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Assessing the Vulnerability of National Food Security to International Food Price Shocks

A New Index

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ABSTRACT

Recent spikes in staple food prices resulting from the invasion of Ukraine have once again highlighted the difficulty faced by low-income countries that rely on imports for a substantial portion of their food supply. To better understand which countries are most affected by higher world food prices, we propose a food import vulnerability index (FIVI). One version of the index describes the vulnerability of each country to higher world prices for each of 15 major staple foods. Another version of the FIVI is a national index, aggregating across the 15 commodities. Both are based on three components, the caloric contribution of the commodity(ies) in the national diet, the dependence on imports, and the level of moderate and severe food insecurity in the country. The values of the FIVI are calculated for 2020, the most recent year for which data are available.

The results indicate that countries are most adversely affected by increases in the world price of wheat, rice, and maize, followed by sugar, and vegetable oil. This is because the five commodities listed are both major contributors to the diet in many countries and because countries often depend on imports for a large share of the domestic requirements of these foods. Yemen, Djibouti, and Afghanistan are most vulnerable to increases in world wheat prices, while Liberia, Gambia, and Guinea-Bissau are particularly vulnerable to spikes in rice prices. In the case of maize, Zimbabwe, Lesotho, and Eswatini have the highest vulnerability score. These results should help policymakers and development partners target their efforts to reduce food import vulnerability through policies and programs to strengthen resilience.

Keywords: food security, vulnerability, import dependence, staple foods, international price volatility

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ACRONYMS

IDR	Import dependence ratio
IFPRI	International Food Policy Research Institute
FAO	Food and Agriculture Organization
FCDO	Foreign, Commonwealth, and Development Office
FIES	Food Insecurity Experience Scale
FIVI	Food import vulnerability index
GDP	Gross domestic product
LIFDC	Low Income Food Deficit Countries
MFI	Moderate and severe food insecurity
NFIDC	Net Food Importing Developing Countries
PoU	Prevalence of Undernourishment
USAID	United States Agency for International Development
WTO	World Trade Organization

1. Introduction

The international prices of food commodities have experienced a series of shocks over the past decade. The prices of rice, maize, and wheat spiked in 2007-08 as a result of supply shocks, demand for biofuels, and trade restrictions by exporters. Commodity prices increased again in 2010-11. And most recently, global supply chain disruptions in the aftermath of the COVID-19 pandemic sent international food and fertilizer prices soaring during 2021. These global price shocks were exacerbated with Russia's invasion of Ukraine in early 2022, given the importance of these countries in global supplies of grains, oil seeds and fertilizers. Even though international food commodity prices have moderated since peaking in mid-2022, the adverse effects of the price spikes have had adverse effects on food security in many countries, but the sharpest impact is on low-income countries that depend heavily on imported food.

National policymakers and international development agencies need better information on the vulnerability of each country to different types of shocks. Such information would facilitate the design of programs and policies to prepare for and respond to shocks in international food prices. The purpose of this report is to propose a simple measure of vulnerability to international price shocks, the food import vulnerability index (FIVI). One version of the index measures vulnerability of countries to world price increases of each of 15 staple food commodities, while another measures vulnerability of countries to general food price increases in international markets.

The proposed food import vulnerability index offers three contributions to the existing research on the topic. First, some existing studies of food import vulnerability identify a list of countries that are vulnerable but do not measure the degree of vulnerability. The FIVI score provides a measure of the degree of vulnerability, allowing countries to be ranked. Second, most of the research on vulnerability to international food prices consists of one index for all food or all staples. Since international food price shocks do not occur simultaneously for all commodities, it is useful to have separate measures for each of the major food staples, as our measure does. Third, some of the existing measures of vulnerability are estimated using complex network analysis or simulation models of world markets. While incorporating a range of factors, such models are less transparent and less replicable than the food import vulnerability index proposed in this paper and which relies on publicly available data and calculations that can be carried out on a spreadsheet.

Section 2 summarizes previous research on vulnerability to international food price shocks. In section 3, we describe the data and methods used in this analysis. Section 4 provides the results of this analysis, including a ranking of countries by vulnerability to world price increases for each internationally traded staple food and a national ranking that takes into account all 15 commodities. A summary and conclusion are provided in Section 5.

2. Previous research on vulnerability to world food prices

Vulnerability has been defined as the combination of exposure to external shocks and lack of ability to manage the related risk (Chambers, 1989). Shocks are unexpected events with potential adverse effects, such as drought, floods, the outbreak of conflict, or dramatic changes in world prices. Managing risk means having strategies or tools to avoid negative impact or to adjust and recover quickly from the negative impact. Some of the earliest studies of vulnerability were in ecology, attempting to understand factors affecting the stability of complex ecosystems (Goh, 1975). Since then, the concept has been applied in a wide variety of fields including disaster management (Maskrey, 1989), climate change (Lewis, 1989), environmental sustainability (Turner et al., 2003), and food security (Maxwell et al., 1999). It is closely related to the concept of resilience, which originated in ecology but has been widely used in the study of food security (Béné et al, 2017).

Food security was defined at the 1996 World Food Summit as "when all people, at all times, have physical and economic access to sufficient safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO, 1996). By including "at all times", the definition includes the dimension of stability over time, but it is often defined using indicators measured at one time. Examples include the Food Insecurity Experience Scale (Cafiero et al., 2018), the Coping Strategy Index (Maxwell and Caldwell, 2008), and the Food Consumption Score, used by the World Food Programme (WFP, 2009). This research has focused attention on the role of risk in understanding poverty and food insecurity (Ravallion, 1988; Dercon, 2005). Some studies emphasize the need for panel household survey data to understand changes in access to food over time. Although such data are becoming more available through programs such as the World Bank Living Standards Measurement Studies, data availability remains a constraint on widespread application.

One important source of shocks affecting food security is volatility in international prices, particularly spikes in staple food prices. In the wake of the spike in commodity prices in 1973-74, the Food and Agriculture Organization (FAO) defined low-income food-deficit countries (LIFDC) as those countries whose per capita income is low enough to qualify for IDA assistance from the World Bank and have net imports of food. Currently, 51 countries qualify under this definition (FAO, 2023c).

Similarly, the World Trade Organization (WTO) identified a list of Net Food Importing Developing Countries (NFIDC) in 1995 as part of the Agreement on Agriculture in the Uruguay Round of trade negotiations. These countries are allowed some flexibility in the application of WTO trade rules in recognition of their vulnerability to world market fluctuations. Currently, there are 74 countries on the list of NFIDCs (FAO, 2023c).

Other studies have attempted to measure vulnerability to international shocks at the national level. Diaz-Bonilla et al. (2000) applied cluster analysis to data on five trade and food security indicators for 167 countries. They identify 12 clusters of countries based on food security and trade vulnerability. Based on the results, the authors question the use of the NFIDC definition given that it includes countries that are not clearly food insecure.

Marchand et al (2016) develops a model of global cereals trade in which 140 countries respond to shortfalls in production by reducing domestic stocks and reducing exports. The shocks consist of proportional reductions in cereal production by each country and vulnerability measured in terms of average reduction in consumption across all shocks. They find that the greatest proportional reductions in consumption are in Central America, the Sahel, Myanmar, and Cambodia.

Seekell et al (2017) develops an index of national resilience to food supply shocks that uses indicators of socio-economic resilience (e.g., income), bio-physical resilience (land and water availability), and food production diversity. They calculate the index for 96 countries over 1992 to 2011. They find that the three types of resilience are not closely related to each other, suggesting that different countries face different risks. No aggregate measure of resilience is provided.

Grassia et al (2022) examines vulnerability in the context of a global trade simulation model. They estimate the caloric shortfall in each country as a result of various shocks and develop an index to measure national vulnerability to these shocks. They find that Cyprus, United Arab Emirates, and Trinidad and Tobago are the most vulnerable. Somewhat surprisingly, they find that vulnerability is positively correlated with per capita GDP, which they attribute to the fact that high-income countries tend to be more integrated in international food markets.

In the wake of the war in Ukraine, numerous studies have examined the vulnerability of different countries to the shocks in commodity markets, particularly for wheat and fertilizer. Hellegers (2022) uses data on bilateral trade patterns and identifies 20 countries that are likely to be adversely affected by the war, though no aggregate index is calculated. Laborde and Vos (2023) describe the methodology of a vulnerability index that is specific to the shock to wheat and fertilizer markets caused by the war in Ukraine. In this approach, country-level vulnerability is based on dependence on Ukraine or Russia for wheat or fertilizer imports prior to the war, reliance on imports from countries that introduced export control measures in response to the war, domestic food inflation, and other factors. This analysis indicates that the countries that are the most vulnerable to impacts from the war are Mauritania, Congo, Sudan, and Yemen. The results of this analysis are also available at IFPRI's Food Security Portal (IFPRI, 2023).

