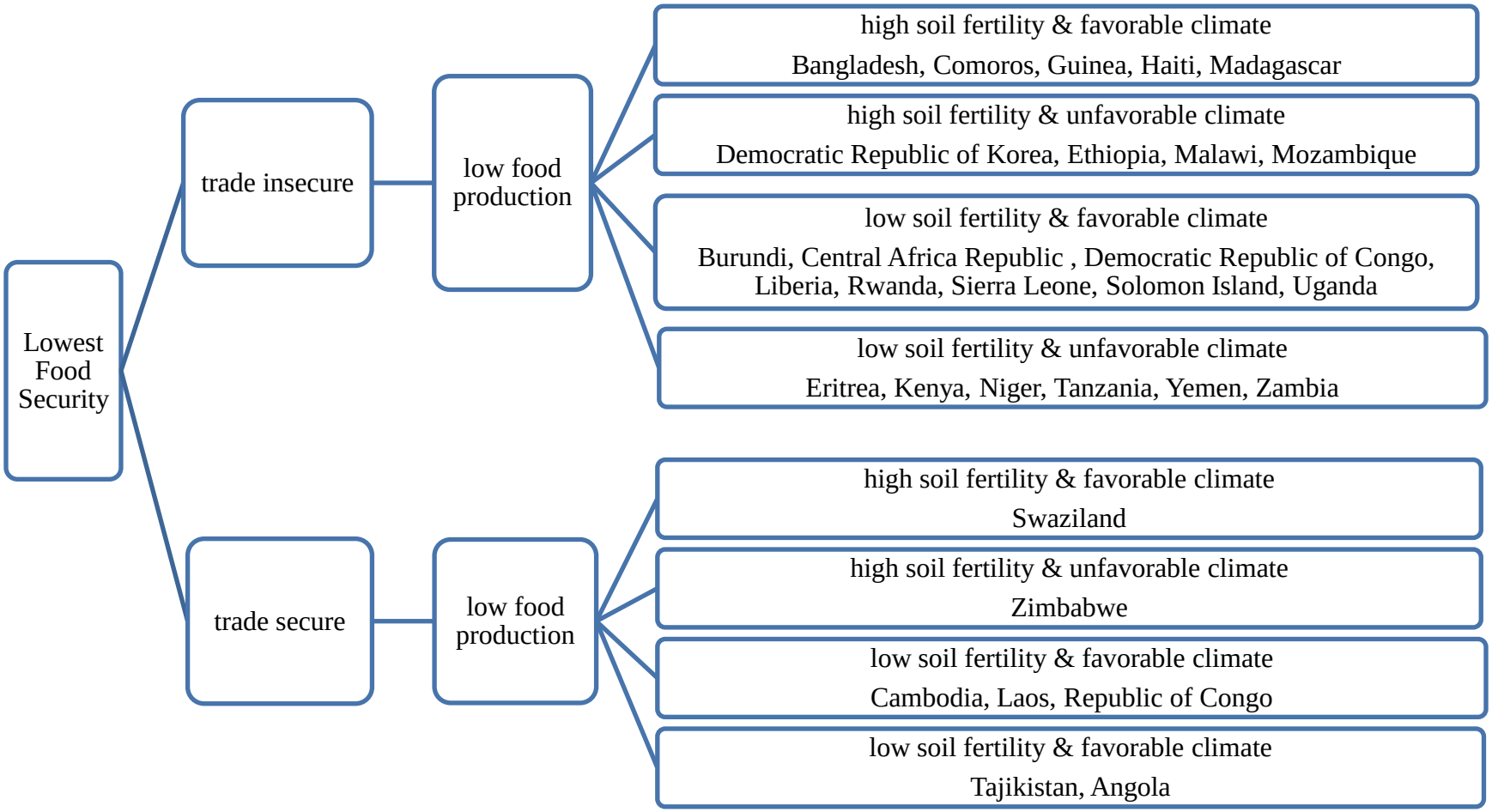


Figure 8. Food security typology for Low Food Security group.

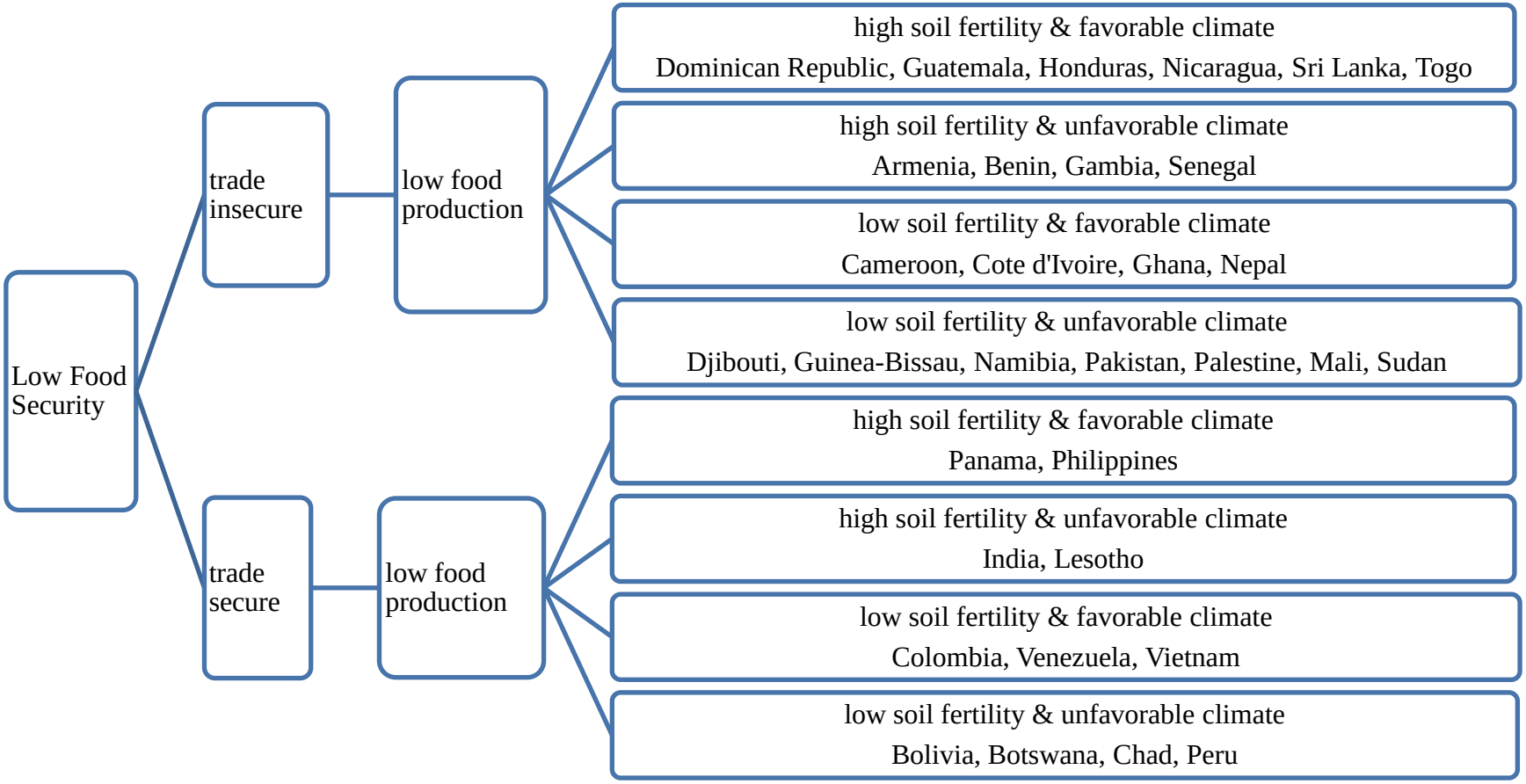


Figure 9. Food security typology for Middle Food Security group.