Most research has concentrated on the vulnerability to increases, rather than decreases, in international food prices. There are three reasons for this focus. First, the volatility in international prices is asymmetric: large positive shocks are relatively common but large negative shocks are rare. Deaton and Laroque (1992) attribute this to the asymmetry in storage: price drops can always be dampened by increased storage, but if stocks are low, it may not be possible to release stocks to avert a price spike. Second, staple food importers are more numerous than staple food exporters, as described in Section 4.2 of this paper. Third, research on the relationship between food prices and poverty suggests that, in most countries, higher food prices exacerbate poverty. While some surplus farmers benefit from higher food prices, urban households and a large share of rural households are net buyers of staple foods, so the net effect is that higher food prices worsen poverty (Ivanic and Martin, 2008).

3. Data and methods

3.1. Conceptual Framework

We define vulnerability in terms of the effect of an increase in the international price of a food commodity, such as rice or wheat, on the food security status of the country, that is, the number of households that are unable to meet a minimum standard of caloric intake. The ideal measure of vulnerability to increases in the world price of a food commodity would take into account at least four factors.

First, how much do international food prices affect local food prices? The degree of price transmission from international markets to domestic markets varies widely across countries and across commodities. For example, a study of 67 staple food markets in sub-Saharan Africa found that price transmission from international markets to local markets was strong for wheat and rice, but much weaker for maize (Minot, 2011).

Second, are there substitutes for the food commodity? This is important because substitutes allow consumers to switch away from a food commodity if its price rises. Countries for which one staple food plays a dominant role in the diet have fewer opportunities to switch and are thus more vulnerable to an increase in the price of that commodity.

Third, how important is the food commodity to households, particularly poor households? The larger the share of spending that a food commodity represents in the budget, the greater the welfare impact of an increase in its price. For example, an increase in the price of rice will affect a household spending 50% of its budget on rice more than a household spending just 20% on it. Similarly, the income patterns matter because a farm household selling food crops benefits from food price increases, particularly if the crop accounts for a large share of its income. Deaton (1989) noted that the proportional impact of a food price change on real income can be estimated by multiplying the proportional change in the price by the net benefit ratio, defined as the value of sales minus the value of purchases expressed as a share of income. This is a first-order approximation of the welfare impact of a price change. A more precise second-order estimate of the welfare impact would also take into account the household response to the price change, which is affected by the availability of substitutes (Minot and Goletti, 1998).

Finally, what is the level of food security or income in the country? High-income households can "afford" a food price increase, meaning that they can easily maintain food consumption patterns by adjusting their non-food expenditure. In contrast, poor households, who may spend 60-70% of their budget on food, are less able to maintain food consumption levels in the face of higher food prices. Being close to subsistence levels of income, a given reduction in caloric intake is likely to have a more adverse impact on nutrition.

However, a vulnerability index which accounts for all four of these factors would require detailed information from detailed household budget surveys which are unavailable or only collected at large time intervals in many countries. A vulnerability index that is only available for few countries would have limited value. In order to provide broader coverage in terms of the number of countries, we seek an index that meets the following four criteria.

- First, the vulnerability index should be a good measure of the adverse effect of a given increase in the world price of staple foods on food security in the country.
- Second, it should be based on indicators that are available for a large number of countries, making it possible to calculate the index for almost every nation.
- Third, it should be based on variables that are quantitative and clearly defined to avoid ambiguity.
- And fourth, the index should be simple and intuitive so that it can be calculated and used independently by other analysts.

In the next two sections, we describe the methods and data used to calculate the food import vulnerability index for each commodity and a national index covering the main staple foods.

3.2. Methods

The Food Import Vulnerability Index (FIVI) used in this analysis has three components:

- the share of calories that the food commodity represents in the national diet,
- the share of national consumption of the commodity that comes from imports, and
- the share of the population that is food insecure.

More specifically, the commodity-level FIVI is calculated at the country and commodity levels as the geometric mean of these three components:

$$FIVI_{ic} = 100\left(\frac{C_{ic}}{\sum_i C_{ic}}\right)^{1/3}\left(\frac{M_{ic}}{Q_{ic}}\right)^{1/3}(MFI_c)^{1/3}$$

where $FIVI_{ic}$ = the food import vulnerability index for commodity i and country c
C_{ic} = the average caloric intake from commodity i in country c
M_{ic} = the quantity of net imports of commodity i in country c
Q_{ic} = the quantity of domestic utilization[1] of commodity i in country c
MFI_c = the share of the population that is moderately or severely food insecure in country c

The rationale for using a multiplicative index is that the vulnerability should be zero if (a) the commodity does not play a role in the local diet, (b) domestic consumption is based entirely on domestic production without relying on imports, or (c) there is no food insecurity in the country. The base index uses equal weights for the three components, but we carried out sensitivity analysis to determine whether the index and rankings are affected by applying different weights to the three components (see Appendix B). We find little sensitivity to changed weights.

We also calculate a national Food Import Vulnerability Index (FIVI) using the following equation:

$$FIVI_c = 100\left(\sum_i \left(\frac{C_{ic}}{\sum_i C_{ic}}\frac{M_{ic}}{Q_{ic}}\right)\right)^{1/2}(MFI_c)^{1/2}$$

where $FIVI_c$ = the food import vulnerability index for country c
C_{ic} = the average caloric intake from commodity i in country c
M_{ic} = the quantity of net imports of commodity i in country c
Q_{ic} = the quantity of domestic consumption of commodity i in country c
MFI_c = the share of the population that is moderately or severely food insecure in country c

The first term in parentheses is the weighted average of the import dependence ratio (M_{ic}/Q_{ic}) across the 15 staple commodities, where the weights are the caloric contribution of each commodity to total staple calories in that country ($C_{ic}/\Sigma C_{ic}$). The weighted average of the import shares for each commodity is equal to the share of the calories from the 15 staple foods that are imported. The second term is the share of the population that is moderately or severely food insecure (MFI_c).

The national FIVI will be low if imports represent a small share of the calories consumed from the 15 staple foods or the share of the population experiencing moderate or severe food insecurity is low. Conversely, the national FIVI will be high if a large share of the calories consumed of the 15 staple foods are imported and a large proportion of the population faces moderate or severe food insecurity.

[1] Domestic utilization is labeled "domestic supply quantity" in the FAO Food Balance database. It is equal to the sum of production, opening stocks, and net imports. Alternatively, it is equal to the sum of food, feed, seed, tourist food, industrial use, losses, residual uses, and closing stocks.

3.3. Data

This section describes the sources of data used to construct the FIVI and methods used to interpolate values that are missing in the original data. The contribution of each commodity to the caloric intake in each country is calculated using the Food Balance Sheets generated by the Food and Agriculture Organization (FAO, 2023a). These data are available on an annual basis for 183 countries. This analysis uses the data for 2020, the most recent available. We calculate the total caloric intake from 15 major staple foods and then the contribution of each commodity to the total in each country. The staple foods included in the index are wheat, rice, maize, sorghum, millet, cassava, sweet potatoes, yams, plantains, beans, groundnuts, soybeans, sugar, and vegetable oil. In the FAO database, the cereals, cassava, and potatoes include products made from the staple crop such as wheat bread and cassava flour. Vegetable oil is an aggregated category that includes 13 types of oil in the original FAO database.

The net import share is also calculated from data in the FAO Food Balance Sheets (FAO, 2023a). Data on the net import share are available on an annual basis for 183 countries. We use the data for 2020, the most recent available. For each country and commodity, we calculate the quantity of imports minus the quantity of exports as a ratio of the quantity of domestic supply.

Finally, the data on moderate and food insecurity (MFI) are obtained from the FAO Suite of Food Security Indicators (FAO, 2023b). The MFI indicators are estimated based on the Food Insecurity Experience Scale (FIES), which in turn is calculated based on a set of eight questions asking respondents to self-report conditions and experiences typically associated with limited access to food. FAO collects this data annually as part of the Gallup World Poll for nationally representative samples in more than 140 countries, covering more than 90% of the world population. The data made available are three-year averages up through 2019-21. This analysis uses the MFI data for 2019-21, which are available for about 142 countries. This leaves 41 countries for which we have data on caloric intake and net imports but not food insecurity. To fill this gap, we use interpolated values based on regression estimates of moderate and severe food insecurity as a function of per capita gross domestic product, the FAO Prevalence of Undernourishment, the Gini coefficient, and the headcount poverty rate (FAO, 2023b and World Bank, 2023). To get estimates of food insecurity, we use as many of these proxy indicators as are available for the country in question, resulting in the use of seven regression models with different combinations of these indicators. All models use linear and quadratic versions of the explanatory variables. These models explain most of the variance in the food insecurity rate, with values of R^2 between 0.61 and 0.81. The interpolation procedure is described in more detail in Appendix A.

In the case of Syria, neither the MFI nor the predictive indicators is available for 2019-21. Thus, we use the estimated value of MFI for the previous year, 2018-2020.

3.4. Rationale for the components

The inclusion of the first component, the share of calories derived from a food commodity, is justified because it captures vulnerability to price increases in several ways. It measures the dependence of households on this food commodity and the availability of substitutes. For example, if over half of the caloric intake is from rice, then an increase in the price of rice is likely to have a highly adverse effect on consumers. In contrast, if the caloric contribution is small, then the direct impact will be small, and substitutes are likely to be available.

The import share in domestic consumption reflects the country's vulnerability to international food prices increases. More specifically, it is a measure of the likely transmission of shocks from international markets to domestic markets. For example, if a country is self-sufficient in maize, the import share would be zero and changes in international maize prices would have little to no effect on domestic markets. In such contexts, domestic prices are determined by domestic supply and demand. On the other hand, if imports account for a high share of consumption, then any increase in world prices is likely to be reflected in higher domestic prices. Furthermore, the scope for international price spikes to raise domestic prices depends on the scale of imports. If a country imports just 10% of its needs, a large international price increase will cause a limited increase in the domestic price, after which the country may stop importing and become self-sufficient. In contrast, if a country imports 50% of its needs, the domestic price is likely to rise by the full extent of the international price increase because it continues to import, albeit on a smaller scale.

And the share of the population experiencing moderate or severe food insecurity reflects the resilience of the country to food price shocks in general. Households not experiencing food insecurity are likely to have higher incomes and to devote a smaller share of their budget to food, following Engel's Law. Thus, the impact of food price increases on overall purchasing power declines as income and food security rise.

The FIV index meets the second criterion as it can be calculated for most countries. As discussed above, the caloric contribution of each food commodity and the net import dependence is available for about 183 countries, while data on food insecurity is available for 142. The econometric interpolation gives us estimates of food insecurity in an additional 41 countries. As a result, we can calculate the FIVI score for 183 countries.

This vulnerability index also meets the third criterion of being based on objective and quantitative data. All the components of the Food Import Vulnerability Index are available online, using data generated by the FAO and the World Bank.

Finally, the vulnerability index satisfies the fourth criterion of being easy to calculate and interpret. Although it does not have any natural unit, it can easily be used to rank countries. Furthermore, it is intuitive in that the first two components reflect some measure of "dependence" (dietary and import dependence), while the third reflects the resilience of the country to economic shocks.

4. Results

Sections 4.1, 4.2, and 4.3 summarize the results for each of the three components of the index: the contribution to caloric intake, import dependence, and food insecurity. Section 4.4 describes the results of the commodity-level food import vulnerability index (FIVI), while Section 4.5 discusses the results of the national FIVI.

4.1. Caloric contribution of selected staple foods to the diet

How important are each of the main staple foods in the diet for each country, based on its contribution to the total caloric intake? The more important a commodity is in the diet, the more vulnerable the country is to an increase in prices of the commodity.

4.1.1. Overview

Table 1 shows the caloric importance of each of the 15 food staples in our analysis according to three indicators. The first column shows the share of caloric intake on a global level, calculated from FAO Food Balance Sheet data as the total calories consumed for each commodity as a percentage of the total calories consumed. The most important staple foods by this measure are wheat, rice, vegetable oil, sugar, and maize.

The second column gives the number of countries for which each commodity is the most important source of calories in the diet. By this measure, wheat is again the most important staple, being the largest source of calories in 95 countries. Wheat is followed by rice (42 countries), maize (21), vegetable oil (9), and cassava (7).

The last column shows the number of countries in which each commodity is among the top five sources of calories. Wheat and vegetable oil are the most important staples by this measure, with each being in the top five in 163 of the 183 countries analyzed. These are followed by sugar (144 countries), rice (91), and maize (65).

Table 1. Measures of importance of the 15 staple foods in the global diet

Staple food	Global share of caloric intake	Number of countries for which it is the most important source of calories	Number of countries for which it is in the top 5 sources of calories
Wheat	18.2	95	163
Rice	17.8	42	dd91
Maize	5.4	21	65
Sorghum	1.0	2	8
Millet	0.8	1	6
Beans	0.8	0	6
Groundnuts	1.2	0	2
Soybeans	0.5	0	0
Cassava	1.9	7	28
Potatoes	2.1	0	14
Sweet potatoes	0.6	0	4
Yams	0.5	1	7
Sugar	6.6	2	144
Vegetable oil	9.1	9	163
Other	33.0	-	-
Total	100.0	-	-

Source: Calculated from the FAO Food Balance Sheet for 2020 (FAO, 2023a).

Below, we discuss the global patterns in the importance of six commodities: wheat, rice, maize, cassava, vegetable oil, and sugar. Maps showing the importance of the other nine commodities are available on IFPRI's Food Security Portal (IFPRI, 2023).

4.1.2. Importance of wheat in the diet

Wheat and wheat products are the most important source of calories by all three indicators in Table 1 (it is tied for first with vegetable oil in the third indicator). Figure 1 shows the contribution of wheat and wheat products to caloric intake in each country, while Table 2 gives the ten countries where wheat accounts for the largest share of caloric intake. Wheat represents the largest share of the diet in Afghanistan, where it accounts for 62% of the total, followed by Turkmenistan where the share is 51%. Wheat contributes to more than 30% of caloric intake across North Africa, in Southwest Asia, most of Central Asia, Russia, and Chile. It is also relatively important in the diet in India, Argentina, and much of western Europe. On the other hand, wheat represents less than 10% of the caloric intake in a large portion of sub-Saharan Africa, most of Southeast Asia, Mexico, and Colombia, among other countries.

Figure 1. Map of importance of wheat in the diet

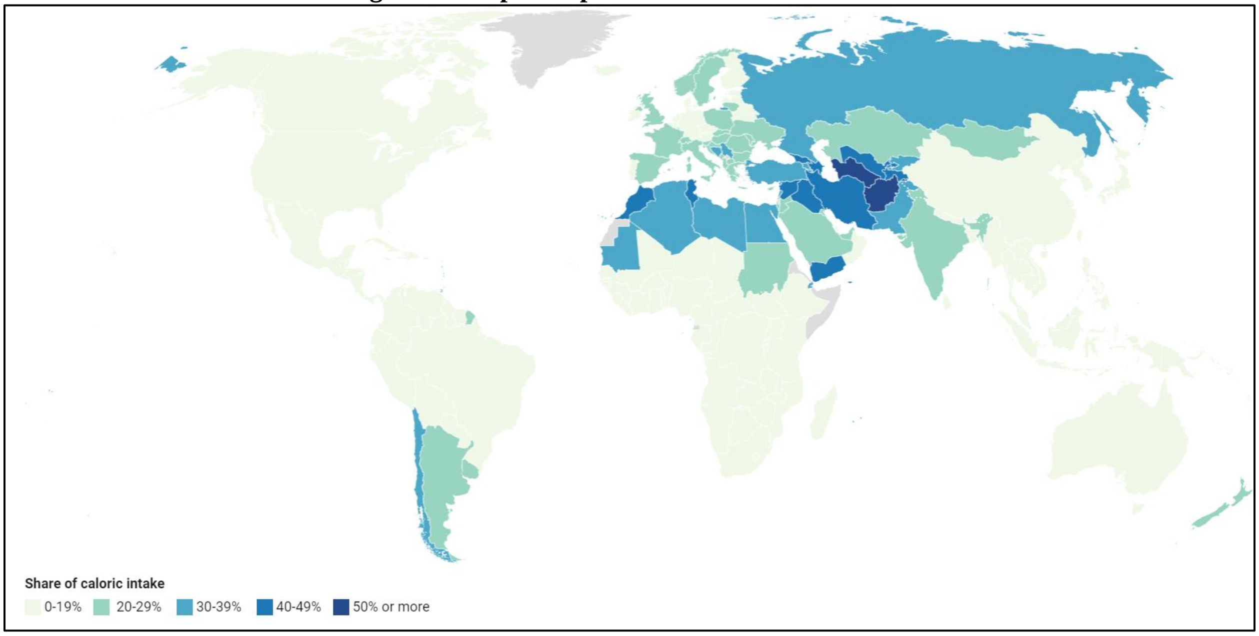


Table 2. Ten countries where wheat contributes the most to the diet

Country	Share of total calories (%)	Rank of wheat among foods in the country
Afghanistan	62	1
Turkmenistan	51	1
Iraq	47	1
Yemen	46	1
Syrian Arab Republic	46	1
Azerbaijan	45	1
Tunisia	45	1
Tajikistan	44	1
Iran (Islamic Republic of)	41	1
Uzbekistan	41	1

Source: Authors' calculation based on FAO (2023a)

4.1.3. Importance of rice in the diet

Rice and rice products are the second most important staple food in terms of global caloric intake and in terms of the number of countries where it is the most important source of calories. Figure 2 and Table 3 show the importance of rice in the diet across countries. The diet is most dependent on rice in Bangladesh, where it accounts for 66% of calories consumed. Rice also accounts for over half of the caloric intake in Cambodia, Madagascar, and the Lao P.D.R. In general, rice is a key staple food in all of Southeast Asia, most of coastal West Africa, and in India and China.