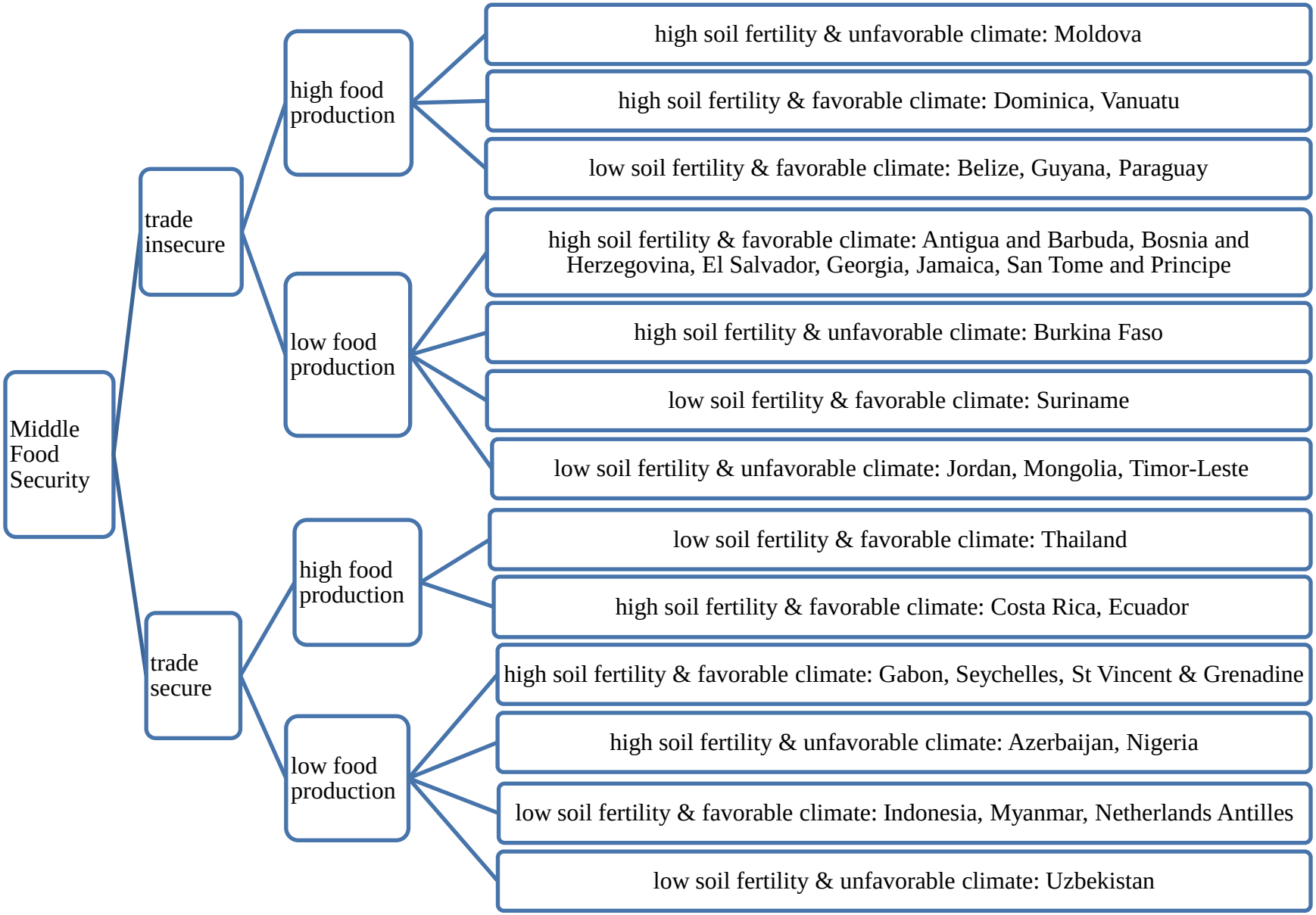


Figure 10. Food security typology for Upper Middle Food Security group.

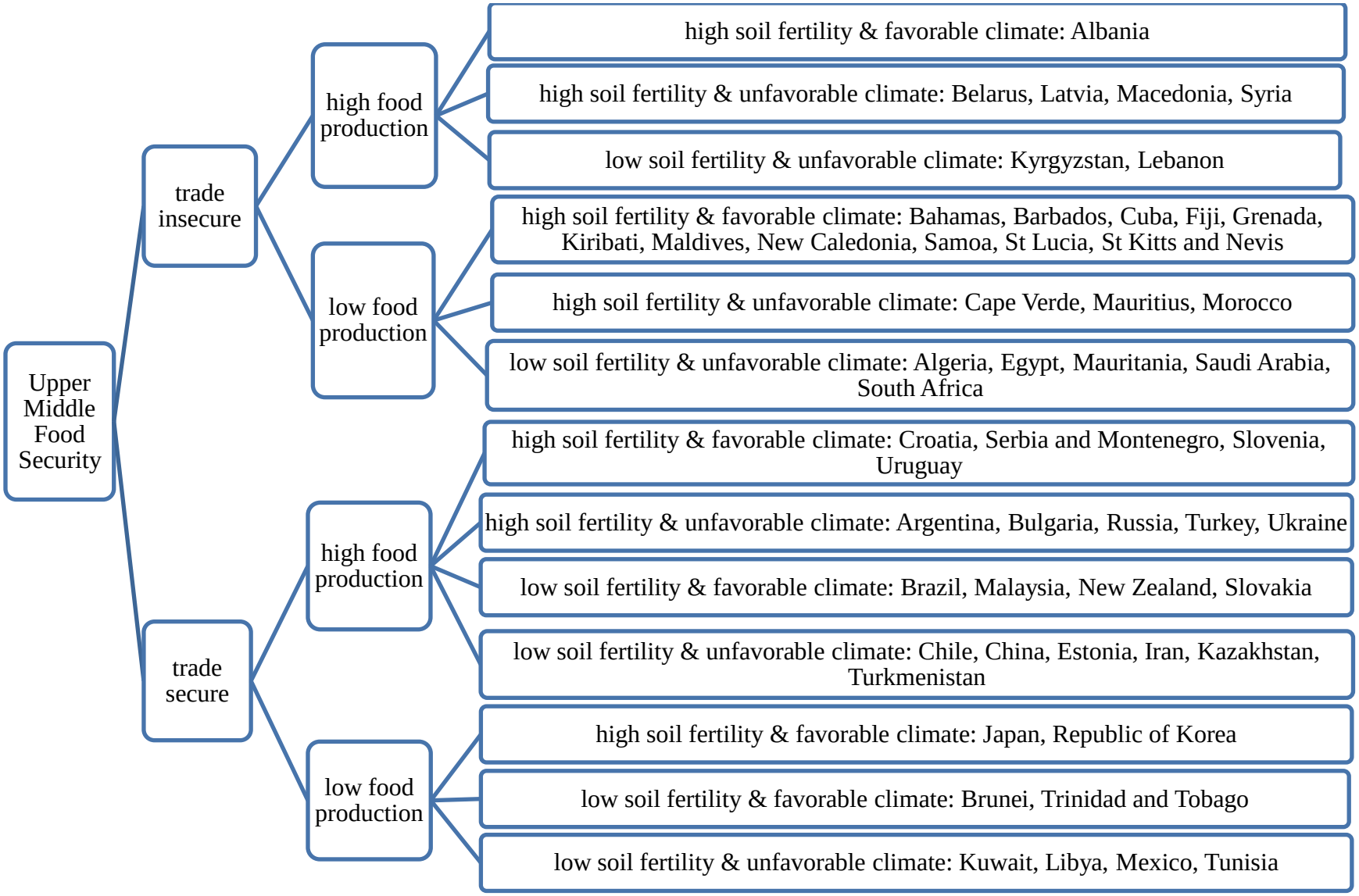


Figure 11. Food security typology for High Food Security Group.

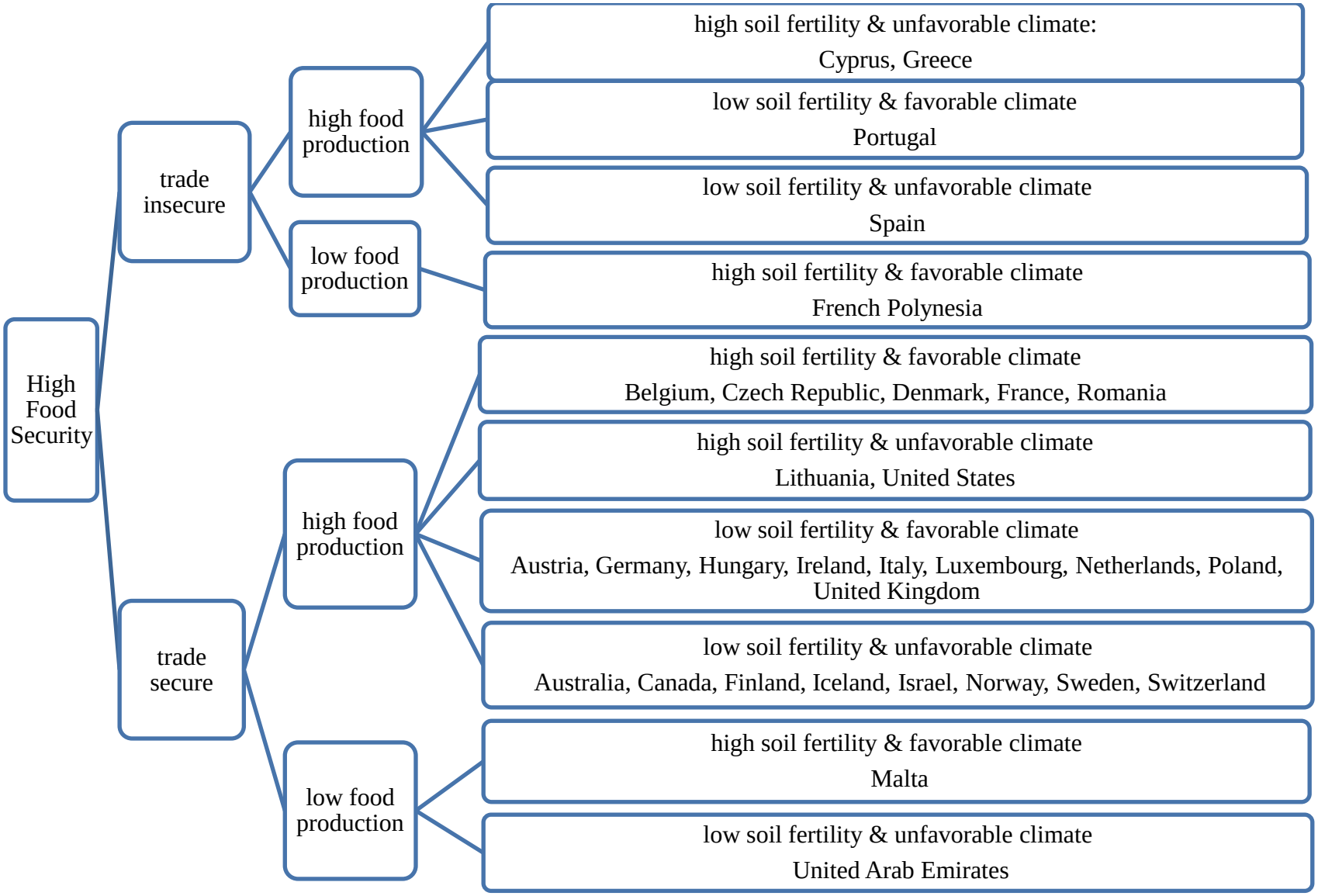


Table 1. List of variables and source.

Variable	Definition	Year	Source
Food utilization			
calorie intake per capita	Energy intake per capita per day measured in calories	2002-04	FAO Statistical Yearbook 2005-2006 (2006)
protein intake per capita	Protein intake per capita per day measured in grams	2002-04	FAO Statistical Yearbook 2005-2006 (2006)
fat intake per capita	Fat intake per capita per day measured in grams	2002-04	FAO Statistical Yearbook 2005-2006 (2006)
Food availability			
food production per capita	Gross sum of all commodities weighted by 1999-2001 average international commodity prices, then divided by total population	2001-2005	FAOSTAT 2008
ratio of total export to food import	Value of all exported goods and market services divided by food imports	2001-2005	World Development Indicator 2008
Food stability			
soil without major constraints	Percentage of soil not affected by eight major fertility constraints		FAO (2000)
length of growing period	Number of days of the year when both natural moisture and temperature conditions are suitable for crop production		Fischer et al. (2001)
CV of length of growing period	Coefficient of variations of length of growing period		Fischer et al. (2001)
Food accessibility			
share of nonagricultural population	Percentage of midyear population of areas defined as urban in total population	2001-2005	World Development Indicator 2008

Table 2. Descriptive statistics of variables.

Variable	Mean	Std. Error	Minimum	Maximum
Food utilization				
calorie intake per capita	2736.4	516.3	1500.0	3760.0
protein intake per capita	82.0	23.7	25.0	136.0
fat intake per capita	77.1	33.9	11.0	161.0
Food availability				
food production per capita	232.5	212.3	6.4	1851.4
ratio of total export to food import	11.3	8.7	0.5	56.2
Food stability				
soil without major constraints	205.0	88.9	0.0	365.0
length of growing period	0.2	0.5	0.0	3.0
CV of length of growing period	59.4	22.4	9.6	98.5
Food accessibility				
share of nonagricultural population	2736.4	516.3	1500.0	3760.0

Source: Author's calculations from FAOSTAT (2008b) and World Development Indicator (2008).

Table 3. Correlation coefficients.

	calorie intake per capita	protein intake per capita	fat intake per capita	food production per capita	ratio of total export to food import	soil without major constraints	length of growing period	CV of length of growing period	share of nonagricultural population
calorie intake per capita	1.000								
protein intake per capita	0.908	1.000							
fat intake per capita	0.830	0.823	1.000						
food production per capita	0.558	0.529	0.563	1.000					
ratio of total export to food import	0.377	0.370	0.351	0.388	1.000				
soil without major constraints	-0.001	-0.006	-0.060	-0.028	-0.171	1.000			
length of growing period	0.005	-0.113	0.061	0.098	-0.041	0.248	1.000		
CV of length of growing period	0.010	0.035	-0.041	-0.111	-0.014	-0.367	-0.597	1.000	
share of nonagricultural population	0.709	0.705	0.705	0.482	0.411	0.035	-0.020	0.099	1.000

Source: Author's calculations from FAOSTAT (2008b), FAO (2000), World Development Indicator (2008) and Fischer et al. (2001).

Table 4. Average values of indicators by food security groups.

	Lowest food security	Low food security	Lower middle food security	Upper middle food security	High food security	Sample total
Food security score	-1.4	-0.7	-0.3	0.4	1.6	0.0
Food utilization						
calorie intake per capita	2026	2368	2636	2977	3486	2736
protein intake per capita (gram)	50.3	64.6	75.8	93.1	117.4	82.0
fat intake per capita (gram)	36.9	55.6	66.9	86.5	131.8	77.1
Food availability						
food production per capita (2000 international dollars)	94.4	140.2	192.5	264.0	445.1	232.5
ratio of total export to food import	6.7	8.3	10.7	12.7	16.9	11.3
Food stability						
soil without major constraint (%)	24.2	27.8	34.8	30.8	23.1	28.4
length of growing period (days)	207.9	191.2	238.2	194.8	203.0	205.0
CV of length of growing period	0.2	0.3	0.2	0.3	0.2	0.2
Food accessibility						
share of nonagricultural population (%)	30.9	49.9	56.7	69.4	82.1	59.4
GNI (2007)	395	1181	2663	5906	24407	6837

Source: Author's calculations from FAOSTAT (2008b), FAO (2000), World Development Indicator (2008) and Fischer et al. (2001).

Table 5. Food security typology by climate and soil condition.

			low soil fertility		high soil fertility	
			unfavorable climate	favorable climate	unfavorable climate	favorable climate
Lowest Food Security	trade insecure	low food production	Eritrea, Kenya, Niger, Tanzania, Yemen, Zambia	Burundi, Central Africa Republic , Democratic Republic of Congo, Liberia, Rwanda, Sierra Leone, Solomon Island, Uganda	Democratic Republic of Korea, Ethiopia, Malawi, Mozambique	Bangladesh, Comoros, Guinea, Haiti, Madagascar, Togo
	trade secure	low food production	Angola, Tajikistan	Cambodia, Laos, Republic of Congo	Zimbabwe	Swaziland
Low Food Security	trade insecure	low food production	Djibouti, Guinea-Bissau, Namibia, Pakistan, Palestine, Mali, Sudan	Cameroon, Cote d'Ivoire, Ghana, Nepal	Armenia, Benin, Gambia, Senegal	Dominican Republic, Guatemala, Honduras, Nicaragua, Sri Lanka
	trade secure	low food production	Bolivia, Botswana, Chad, Peru	Colombia, Venezuela, Vietnam	India, Lesotho	Panama, Philippines
Middle Food Security	trade insecure	high food production		Belize, Guyana, Paraguay	Moldova	Dominica, Vanuatu
		low food production	Jordan, Mongolia, Timor-Leste	Suriname	Burkina Faso	Antigua and Barbuda, Bosnia and Herzegovina, El Salvador, Georgia, Jamaica, San Tome and Principe
	trade secure	high food production		Thailand		Costa Rica, Ecuador

		low food production	Uzbekistan	Indonesia, Myanmar, Netherlands Antilles	Azerbaijan, Nigeria	Gabon, Seychelles, St Vincent and Grenadine
Upper Middle Food Security	trade insecure	high food production	Kyrgyzstan, Lebanon		Belarus, Latvia, Macedonia, Syria	Albania
		low food production	Algeria, Egypt, Mauritania, Saudi Arabia, South Africa		Cape Verde, Mauritius, Morocco	Bahamas, Barbados, Cuba, Fiji, Grenada, Kiribati, Maldives, New Caledonia, Samoa, St Lucia, St Kitts and Nevis
	trade secure	high food production	Chile, China, Estonia, Iran, Kazakhstan, Turkmenistan	Brazil, Malaysia, New Zealand, Slovakia	Argentina, Bulgaria, Russia, Turkey, Ukraine	Croatia, Serbia and Montenegro, Slovenia, Uruguay
		low food production	Kuwait, Libya, Mexico, Tunisia	Brunei, Trinidad and Tobago		Japan, Republic of Korea
High Food Security	trade insecure	high food production	Spain	Portugal	Cyprus, Greece	
		low food production				French Polynesia
	trade secure	high food production	Australia, Canada, Finland, Iceland, Israel, Norway, Sweden, Switzerland	Austria, Germany, Hungary, Ireland, Italy, Luxembourg, Netherlands, Poland, United Kingdom	Lithuania, United States	Belgium, Czech Republic, Denmark, France, Romania
		low food production	United Arab Emirates			Malta

Source: Author's calculations from FAOSTAT (2008b), FAO (2000), World Development Indicator (2008) and Fischer et al. (2001).

Table 6. Food security typology profile summary.