Figure 2. Map of importance of rice in the diet

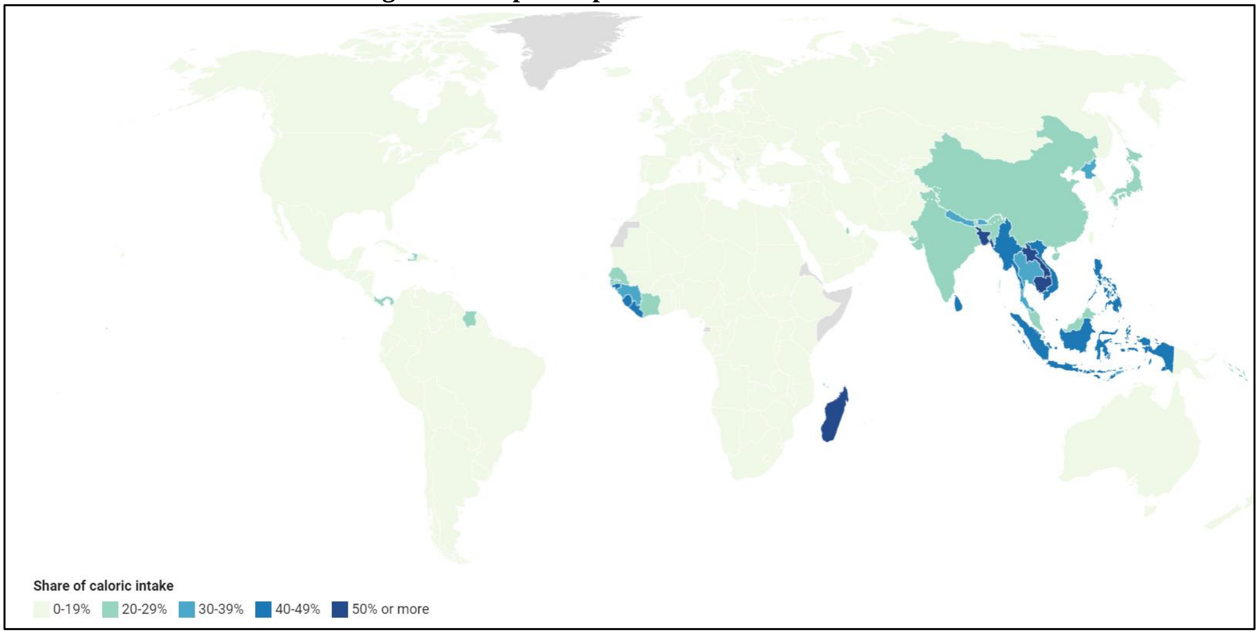


Table 3. Ten countries where rice contributes the most to the diet

Country	Share of total calories (%)	Rank of rice among foods in the country
Bangladesh	66	1
Cambodia	57	1
Madagascar	56	1
Lao P.D.R.	52	1
Liberia	47	1
Guinea-Bissau	46	1
Philippines	44	1
Viet Nam	44	1
Sierra Leone	42	1
Indonesia	42	1

Source: Authors' calculation based on FAO (2023a)

4.1.4. Importance of maize in the diet

Maize is the third most important staple cereal. As shown in Table 1, maize and maize products are fifth in caloric contribution to the global diet, behind wheat, rice, vegetable oil and sugar, it is the largest source of calories in more countries (21) than either vegetable oil (9) or sugar (2). Figure 3 and Table 4 show that maize is most important in the diet in southern Africa and Central America. Maize accounts for more than 40% of caloric intake in Malawi, Lesotho, and Zambia. In Mexico and most of Central America, people rely on maize for at least 25% of their calories. Similarly, maize accounts for more than 20% of the diet in almost all of southern and East Africa, the exceptions being Namibia, Rwanda, and Burundi (data are not available for Somalia and Eritrea).

Figure 3. Map of importance of maize in the diet

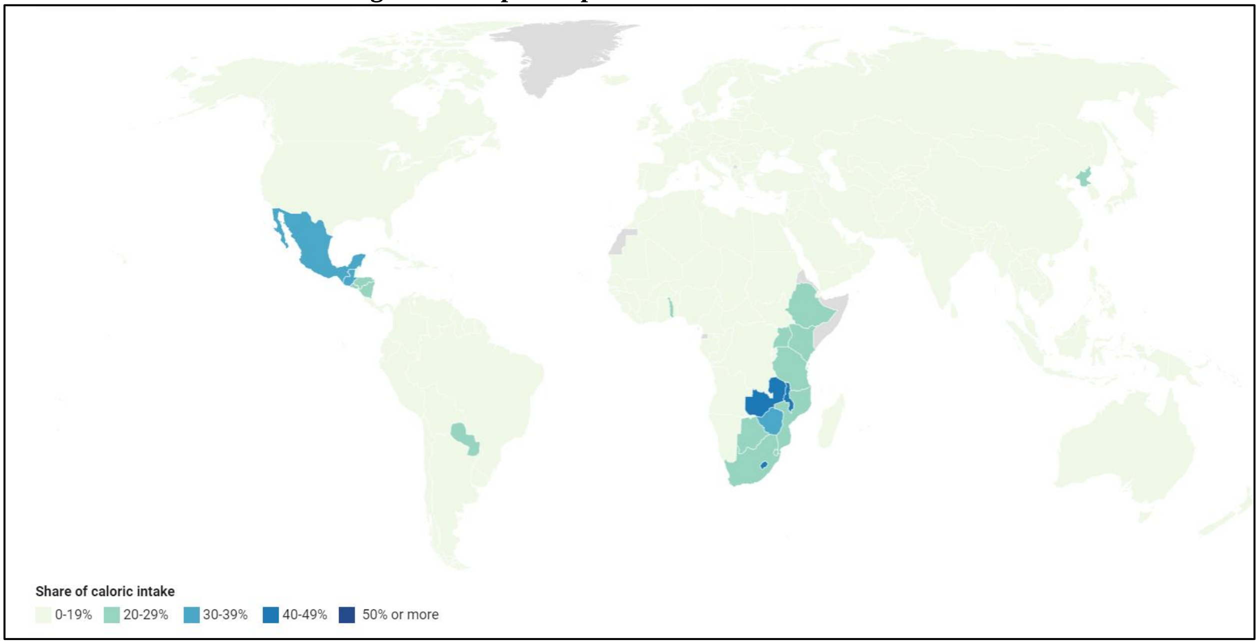


Table 4. Ten countries where maize contributes the most to the diet

Country	Share of total calories (%)	Rank of maize among foods in the country
Malawi	48	1
Lesotho	47	1
Zambia	46	1
Zimbabwe	34	1
Mexico	32	1
Guatemala	32	1
El Salvador	30	1
Honduras	28	1
Eswatini	27	1
Kenya	27	1

Source: Authors' calculation based on FAO (2023a)

4.1.5. Importance of cassava in the diet

Cassava accounts for 1.9% of all calories consumed by people globally, making it the seventh ranked food by this measure. Furthermore, it is the most important source of calories in seven countries, placing it fifth by this indicator.

As shown in Figure 4, cassava is most important in the diet of the Democratic Republic of Congo, where it accounts for 61% of caloric intake. Cassava is also an important source of calories in Congo, Burundi, Angola, and Zambia, where it represents 25-34% of caloric intake. The next five countries on the list are all in sub-Saharan Africa, including three countries in West Africa. Rwanda does not appear on this table, but it is the seventh country for which cassava is the most important source of calories.

Figure 4. Map of importance of cassava in the diet

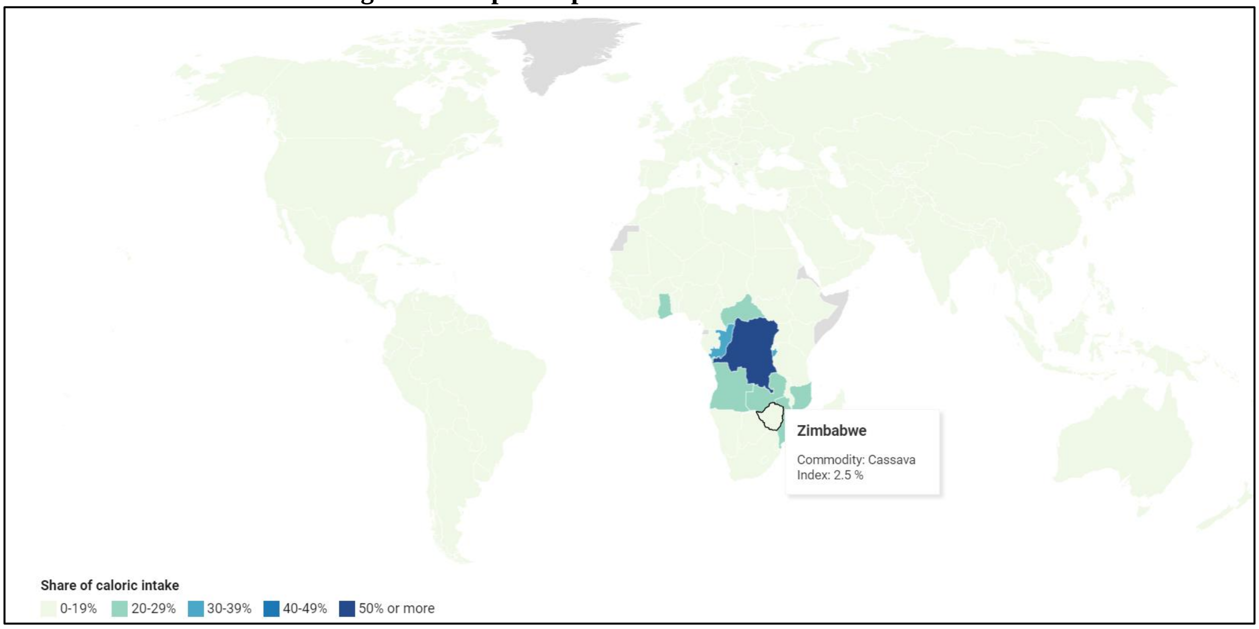


Table 5. Ten countries where cassava contributes the most to the diet

Country	Share of calories (%)	Rank of cassava among foods in the country
D.R. Congo	61	1
Congo	34	1
Burundi	32	1
Angola	25	1
Zambia	25	2
Ghana	23	1
Mozambique	22	2
Central African Republic	21	1
Liberia	17	2
Guinea	17	2