			Sub-Saharan Africa	East Asia and Pacific	South Asia	East Europe and Central Asia	Middle East and North Africa	Latin America and the Caribbean	West Europe and North America
Lowest Food Security	trade insecure	low food production	Burundi, Central Africa Republic, Comoros, Democratic Republic of Congo, Eritrea, Ethiopia, Guinea, Kenya, Liberia, Madagascar, Malawi, Mozambique, Niger, Rwanda, Solomon Island, Sierra Leone, Tanzania, , Togo, Uganda, Zambia	Democratic Republic of Korea, Solomon Island	Bangladesh		Yemen	Haiti	
	trade secure	low food production	Angola, Republic of Congo, Swaziland, Zimbabwe	Cambodia, Laos		Tajikistan			
Food	trade insecure	low food production	Benin, Cameroon, Cote d'Ivoire,		Nepal, Pakistan, Sri Lanka	Armenia	Djibouti, Palestine	Dominican Republic, Guatemala,	

			Gambia, Ghana, Guinea-Bissau, Mali, Namibia, Senegal, Sudan					Honduras, Nicaragua	
	trade secure	low food production	Botswana, Chad, Lesotho	Philippines, Vietnam	India			Bolivia, Colombia, Panama, Peru, Venezuela	
Middle Food Security	trade insecure	high food production		Vanuatu		Moldova		Belize, Dominica, Guyana, Paraguay	
		low food production	Burkina Faso, San Tome and Principe	Mongolia, Timor-Leste		Bosnia and Herzegovina, Georgia	Jordan	Antigua and Barbuda, El Salvador, Jamaica, Suriname	
	trade secure	high food production		Thailand				Costa Rica, Ecuador	
		low food production	Gabon, Nigeria, Seychelles,	Indonesia, Myanmar,		Azerbaijan, Uzbekistan		Netherlands Antilles, St Vincent & Grenadine	
Upper Middle Food Security	trade insecure	high food production				Albania, Belarus, Kyrgyzstan, Latvia, Macedonia	Lebanon, Syria		
		low food production	Cape Verde, Mauritania, Mauritius, South Africa	Fiji, Kiribati, Samoa	Maldives,		Algeria, Egypt, Morocco, Saudi	Bahamas, Barbados, Cuba, Grenada,	

							Arabia	New Caledonia, St Lucia, St Kitts and Nevis	
	trade secure	high food production		China, Malaysia, New Zealand		Bulgaria, Croatia, Estonia, Kazakhstan, Russia, Serbia and Montenegro, Slovakia, Slovenia, Turkey, Turkmenistan, Ukraine	Iran	Argentina, Brazil, Chile, Uruguay	
		low food production		Brunei, Japan, Republic of Korea			Kuwait, Libya, Tunisia	Mexico, Trinidad and Tobago	
High Food Security	trade insecure	high food production							Cyprus, Greece, Portugal, Spain
		low food production		French Polynesia					
	trade secure	high food production				Czech Republic, Hungary, Lithuania, Romania	Israel		Australia, Austria, Belgium, Canada, Denmark, France,

									Finland, Germany, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Poland, Sweden, Switzerland, United Kingdom, United States
		low food production					United Arab Emirates		Malta

Source: Author's calculations from FAOSTAT (2008b), FAO (2000), World Development Indicator (2008) and Fischer et al. (2001).

Table 7. Annual growth rate in percentage of food security indicators from 1993-97 average to 2001-05.

	calorie intake per capita	protein intake per capita	food production per capita	ratio of total export to food import	share of non-agricultural population
Lowest Food Security group	0.3	0.7	1.5	0.5	1.5
Low Food Security group	0.3	1.5	1.8	2.6	0.4
Middle Food Security group	0.4	1.4	0.2	2.5	1.1
Upper Middle Food Security group	0.3	1.6	2.1	0.8	0.7
High Food Security group	0.6	1.7	1.0	4.0	0.0
Total	0.4	1.5	1.4	2.1	0.7

Source: Author's calculations from FAOSTAT (2008b) and World Development Indicator (2008) and Diaz-Bonilla et al. (2000).

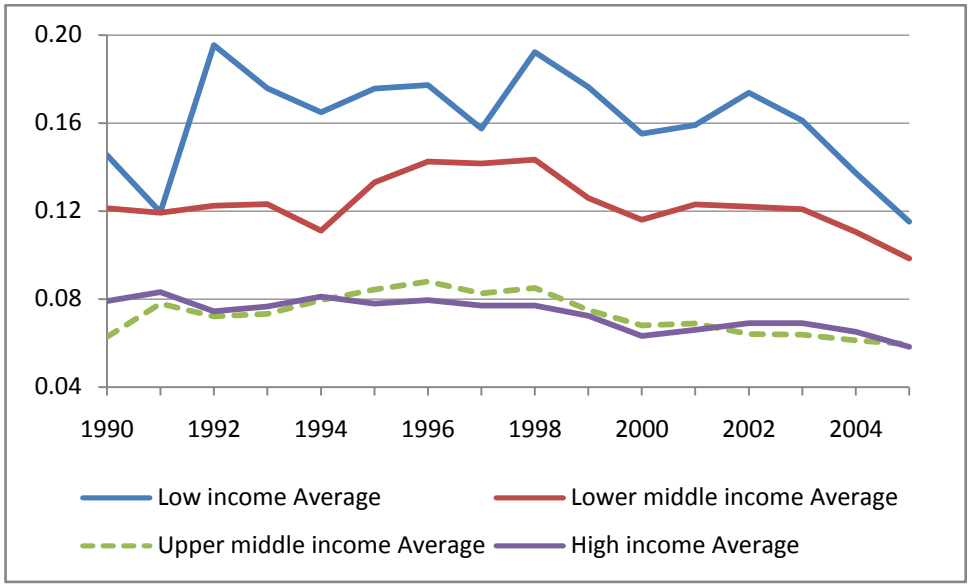
Table 8. Broad policy recommendations by food security typologies for the Lowest and Low Food Security countries.

Trade	Food production	Soil fertility	Climate	Policy recommendations
Insecure	Low	Low	Unfavorable	• Appropriate soil management to improve soil fertility • Investment in irrigation and other water management technologies • Improve terms of trade to lower the relative cost of food imports • Increased foreign aid in agricultural and rural sector • Targeted safety net for the poor
Insecure	Low	Low	favorable	• Take advantage of the beneficial climate to maximize food output • Appropriate soil management to improve soil fertility • Improve terms of trade to lower the relative cost of food imports • Increased foreign aid in agricultural and rural sector • Targeted safety net for the poor
Insecure	Low	High	Unfavorable	• Intensify crop cultivation by using improved seeds and chemical fertilizer • Investment in irrigation and other water management technologies • Improve terms of trade to lower the relative cost of food imports • Increased foreign aid in agricultural and rural sector • Targeted safety net for the poor
Insecure	Low	High	favorable	• Intensify crop cultivation by using improved seeds and chemical fertilizer • Take advantage of the beneficial climate to maximize food output • Improve terms of trade to lower the relative cost of food imports • Increased foreign aid in agricultural and rural sector • Targeted safety net for the poor
secure	Low	Low	Unfavorable	• Appropriate soil management to improve soil fertility • Investment in irrigation and other water management technologies • Increased foreign aid in agricultural and rural sector • Targeted safety net for the poor
secure	Low	Low	favorable	• Take advantage of the beneficial climate to maximize food output • Appropriate soil management to improve soil fertility • Increased foreign aid in agricultural and rural sector • Targeted safety net for the poor

secure	Low	High	Unfavorable	• Intensify crop cultivation by using improved seeds and chemical fertilizer • Investment in irrigation and other water management technologies • Increased foreign aid in agricultural and rural sector • Targeted safety net for the poor
secure	Low	High	favorable	• Intensify crop cultivation by using improved seeds and chemical fertilizer • Take advantage of the beneficial climate to maximize food output • Increased foreign aid in agricultural and rural sector • Targeted safety net for the poor

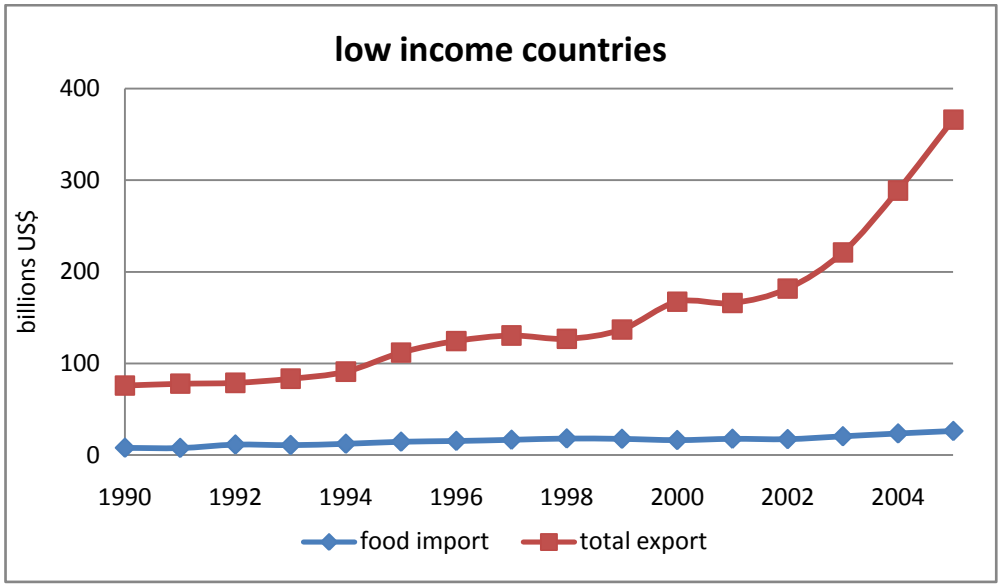
Note: This table provides a general picture at national level. Policies targeted at remote and high vulnerability populations within a country are not presented because it is beyond the scope of this study.

Appendix Figure 1. Ratio of food import value to total merchandise and service export value.

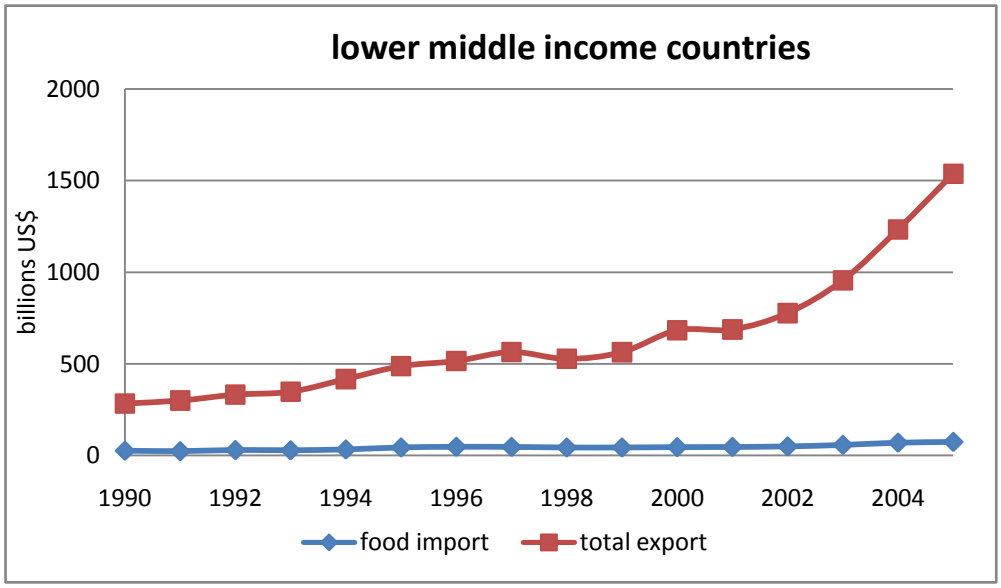


Source: Author's calculations from World Bank World Development Indicator (2008).

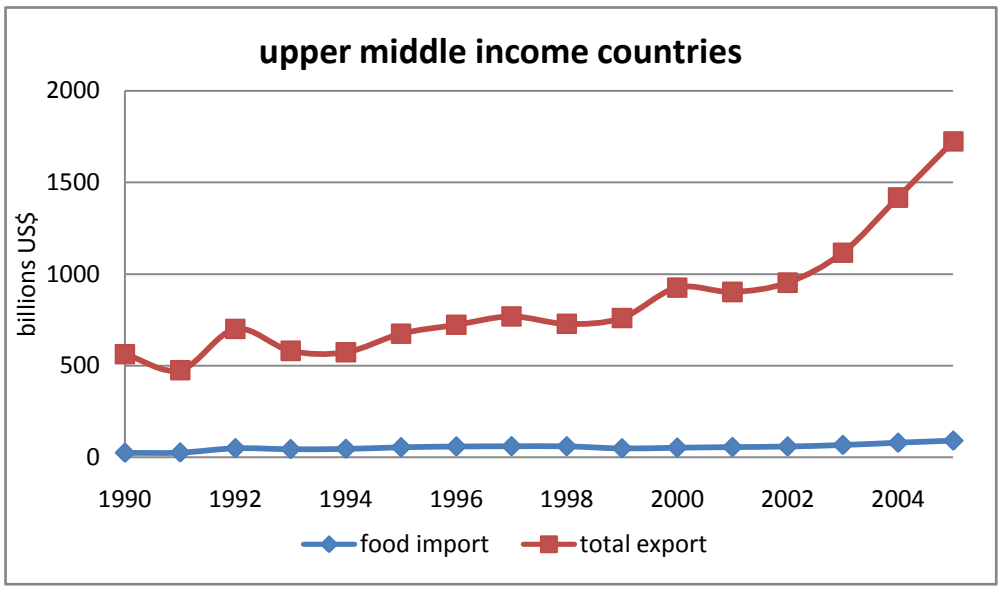
Appendix Figure 2a. Low income countries food import and total export value, 1990-2005.



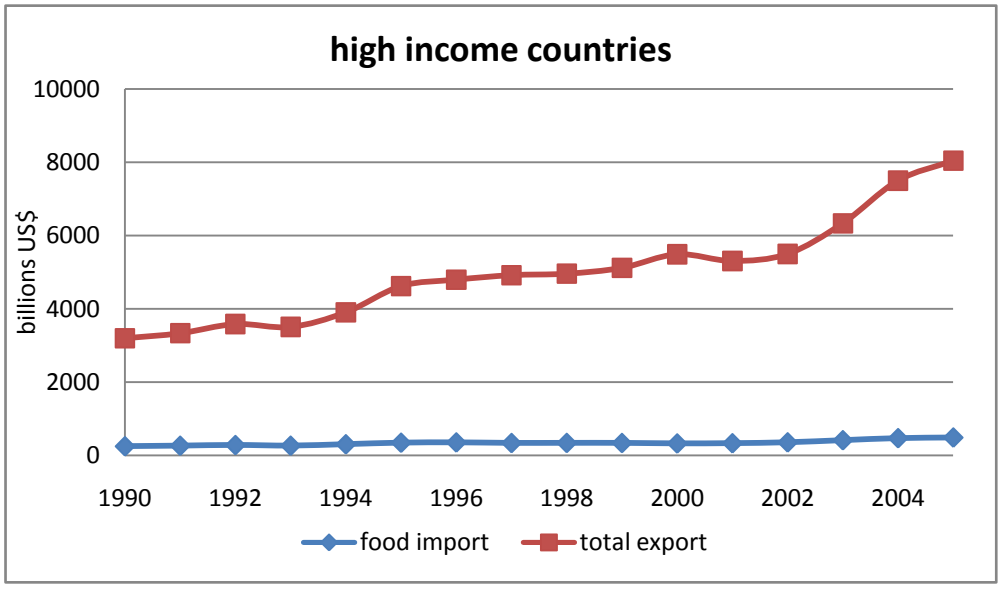
Appendix Figure 2b. Low middle income countries food import and total export value, 1990-2005.



Appendix Figure 2c. Upper middle income countries food import and total export value, 1990-2005.



Appendix Figure 2d. High income countries food import and total export value, 1990-2005.



Source: Author's calculations from World Bank World Development Indicator (2008).

Appendix Table 1. List of countries and indicator values.

country	calorie intake per capita	protein intake per capita	fat intake per capita	food production per capita	ratio of total export to food import	soil without major constraints	length of growing period	CV of LGP	share of nonagricultural population	food security factor score
Albania	2870	102	85	244	3.3	45	225	0.10	47.8	0.47
Algeria	3070	91	65	111	8.7	7	169	0.29	67.6	0.24
Angola	2120	51	42	81	23.3	18	193	0.09	42.5	-1.24
Antigua and Barbuda	2320	73	83	67	4.4	49	285	0.06	54.2	-0.36
Argentina	2920	96	94	704	56.2	33	172	0.41	90.1	0.51
Armenia	2340	75	50	200	3.4	55	109	0.20	74.5	-0.65
Australia	3120	113	124	958	22.8	19	136	0.35	90.9	1.20
Austria	3740	118	154	442	20.3	28	208	0.02	77.8	2.01
Azerbaijan	2730	86	43	178	11.6	63	125	0.22	60.7	-0.29
Bahamas	2660	95	87	62	1.8	39	285	0.06	92.5	0.24
Bangladesh	2200	50	25	88	4.4	29	243	0.09	33.9	-1.37
Barbados	3070	102	89	131	6.5	49	285	0.06	69.1	0.65
Belarus	2880	94	92	498	9.0	51	203	0.09	78.1	0.43
Belgium	3610	99	149	470	12.7	52	251	0.07	97.7	1.58
Belize	2850	82	68	480	6.5	21	331	0.06	57.0	-0.01
Benin	2590	65	53	153	2.4	41	193	0.09	43.6	-0.60
Bolivia	2220	62	61	229	10.1	27	180	0.40	60.9	-0.82
Bosnia and Herzegovina	2730	79	59	177	4.0	50	233	0.06	65.1	-0.23
Botswana	2150	70	54	90	11.1	4	35	0.90	55.5	-0.82
Brazil	3110	92	90	412	26.7	9	263	0.11	83.8	0.54
Brunei	2800	86	71	68	30.1	21	365	0.02	83.0	0.04
Bulgaria	2910	98	98	349	18.5	50	172	0.18	79.3	0.57
Burkina Faso	2500	78	59	110	2.3	37	138	0.11	13.5	-0.41
Burundi	1660	44	11	91	3.0	21	260	0.04	9.6	-1.98