Source: Authors' calculation based on FAO (2023a)

4.1.6. Importance of vegetable oil in the diet

Vegetable oil includes 13 types of edible oils in the FAO Food Balance Sheet data, the most important of which are soybean oil and palm oil. Taken together, vegetable oils represent 9.1% of global caloric consumption, placing it third after wheat and rice. Unlike staple crops, vegetable oil consumption is relatively even distributed across the world. It is the largest source of calories in few countries (9) countries, but it is among the top five in almost all (163) (see Table 1). As shown in Table 6, the share of vegetable oils in the diet is highest in the United Arab Emirates (23%), Spain, Greece, Italy, and Taiwan (we exclude the map because the contribution exceeds 20% in just five countries). In the case of southern Europe, olive oil is the main form of vegetable oil consumed. It is notable that the ten countries where vegetable oil represents the largest share of caloric intake are middle- and high-income countries, reflecting the fact that vegetable oil is a more expensive source of calories than cereals and root crops.

Table 6. Ten countries where vegetable oil contributes the most to the diet

Country	Share of calories (%)	Rank of vegetable oil among foods in the country
United Arab Emirates	23	2
Spain	22	1
Greece	20	2
Italy	20	2
Taiwan	20	1
Jordan	19	2
Venezuela	19	1
Bulgaria	18	2
United States of America	18	1
Austria	18	1

Source: Authors' calculation based on FAO (2023a).

4.1.7. Importance of sugar in the diet

Sugar ranks fifth among the food commodities in terms of its contribution to global caloric intake. It is the most important source of calories in just two countries (Grenada and Costa Rica), but it is among the top five in 144 countries. As shown in Table 7, Central American and Caribbean countries make up six of the top ten countries in terms of the contribution of sugar to caloric intake (we exclude the map because in no country does sugar contributes more than 20% of calories). This probably reflects the fact that most of these countries are current or historical producers of sugarcane, making sugar a relatively inexpensive source of calories.

Table 7. Ten countries where sugar contributes the most to the diet

Country	Share of calories (%)	Rank of sugar among foods in the country
Guatemala	19	2
Barbados	17	2
Kiribati	16	3
Gambia	16	2
Saint Lucia	15	2
Trinidad and Tobago	15	2
Jamaica	15	2
Lebanon	15	2
Costa Rica	15	1
Jordan	15	3

Source: Authors' calculation based on FAO (2023a)

These maps and maps for nine other staple foods are available on the IFPRI Food Security Portal (IFPRI, 2023b).

4.2. Import dependence for selected staple foods

This section describes the patterns of import dependence for the 15 staple foods selected for analysis. The import dependence ratio (IDR) is calculated here as the quantity of net imports as a percentage of domestic supply, based data from the FAO Food Balance Sheet for 2020 (FAO, 2023a). The rationale for examining import dependence is that greater import dependence means there is more scope for higher world prices to be transmitted to local markets. A country that imports only a small share of domestic requirements will cease to import if the world price rises beyond a certain point, preventing further transmission of international price increases.

4.2.1. Overview

Table 8 gives some characteristics of the trade patterns for each of the 15 staple commodities. The first three columns show the percentage of the 183 countries classified as importers, self-sufficient, and exporters, based on their IDR. Importers are defined as having an IDR of at least 5%, self-sufficient countries are between -5% and +5%, and exporters have an IDR of less than –5%, meaning their exports are equivalent to 5% of domestic consumption. The last column shows the average import dependency ratio among importers.

Three results stand out. First, for every staple food, there are substantially more importing countries than exporting countries. The ratio of importers to exporters ranges from 2:1 for sorghum to 10:1 for cassava. Second, the share of self-sufficient countries varies widely. Fewer than 10% of countries are self-sufficient in wheat, rice, vegetable oil, and sugar, indicating that these commodities are widely traded. In contrast, more than 60% of countries are self-sufficient in sorghum, millet, cassava, sweet potatoes, and yams, indicating that international trade is limited. The pulses (beans, groundnuts, and soybeans) are in an intermediate position. Third, the average import dependency ratio follows the same pattern, with the average IDR being above 60% for wheat, rice, vegetable oil, and sugar and below 30% for sorghum, millet, cassava, sweet potatoes, and yams.

Table 8. Trade indicators for the 15 staple foods used in the vulnerability index

	Trade position of countries			Average import dependence ratio
	Importing countries	Self-sufficient countries	Exporting countries	
Staple food	(% of countries)	(% of countries)	(% of countries)	(% of domestic supply)
Wheat	84	2	14	79
Rice	81	7	12	72
Maize	67	19	14	51
Sorghum	21	69	9	18
Millet	27	67	5	25
Beans	53	36	11	45
Groundnuts	58	31	11	54
Soybeans	50	39	11	46
Cassava	30	67	3	28
Potatoes	63	27	9	41
Sweet potatoes	23	72	4	24
Yams	11	87	2	12
Sugar	73	4	23	78
Vegetable oil	75	7	19	62

Source: Calculated from the FAO Food Balance Sheet for 2020 (FAO, 2023a).

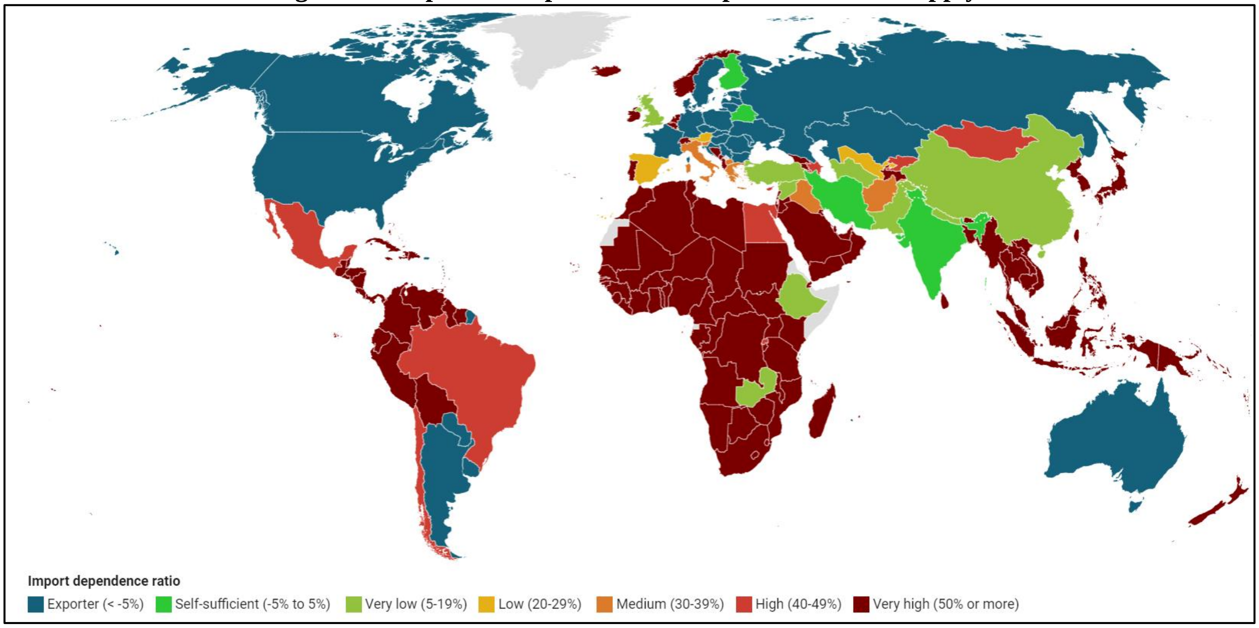
Note: Importing countries are defined as those with net imports that are at least 5% of domestic supply. Self-sufficient countries are those with an import dependence between -5% and 5%. Exporting countries are those with net exports are at least 5% of domestic supply. The last column excludes exporters.

In the sections below, we review the patterns of import dependence for six staple foods: wheat, rice, maize, cassava, vegetable oil, and sugar. These maps and maps for nine other staple foods are available on the IFPRI Food Security Portal (IFPRI, 2023b).