country	calorie intake per capita	protein intake per capita	fat intake per capita	food production per capita	ratio of total export to food import	soil without major constraints	length of growing period	CV of LGP	share of nonagricultural population	food security factor score
Cambodia	2070	52	32	116	12.7	12	251	0.04	23.5	-1.36
Cameroon	2260	62	47	137	7.1	19	232	0.06	52.2	-0.93
Canada	3630	117	141	644	22.6	21	145	0.16	86.9	1.78
Cape Verde	3220	76	99	56	2.4	61	127	0.06	65.0	0.46
Central African Republic	1960	49	63	152	4.3	18	242	0.05	35.2	-1.17
Chad	2130	69	66	110	12.2	16	118	0.14	26.2	-0.72
Chile	2870	89	83	339	19.3	18	148	0.49	86.1	0.26
China	2930	91	91	260	34.3	20	176	0.20	37.0	0.41
Colombia	2580	64	62	200	11.7	27	335	0.04	75.7	-0.53
Comoros	1770	43	45	55	3.1	43	225	0.07	32.4	-1.57
Congo, Dem Rep	1590	25	25	50	6.0	14	260	0.02	34.0	-2.17
Congo, Rep	2160	48	50	54	11.6	13	313	0.04	60.7	-1.18
Costa Rica	2810	77	74	361	13.5	38	289	0.05	68.6	-0.06
Cote d'Ivoire	2640	56	57	186	9.8	26	278	0.08	48.6	-0.66
Croatia	2800	84	87	269	11.7	47	260	0.06	71.1	0.17
Cuba	3320	91	54	230	3.0	39	243	0.11	79.5	0.30
Cyprus	3280	117	126	422	6.5	44	152	0.18	78.5	1.39
Czech Republic	3330	103	111	364	22.7	46	216	0.09	81.4	1.06
Denmark	3480	110	137	1004	14.1	50	219	0.10	89.9	1.54
Djibouti	2270	57	84	54	2.1	0	0	1.87	60.0	-0.62
Dominica	2760	84	72	251	4.1	49	285	0.06	74.2	-0.01
Dominican Republic	2270	59	73	162	7.2	49	289	0.12	72.6	-0.71
Ecuador	2670	63	93	275	12.4	37	247	0.16	67.0	-0.17

country	calorie intake per capita	protein intake per capita	fat intake per capita	food production per capita	ratio of total export to food import	soil without major constraints	length of growing period	CV of LGP	share of nonagricultural population	food security factor score
Egypt	3330	98	56	199	6.9	0	0	3.02	52.2	0.43
El Salvador	2560	73	57	103	4.0	48	210	0.05	63.4	-0.46
Eritrea	1500	48	30	31	1.4	24	70	0.22	20.6	-1.83
Estonia	3220	101	94	310	10.2	11	188	0.08	77.5	0.79
Ethiopia	1850	54	21	63	3.2	34	178	0.18	17.0	-1.59
Fiji	2940	80	91	183	5.8	30	345	0.06	54.5	0.25
Finland	3130	108	119	355	24.9	8	168	0.07	74.7	1.08
France	3630	125	157	603	13.8	54	250	0.10	84.6	2.06
French Polynesia	2900	109	126	67	0.7	30	345	0.06	58.8	1.01
Gabon	2680	78	53	146	17.8	33	298	0.05	76.0	-0.34
Gambia	2240	57	67	73	2.5	61	145	0.07	39.6	-0.82
Georgia	2630	79	61	185	5.9	46	217	0.10	64.5	-0.28
Germany	3500	109	135	359	19.7	9	226	0.09	84.3	1.51
Ghana	2690	58	42	178	4.6	24	248	0.09	45.2	-0.74
Greece	3720	125	140	526	7.4	45	193	0.12	70.7	1.95
Grenada	2930	98	100	126	3.6	49	360	0.06	49.9	0.60
Guatemala	2230	62	48	149	4.3	35	316	0.04	49.1	-0.94
Guinea	2030	43	61	109	1.1	36	227	0.06	25.2	-1.23
Guinea-Bissau	2430	53	54	109	5.4	27	177	0.06	26.3	-0.88
Guyana	2790	82	58	318	7.1	17	329	0.07	50.6	-0.16
Haiti	2110	50	34	77	1.3	49	275	0.09	38.2	-1.34
Honduras	2340	61	65	176	4.6	36	251	0.06	54.9	-0.71
Hungary	3590	105	141	548	32.1	11	231	0.15	75.1	1.58
Iceland	3270	134	126	250	13.0	0	102	0.04	92.5	1.64
India	2470	63	51	135	27.0	41	153	0.18	36.2	-0.73
Indonesia	2890	67	64	137	15.6	27	355	0.04	50.2	-0.25
Iran	3120	97	58	246	15.9	23	75	0.26	69.4	0.29

country	calorie intake per capita	protein intake per capita	fat intake per capita	food production per capita	ratio of total export to food import	soil without major constraints	length of growing period	CV of LGP	share of nonagricultural population	food security factor score
Ireland	3670	126	132	935	30.7	0	319	0.03	72.3	1.85
Israel	3610	136	133	305	19.7	25	159	0.11	94.0	1.97
Italy	3730	125	149	434	13.8	2	237	0.08	78.7	2.05
Jamaica	2710	81	69	153	6.1	55	285	0.06	63.8	-0.11
Japan	2770	102	84	121	10.8	57	246	0.00	78.1	0.39
Jordan	2730	76	74	120	4.7	8	66	1.60	84.7	-0.13
Kazakhstan	2820	97	85	377	22.8	22	54	0.27	66.9	0.36
Kenya	2150	61	46	109	8.5	27	131	0.40	22.7	-1.03
Kiribati	2800	67	115	146	0.5	30	345	0.06	57.1	0.20
Korea, Dem Rep	2180	68	35	128	5.0	57	201	0.01	65.7	-1.02
Korea, Rep	3030	101	78	175	24.5	45	241	0.01	85.4	0.49
Kuwait	3110	94	102	55	25.4	0	0	2.33	98.5	0.69
Kyrgyzstan	3110	108	55	269	7.8	23	64	0.13	52.1	0.42
Laos	2370	61	28	164	10.1	15	252	0.06	21.5	-1.06
Latvia	3030	96	106	281	7.8	40	194	0.08	76.6	0.70
Lebanon	3190	99	103	258	2.4	28	186	0.08	90.7	0.83
Lesotho	2580	75	35	53	10.8	57	189	0.26	35.6	-0.64
Liberia	1930	32	49	53	1.9	13	327	0.05	47.4	-1.58
Libya	3380	93	90	133	11.1	2	57	0.43	88.5	0.74
Lithuania	3410	125	104	434	11.7	44	202	0.08	75.2	1.38
Luxembourg	3710	118	161	412	23.6	0	238	0.09	89.4	2.06
Macedonia	2900	85	95	254	5.7	38	161	0.17	75.9	0.34
Madagascar	2050	48	28	111	7.6	38	237	0.08	26.9	-1.48
Malawi	2120	55	32	93	3.9	31	168	0.09	19.5	-1.28
Malaysia	2880	82	80	296	26.2	20	365	0.01	72.5	0.13
Maldives	2600	109	76	48	5.7	37	225	0.02	47.8	0.30
Mali	2200	67	46	109	7.5	13	114	0.17	26.0	-0.91