4.2.2. Import dependence on wheat

Figure 5 shows the international pattern of import dependence for wheat and wheat products. Almost all of sub-Saharan Africa, Central America, and the Andean countries of South America are highly dependent on wheat imports. The map shows that all these countries import more than 50% of their requirements, but in fact most of the countries listed import 95-100% of their wheat needs. In fact, 65 countries rely on imports for 100% of their wheat needs, and another 24 countries import 90-99% of their needs. This is not surprising given the fact that wheat grows best in cooler temperatures, so it is only economical in tropical latitudes if grown at high altitude (as in Kenya and Ethiopia). At the other extreme, 26 countries have net exports of wheat, including Canada, the United States, Argentina, Russia, Ukraine, and Australia. These countries are not vulnerable to higher international wheat prices, and, in fact, benefit from them.

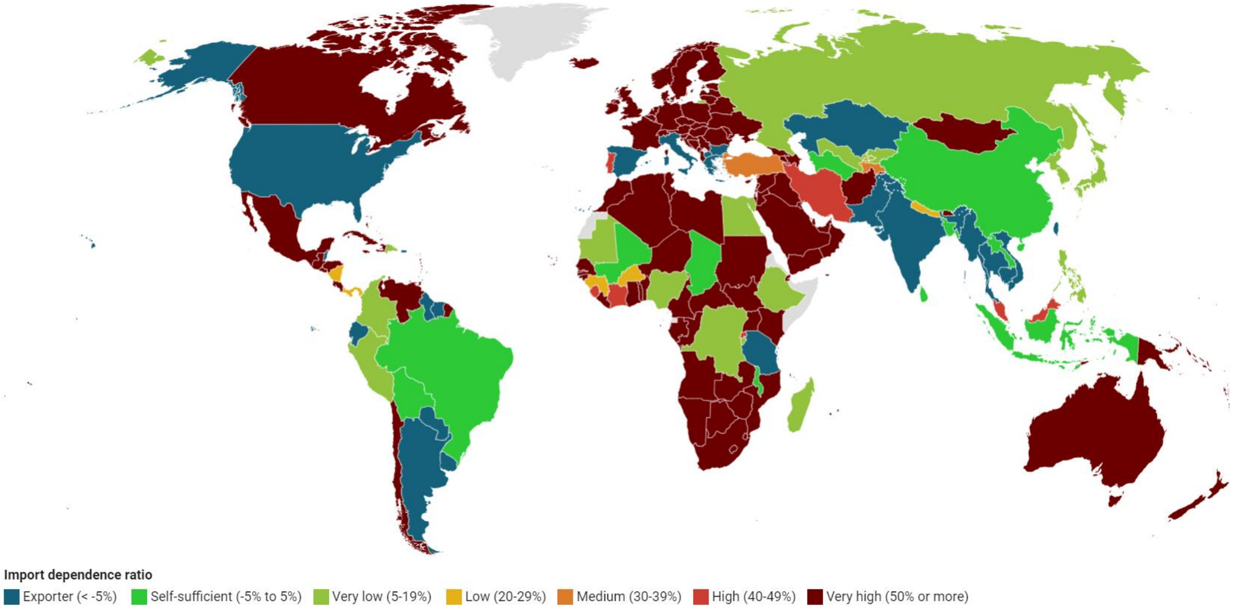
Figure 5. Map of the dependence on imports for wheat supply



4.2.3. Import dependence on rice

As shown in Figure 6, most countries are dependent on imports for rice. Some 74 countries depend on imports for 100% of their rice consumption, implying no local production. Canada, Mexico, northern Europe, and most of sub-Saharan Africa, North Africa, and Southwest Asia rely on imports for over half of consumption requirements. Only a few countries have medium dependence on rice imports (30-39%), such as Turkey and Tajikistan. Eighteen countries have a low level of dependence on rice imports (5-20%), including Colombia, Peru, several West African nations, Nigeria, Egypt, Ethiopia, Madagascar, and Russia. These are countries with significant domestic production but not enough to meet local demand. Brazil, China, Mali, Chad, and Indonesia are close to self-sufficient, meaning that they have net imports or net exports that are less than 5% of domestic consumption. Twenty-one countries had net exports of rice in 2020 representing at least 5% of domestic consumption. These include the United States, Argentina, several countries in southern Europe, Tanzania, most of South Asia, and most of Southeast Asia. Overall, these countries benefit from higher rice prices on the international market.

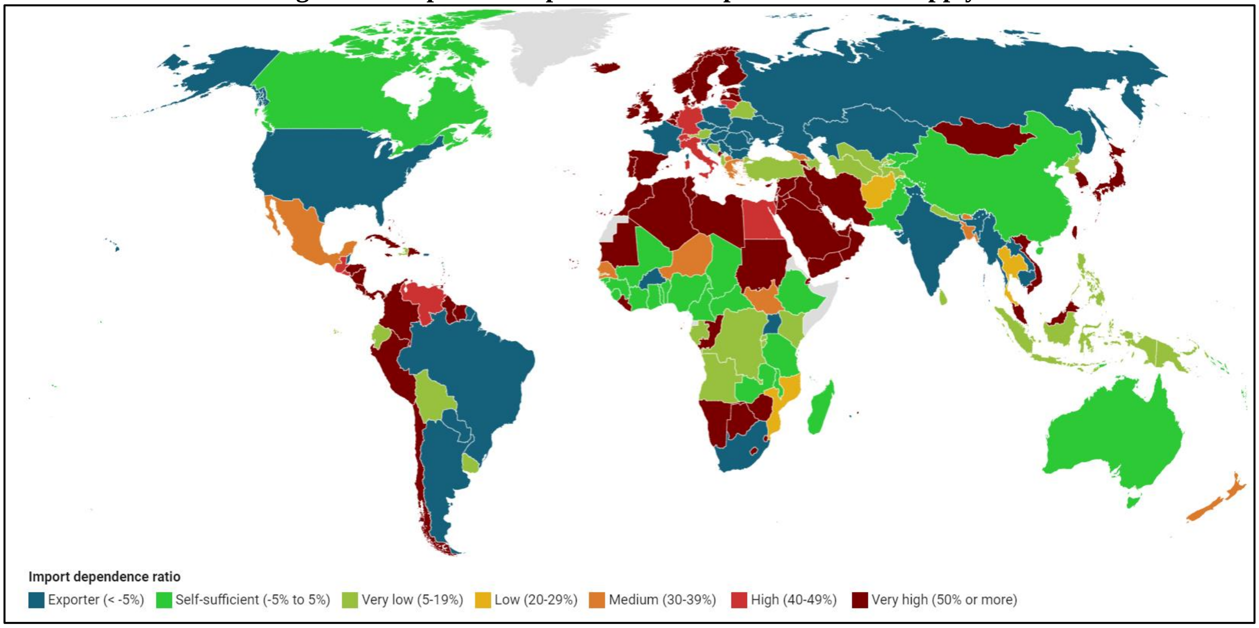
Figure 6. Map of the dependence on imports for rice supply



4.2.4. Import dependence on maize

Maize is grown in more countries than either wheat or rice, largely because it can be cultivated in a wider range of agroecological conditions. Only 31 countries rely on imports for 100% of their maize requirements. As shown in Figure 7, countries that are highly dependent on maize imports include Colombia, Peru, northern Europe, North Africa, Southwest Asia, and Japan. Much of sub-Saharan Africa has either a low level of maize import dependence (the D.R. Congo, Angola, and Mozambique) or near self-sufficiency (most of West Africa, Ethiopia, Tanzania, Zambia, and Madagascar). An exception is three southern African countries, Namibia, Botswana, and Zimbabwe, which are heavily dependent on maize imports. This is largely due to the semi-arid conditions in Namibia and Botswana and economic instability in Zimbabwe. Outside Africa, Canada, Pakistan, China, and Australia are near self-sufficient in maize. There were 29 maize exporters in 2020, including the United States, Brazil, Argentina, South Africa, Russia, and India. These countries benefit from higher world prices of maize.

Figure 7. Map of the dependence on imports for maize supply



4.2.5. Import dependence on cassava

The map of import dependence for cassava looks quite different than the maps for wheat, rice, and maize (see Figure 8). Rather than a patchwork of various colors, a large majority of countries are either highly dependent on imports (red) or close to self-sufficient in cassava (green). The self-sufficient countries are found in the tropics and sub-tropics of South America, Africa, and Asia. In contrast, most of the import-dependent countries are concentrated in the northern temperate zone (Canada, United States, northern Europe, Russia and China) or in the southern temperate zone (Chile, South Africa, and Australia).

This pattern is the result of two facts. First, cassava grows best in the warm tropics. Second, fresh cassava is perishable, making international trade in the commodity costly and rare. As a result, most cassava tends to be consumed in tropical and sub-tropical countries where it is produced. The "import dependence" of the temperate latitude countries is misleading: in most cases, cassava represents a negligible share of the diet. For example, in South Africa and Burkina Faso, which have import dependence ratios of 100%, cassava accounts for less than 0.1% of the caloric intake.

A few countries export cassava, such as Thailand, Vietnam, and several Central American countries. These exports consist primarily of processed cassava used as animal feed. The FAO trade data do not allow us to distinguish between cassava destined for human and animal consumption.