country	calorie intake per capita	protein intake per capita	fat intake per capita	food production per capita	ratio of total export to food import	soil without major constraints	length of growing period	CV of LGP	share of nonagricultural population	food security factor score
Malta	3530	126	109	152	10.4	82	237	0.08	95.9	1.53
Mauritania	2740	88	69	110	2.2	1	59	0.43	43.4	0.01
Mauritius	2980	93	74	140	7.5	38	0	0.00	61.6	0.30
Mexico	3170	97	87	227	16.0	28	122	0.51	76.8	0.62
Moldova	2720	74	55	314	6.0	78	174	0.22	60.1	-0.35
Mongolia	2250	86	81	193	7.2	22	83	0.40	65.5	-0.24
Morocco	3110	97	54	163	8.1	34	148	0.26	60.6	0.25
Mozambique	2080	42	31	63	6.5	43	169	0.16	29.1	-1.51
Myanmar	2940	80	49	194	12.6	20	251	0.07	29.9	-0.17
Namibia	2240	69	52	164	8.3	7	46	1.06	41.9	-0.79
Nepal	2430	65	36	127	3.7	26	210	0.10	11.4	-0.88
Netherlands	3490	113	139	595	11.9	1	257	0.09	85.7	1.61
Netherlands Antilles	2550	78	81	6	28.3	21	285	0.06	81.6	-0.15
New Caledonia	2790	91	108	87	1.5	30	345	0.06	64.1	0.48
New Zealand	3190	98	108	1851	15.9	19	317	0.05	88.2	0.86
Nicaragua	2290	65	44	154	3.6	32	274	0.05	67.7	-0.90
Niger	2150	61	40	100	2.0	4	74	0.23	15.2	-1.09
Nigeria	2720	64	62	173	20.1	29	181	0.08	55.6	-0.43
Norway	3550	124	140	248	31.9	7	191	0.05	84.2	1.82
Pakistan	2240	73	66	166	8.3	9	54	1.23	40.9	-0.59
Palestine	2240	73	69	135	1.1	0	109	0.33	78.8	-0.56
Panama	2300	69	62	192	20.7	34	280	0.06	72.4	-0.65
Paraguay	2530	79	86	423	9.9	28	248	0.22	58.7	-0.10
Peru	2580	71	47	181	10.6	15	154	0.55	72.0	-0.58
Philippines	2490	60	50	145	14.3	57	310	0.06	61.5	-0.77
Poland	3420	106	110	424	18.0	24	219	0.10	70.3	1.16

country	calorie intake per capita	protein intake per capita	fat intake per capita	food production per capita	ratio of total export to food import	soil without major constraints	length of growing period	CV of LGP	share of nonagricultural population	food security factor score
Portugal	3750	125	137	319	7.3	6	228	0.10	68.5	1.94
Romania	3620	119	103	381	12.9	46	209	0.15	68.1	1.42
Russia	3090	98	81	278	11.2	45	144	0.16	80.2	0.52
Rwanda	2110	50	16	138	5.5	25	310	0.04	13.7	-1.53
Saint Kitts and Nevi	2730	88	106	135	2.5	49	285	0.06	50.6	0.38
Saint Lucia	2930	100	81	100	1.9	49	285	0.06	48.0	0.44
Saint Vincent and Grenadine	2660	80	64	133	17.5	49	285	0.06	58.2	-0.21
Samoa	2930	87	133	170	2.8	30	345	0.06	40.8	0.77
Sao Tome and Principe	2490	57	83	116	5.1	33	300	0.06	48.5	-0.48
Saudi Arabia	2800	82	78	104	5.5	0	0	3.00	85.3	0.05
Senegal	2360	68	64	80	2.5	29	121	0.16	35.7	-0.60
Serbia and Montenegro	2720	82	115	390	20.1	38	220	0.13	82.4	0.37
Seychelles	2460	91	69	73	18.4	38	225	0.02	40.3	-0.14
Sierra Leone	1910	44	43	56	9.5	13	238	0.05	39.2	-1.48
Slovakia	2780	84	98	288	24.0	18	220	0.09	70.6	0.27
Slovenia	2950	104	102	347	11.1	46	241	0.01	70.1	0.73
Solomon Islands	2230	49	54	143	7.1	0	345	0.06	21.1	-1.07
South Africa	2980	86	72	180	5.0	19	107	0.65	69.8	0.18
Spain	3450	123	149	593	4.1	3	171	0.20	83.5	1.83
Sri Lanka	2390	56	46	77	3.9	37	294	0.11	31.3	-0.94
Sudan	2270	75	67	148	5.5	14	141	0.16	40.0	-0.53
Suriname	2730	70	67	166	3.1	20	337	0.07	76.5	-0.29
Swaziland	2300	55	42	169	10.7	33	210	0.19	41.7	-1.06

country	calorie intake per capita	protein intake per capita	fat intake per capita	food production per capita	ratio of total export to food import	soil without major constraints	length of growing period	CV of LGP	share of nonagricultural population	food security factor score
Sweden	3190	110	123	305	21.3	4	193	0.11	89.2	1.19
Switzerland	3550	105	149	309	24.2	17	188	0.01	82.1	1.63
Syria	3070	89	91	237	8.9	37	122	0.24	59.8	0.47
Tajikistan	1900	59	39	105	14.1	26	82	0.11	42.9	-1.30
Tanzania	1960	50	33	89	6.4	25	195	0.11	23.5	-1.46
Thailand	2400	60	53	239	25.8	19	233	0.07	40.8	-0.49
Timor-Leste	2750	72	45	72	0.8	27	202	0.12	22.8	-0.46
Togo	2350	53	48	76	4.4	36	227	0.08	40.0	-0.99
Trinidad and Tobago	2820	82	75	88	15.6	21	285	0.06	43.7	0.04
Tunisia	3280	106	83	220	11.2	14	186	0.19	69.3	0.79
Turkey	3320	105	86	333	27.8	48	133	0.15	68.2	0.83
Turkmenistan	2820	95	70	322	17.6	7	46	0.39	54.7	0.18
Uganda	2370	60	32	171	4.0	13	279	0.09	16.7	-1.04
Ukraine	3080	94	79	376	18.6	76	169	0.18	74.9	0.43
United Arab Emirates	3250	119	92	114	17.2	0	0	3.00	84.7	1.06
United Kingdom	3460	114	127	249	13.6	5	255	0.06	93.1	1.48
United States	3760	133	144	574	17.9	33	149	0.36	87.1	2.14
Uruguay	2920	94	80	636	12.2	39	344	0.12	90.7	0.33
Uzbekistan	2290	80	62	187	30.1	16	65	0.30	52.4	-0.49
Vanuatu	2600	69	97	235	4.9	30	345	0.06	39.9	-0.09
Venezuela	2340	70	64	154	17.6	21	252	0.08	92.0	-0.58
Vietnam	2630	66	48	188	16.3	16	285	0.06	28.9	-0.61
Yemen	2010	58	40	44	4.9	2	2	2.58	37.4	-1.23
Zambia	1950	50	29	54	6.8	17	166	0.10	34.3	-1.50
Zimbabwe	1980	48	50	75	11.9	34	113	0.34	36.8	-1.30

Source: FAOSTAT (2008b), FAO (2000), World Development Indicator (2008) and Fischer et al. (2001).

Appendix Table 2. Annual growth rate of 1993-97 average to 2001-05 average.

	calorie intake per capita	protein intake per capita	food production per capita	ratio of total export to food import	share of non-agricultural population
Lowest Food Security Group					
Congo Dem Rep	-2.1	-2.5	-3.2	-2.1	-0.6
Burundi	-0.4	-2.3	-2.0	0.9	0.1
Eritrea	-1.0	-1.0	-3.0	-10.9	1.9
Ethiopia	0.6	0.6	-1.4	-1.3	-0.7
Liberia	-0.5	-1.7	1.0	-11.9	1.5
Comoros	-0.4	0.1	-1.1	5.5	-1.0
Rwanda	0.4	0.6	5.6	25.5	-0.1
Mozambique	2.4	3.0	3.1	14.4	2.3
Zambia	-0.1	-0.3	-2.7	-12.4	1.0
Sierra Leone	-0.7	0.1	-0.5	27.0	-0.2
Madagascar	0.1	0.2	-1.0	-4.5	3.9
Tanzania	-0.3	0.3	-0.4	1.6	1.9
Bangladesh	0.9	1.6	3.5	-1.7	2.1
Cambodia	0.3	1.4	2.4	3.9	0.4
Haiti	2.0	2.3	1.5	6.4	-0.2
Tajikistan	-1.8	-0.2	1.8	20.9	1.6
Zimbabwe	-0.6	-0.7	-1.4	-5.3	-0.3
Malawi	0.5	0.2	4.1	0.3	2.3
Angola	1.7	3.6	3.7	7.6	-0.4
Yemen	-0.1	0.6	0.2	15.8	0.6
Guinea	1.0	1.3	3.6	3.4	-1.7
Congo Rep	0.2	1.0	-1.7	-0.4	0.4
Central African Republic	0.0	1.7	2.5	-6.6	5.2
Niger	0.7	1.0	1.4	-8.4	3.4
Solomon Islands	0.7	-0.3	0.7	-7.5	-0.9
Laos	1.9	2.4	6.6	-6.2	2.3
Swaziland	-1.0	-1.1	-0.7	0.1	1.5
Uganda	0.9	2.3	4.6	-11.2	1.5
Kenya	1.3	2.2	2.6	-0.3	3.3
Togo	0.7	0.0	-1.3	-9.1	0.6
Low Food Security Group					
Guatemala	-0.7	0.3	1.7	-7.6	0.7
Sri Lanka	0.7	1.3	0.6	-9.6	1.1
Cameroon	0.6	2.8	3.4	-10.6	3.1
Mali	0.1	0.6	-0.2	1.3	0.5
Nicaragua	0.6	3.1	3.8	3.0	0.2
Nepal	0.6	1.1	2.5	-10.9	-4.4
Guinea-Bissau	-2.3	-1.6	-0.5	-0.3	-1.3

Gambia	-0.3	2.0	2.5	-0.8	1.2
Bolivia	0.2	1.0	2.2	-0.1	-0.5
Botswana	-0.3	-0.1	-2.8	3.4	-0.8
Namibia	0.6	2.0	-4.5	-8.3	0.8
Philippines	0.6	0.8	1.3	-1.9	0.5
Ghana	0.6	2.0	5.5	-6.3	1.3
India	0.4	1.2	2.3	2.5	2.2
Chad	1.5	3.0	2.7	6.6	4.1
Honduras	-0.1	1.1	4.0	-5.4	1.6
Dominican Republic	0.0	2.2	1.5	-8.5	0.7
Cote d'Ivoire	0.5	1.4	2.4	-1.1	1.0
Armenia	1.4	2.9	7.6	4.0	-0.2
Panama	-0.8	0.8	-0.2	-7.4	-0.2
Lesotho	1.9	2.3	-0.1	27.9	0.3
Djibouti	1.2	3.2	0.7	-5.4	-14.6
Vietnam	1.0	2.0	5.4	-1.7	1.5
Senegal	-0.1	0.5	-3.1	-4.3	-1.3
Benin	0.8	1.3	3.0	-8.8	2.6
Pakistan	-1.1	2.3	4.1	1.9	0.2
Venezuela	-0.3	2.0	1.0	-1.5	0.2
Peru	1.4	2.6	5.2	7.2	0.2
Colombia	0.2	0.6	2.4	-0.6	0.1
Sudan	-0.4	0.2	-0.1	8.2	0.5
Middle Food Security Group					
Thailand	0.4	1.4	2.8	-10.8	0.8
Uzbekistan	-1.4	1.1	2.0	31.8	0.8
El Salvador	0.1	2.0	1.4	-5.7	1.8
Nigeria	-0.1	0.5	3.3	6.0	1.8
Burkina Faso	1.2	1.8	3.8	-5.4	-3.0
Antigua and Barbuda	-0.3	-1.0	-3.1	-14.5	8.7
Moldova	0.1	0.2	0.3	-15.7	1.6
Gabon	0.8	0.6	3.6	-3.3	1.2
Azerbaijan	2.8	3.7	5.8	14.6	0.8
Suriname	0.3	0.7	-0.8	-9.6	0.3
Georgia	1.6	2.5	3.3	7.1	0.3
Indonesia	0.1	0.1	2.4	-3.3	1.8
Mongolia	2.4	2.9	-2.3	-0.4	1.3
St Vincent & Grenadines	1.0	2.6	-3.0	18.2	5.6
Myanmar	0.4	1.4	4.6	-7.7	0.3
Ecuador	0.2	1.6	2.6	-6.8	0.8
Guyana	1.6	2.6	4.3	-6.5	0.5
Seychelles	0.2	2.4	-1.6	11.5	-11.6
Jordan	-0.5	0.4	0.3	-0.4	-0.1
Jamaica	0.4	2.5	0.4	-3.9	0.1
Paraguay	0.0	0.5	1.5	-1.8	0.2
Vanuatu	-0.5	1.8	-4.2	-6.1	15.9

Costa Rica	0.6	1.6	2.7	0.1	0.1
Belize	0.1	3.1	2.8	-2.8	0.0
Dominica	-1.0	0.1	-2.6	-3.6	1.3
Upper Middle Food Security Group					
Mauritania	0.7	1.7	-0.8	-6.1	-0.5
Trinidad and Tobago	0.8	3.8	2.5	3.8	0.3
Brunei Darussalam	-0.2	0.5	5.1	8.5	-0.1
Saudi Arabia	-0.2	0.6	5.7	-12.1	0.3
Malaysia	0.0	1.3	5.4	-0.8	0.7
Croatia	1.9	3.6	4.6	-4.1	0.4
South Africa	0.2	1.5	0.7	-19.4	1.1
Kiribati	0.3	-0.3	-1.4	-18.5	8.1
Algeria	0.4	1.4	2.6	8.0	-0.5
Bahamas	0.7	2.6	-0.9	-20.6	-0.4
Morocco	-0.1	1.8	1.5	0.0	1.1
Fiji	0.5	1.0	-1.8	-7.2	0.3
Chile	0.5	1.7	2.9	-2.3	0.8
Slovakia	-0.7	0.5	0.2	0.4	0.2
Iran	1.2	3.2	3.2	9.2	0.9
Maldives	0.5	1.7	1.4	21.6	1.0
Mauritius	0.2	3.2	1.3	-3.2	-0.1
Cuba	4.0	7.2	6.5	1.4	0.7
Uruguay	0.6	1.0	0.6	-4.7	-0.1
Macedonia	1.5	2.2	1.4	7.0	1.4
Kazakhstan	-1.5	-0.2	3.9	-0.6	0.2
Saint Kitts and Nevis	0.3	3.2	-0.4	-11.6	12.5
Japan	-0.6	0.8	0.7	-5.9	-0.4
China	0.7	2.9	5.0	10.1	2.0
Kyrgyzstan	3.8	4.3	4.8	1.1	1.0
Belarus	-1.1	0.3	6.5	-11.5	1.2
Egypt	0.3	1.4	4.1	3.3	1.1
Ukraine	0.6	1.6	3.5	-9.3	0.8
Saint Lucia	0.9	2.2	-9.2	-13.4	8.6
Cape Verde	0.6	0.8	-0.2	6.3	1.5
Albania	-0.2	0.6	4.1	13.5	0.9
Syria	-0.9	0.6	2.1	1.7	0.6
Korea Rep	-0.4	2.1	2.3	-2.0	0.4
Argentina	-0.8	-0.1	2.3	10.3	0.1
Russia	0.7	1.3	3.9	-0.4	0.0
Brazil	1.0	3.0	4.1	8.7	0.8
Bulgaria	0.4	2.0	2.3	1.0	0.5
Grenada	1.0	4.7	-2.5	-0.9	8.7
Mexico	0.2	2.0	1.9	-0.2	1.4
Barbados	-0.2	1.9	1.5	-5.1	-0.5
Kuwait	0.5	0.0	6.8	8.0	-0.1
Latvia	0.9	0.8	1.7	-11.5	-0.1

Slovenia	-0.5	0.6	2.2	-6.2	-0.2
Libya	0.5	2.1	5.0	2.8	0.7
Estonia	2.1	0.6	2.5	-0.5	-0.1
Tunisia	0.1	2.6	2.4	-1.8	1.1
Lebanon	-0.3	2.2	-1.4	8.2	-0.4
Turkey	-0.7	0.5	1.2	2.9	0.2
New Zealand	-0.7	-1.4	1.9	-6.0	0.2
High Food Security Group					
United Arab Emirates	-0.3	1.9	1.2	0.5	0.8
Czech Republic	0.7	1.2	1.0	-1.8	0.3
Finland	0.3	1.3	1.5	-4.3	0.6
Poland	0.3	0.9	3.7	1.5	0.4
Sweden	0.1	1.1	1.3	-5.3	-0.4
Australia	-0.4	0.4	1.5	-9.0	-0.6
Lithuania	1.6	3.5	3.8	-5.6	1.0
Romania	1.5	2.7	3.9	-1.3	1.2
United Kingdom	0.9	2.6	0.3	-2.5	-0.2
Germany	0.5	1.7	2.0	2.1	-0.3
Malta	0.7	2.3	2.3	-4.4	-0.2
Denmark	0.5	0.7	1.2	-8.0	-0.4
Hungary	0.8	2.1	3.1	1.0	-0.1
Belgium	0.0	-0.6	0.6	-2.6	-0.2
Netherlands	0.9	1.1	-0.9	-1.3	-0.4
Switzerland	1.1	1.8	1.1	-3.4	0.5
Iceland	0.8	1.9	0.6	-6.0	0.3
Canada	2.1	2.4	2.1	-3.6	-0.3
Norway	0.9	2.4	-0.2	-4.6	0.7
Spain	0.6	1.8	3.6	-15.5	0.5
Ireland	0.4	1.8	-0.9	4.1	0.1
Portugal	0.4	1.4	2.1	-5.7	1.1
Greece	0.4	1.2	0.8	1.7	-0.3
Israel	1.4	3.0	3.5	0.5	-0.3
Austria	0.8	1.5	1.6	-6.2	0.7
Italy	0.9	1.8	1.8	-1.8	0.7
Luxembourg	0.4	1.6	-1.1	5.3	-0.2
France	0.4	1.2	1.3	-3.3	-0.4
United States of America	0.4	2.2	1.6	-9.0	-0.3
Lowest Food Security	0.2	0.6	1.0	1.5	1.1
Low Food Security	0.3	1.5	1.7	-1.4	0.1
Middle Food Security	0.4	1.5	1.2	-0.8	1.3
Upper Middle Food Security	0.4	1.7	2.1	-1.0	1.2
High Food Security	0.7	1.7	1.5	-3.0	0.2
Total	0.4	1.4	1.6	-1.0	0.8

Source: Author's calculations from FAOSTAT (2008b), World Development Indicator (2008) and Diaz-Bonilla et al. (2000) .