Figure 8. Map of the dependence on imports for cassava supply

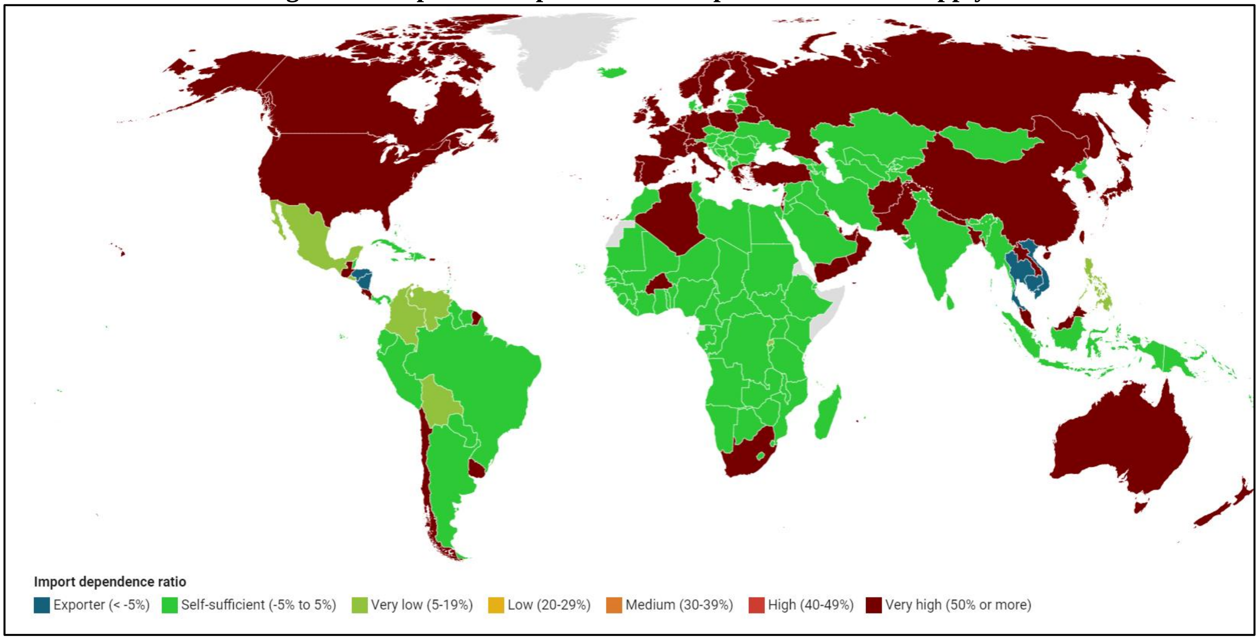
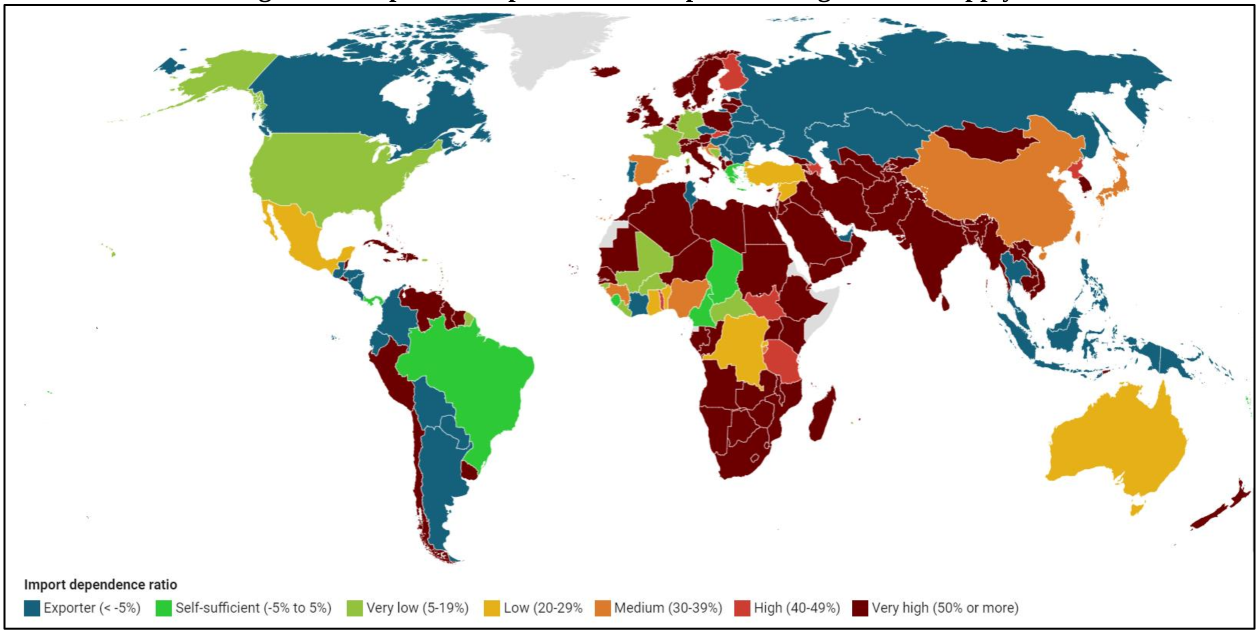


Figure 9. Map of the dependence on imports for vegetable oil supply



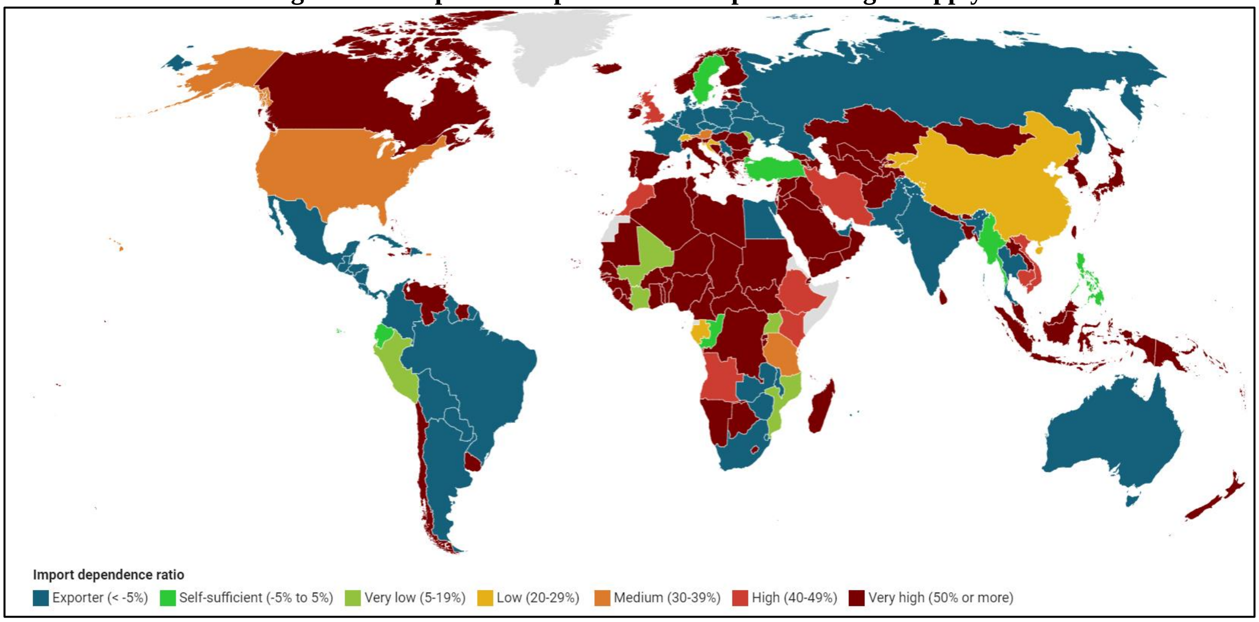
4.2.6. Import dependence on vegetable oil

As shown in Figure 9, most countries (56%) import more than half of their domestic requirements of vegetable oil. This includes much of Africa, Southwest Asia, northern Europe, and Southeast Asia, as well as India. Exporters of vegetable oil include Canada, nine Latin American nations, Eastern Europe, Russia, and parts of Southeast Asia. The type of oil exported varies by region. Argentina and Brazil are important exporters of soybean oil, Indonesia and Malaysia account for a large share of palm oil exports, and Canada is the largest exporter of rapeseed (canola) oil.

4.2.7. Import dependence on sugar

Most countries (61%) rely on imports for at least half of their domestic sugar consumption (see Figure 10). This includes Canada and parts of Europe, North Africa, and Southwest Asia. The main sugar exporters are Brazil, India, Thailand, and Australia, but others include Caribbean nations, Central America, Mexico, Uganda, South Africa, Zimbabwe, and Egypt. While most sugar exports are produced from sugar cane, sugar exports from Europe and Russia are derived from sugar beets.

Figure 10. Map of the dependence on imports for sugar supply



In this section, we reviewed the maps of import dependence for six major food commodities. These maps and those for nine other staple foods are available on the IFPRI Food Security Portal (IFPRI, 2023b).

4.3. Food insecurity

This section describes the spatial patterns in moderate and severe food insecurity, the third component in our food import vulnerability index. As discussed earlier, the FAO has estimated the share of the population experiencing moderate or severe food insecurity (MFI) using survey data that are part of the Gallup World Poll for nationally representative samples and on the basis of which it calculates the Food Insecurity Experience Score for each country covered (Cafiero et al., 2018). The FAO provides estimates MFI for 142 countries in 2020. For the other 41 countries in our database, we interpolate the value of MFI using data on per capita gross domestic product, the prevalence of undernourishment, the Gini coefficient of inequality and the incidence of poverty (see Appendix A).

As shown in Table 9, the ten countries with the highest share of the population experiencing food insecurity are almost all in sub-Saharan Africa, the only exception being Haiti. In these countries, more than three-quarters of the population are estimated to be moderately or severely food insecure, according to estimates by the FAO (2023a).

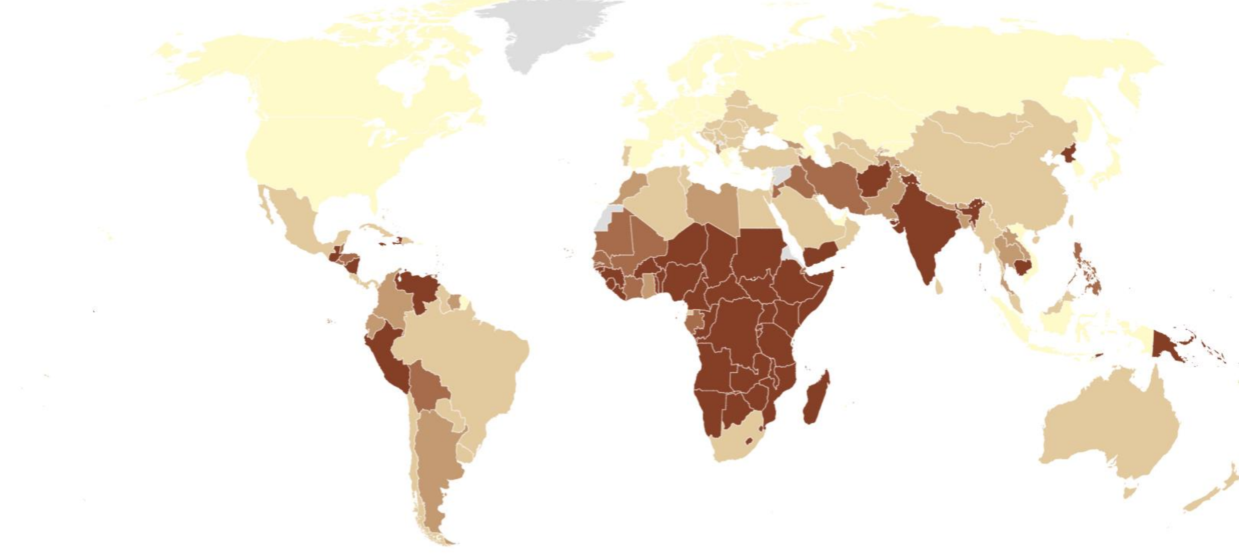
Table 9. Ten countries with highest share of food insecure

Country	Share of population experiencing moderate or severe food insecurity (%)
Congo	89
Sierra Leone	87
South Sudan	86
Haiti	82
Malawi	81
Central African Republic	81
Liberia	81
Comoros	80
Angola	78
Guinea-Bissau	75

Source: Authors' calculations based on data from FAO (2023a).

Figure 13 shows the global patterns in food insecurity. In Latin America and the Caribbean, only a few countries have food insecurity rates of 50% or more, including Haiti, Nicaragua, Honduras, Venezuela, and Peru. In sub-Saharan Africa, on the other hand, most countries fall in this category, the exceptions being South Africa, Gabon, Equatorial Guinea, and several West African nations. In Asia, the most food insecure countries are Yemen, North Korea, and Afghanistan, where more than 70% of the population is considered food insecure. Other Asian countries with rates over 50% include Papua New Guinea, India, and Cambodia.

Figure 11. Map of the share of the population experiencing moderate or severe food insecurity



4.4. Food Import Vulnerability Index

This section describes the results of our food import vulnerability index (FIVI). As discussed in Section 3, the commodity-level index is the geometric mean of three components: the share of calories derived from the commodity, the share of the domestic supply of the commodity from imports, and the proportion of the population that is food insecure. First, we present an overview of the results for all 15 staple foods covered in this analysis. Then, we examine more closely the patterns in import vulnerability for the six most important commodities: wheat, rice, maize, cassava, vegetable oil, and sugar. Finally, we describe the results of the national food import vulnerability index, a measure of vulnerability to world price increases of all 15 key food commodities.

4.4.1. Overview

To facilitate mapping and interpretation, the FIVI score is divided into seven categories. The first category consists of exporters of the commodity, who are not considered vulnerable to higher world prices[2]. The other six categories consist of different levels of vulnerability depending on the FIVI score: negligible (FIVI of 0 to 9%), very low (10-19%), low (20-29%), medium (30-39%), high (40-49%), and very high (50% or more).

Table 10 shows the share of countries in each vulnerability category for each of the 15 commodities. The proportion of countries that are vulnerable varies substantially across commodities. In the case of wheat,

[2] Even in an exporting country, some poor households are net buyers of the commodity and are adversely affected by higher prices. However, the aggregate effect on poverty is likely to be muted by the large number of surplus farmers. One study of Vietnam estimated that rice prices have a negligible effect on poverty due to these offsetting effects (Minot and Goletti, 1998).

almost half of the countries (46% or 85 countries) are in the medium, high, or very high categories. Similarly, for rice and maize the share of countries in these three categories is 24% and 8%, respectively. A significant number of countries are in these vulnerable categories for sugar (18%) and vegetable oil (22%). In the case of sorghum, by contrast, just one country (South Sudan) is in the medium vulnerability category, and no country falls into the high and very high vulnerability categories. Furthermore, no country is in the medium, high, and very high vulnerability categories for millet, beans, groundnuts, soybeans, cassava, potatoes, sweet potatoes, yams, and plantains. The reason is that these commodities rarely account for a large share of the caloric intake of the country (see Section 4.1), and when they do, imports only account for a small share of domestic supply (see Section 4.2).

The last column of Table 10 shows the average food import vulnerability index (FIVI) for each commodity. Not surprisingly, the average FIVI score is highest for wheat (27), rice (20), vegetable oil (19), sugar (18), and maize (12). For the other ten commodities, the average FIVI score is much lower, ranging from 0.2 for yams and 6.8 for potatoes.

Table 10. Distribution of countries by vulnerability category and average FIVI score

	Import vulnerability category (% of countries)								Average FIVI score
	Exporter	Negligible (0-9%)	Very low (10-19%)	Low (20-29%)	Medium (30-39%)	High (40-49%)	Very high (>=50%)	Total	
Wheat	14.2	0.6	14.2	24.6	29.0	14.2	3.3	100.0	26.8
Rice	12.6	18.6	23.5	21.9	13.1	6.6	3.8	100.0	19.7
Maize	16.9	36.1	27.3	11.5	4.4	2.2	1.6	100.0	11.7
Sorghum	12.6	82.5	4.4	0.0	0.6	0.0	0.0	100.0	1.3
Millet	9.3	90.7	0.0	0.0	0.0	0.0	0.0	100.0	0.5
Beans	14.2	72.7	12.0	1.1	0.0	0.0	0.0	100.0	4.3
Groundnuts	13.7	74.3	12.0	0.0	0.0	0.0	0.0	100.0	4.5
Soybeans	12.6	82.5	4.9	0.0	0.0	0.0	0.0	100.0	2.1
Cassava	9.3	89.6	0.0	1.1	0.0	0.0	0.0	100.0	1.3
Potatoes	15.9	60.7	23.0	0.6	0.0	0.0	0.0	100.0	6.8
Sw. potatoes	11.5	88.5	0.0	0.0	0.0	0.0	0.0	100.0	0.6
Yams	5.5	94.5	0.0	0.0	0.0	0.0	0.0	100.0	0.2
Plantains	7.7	90.7	1.6	0.0	0.0	0.0	0.0	100.0	1.3
Sugar	24.0	5.5	23.0	29.5	15.9	2.2	0.0	100.0	18.1
Veg. oil	19.7	4.4	28.4	25.7	18.6	3.3	0.0	100.0	18.9
Total	13.3	59.5	11.6	7.7	5.4	1.9	0.6	100.0	7.9

Source: Authors' calculations based on data from FAO (2023a), FAO (2023b), and World Bank (2023).

In light of the results in Table 10, the following sections focus on the patterns of the FIVI score for wheat, rice, maize, cassava, sugar, and vegetable oil. Cassava is included because it is relatively important as a source of calories and to illustrate the patterns for low-vulnerability staple foods.

4.4.2. Vulnerability to higher wheat prices

The fifteen countries that are most vulnerable to increases of world wheat prices are shown in Table 11, along with the components used to calculate the index. The most vulnerable country, according to this measure, is Yemen, with a FIVI score of 70. This is because almost half the calories consumed by Yemeni households are from wheat and wheat products, virtually all wheat is imported, and a large share of the population is food insecure. Some countries, like Afghanistan, are on the list because the diet relies heavily on wheat and food insecurity is widespread, even though the import dependence is modest. Other countries, like the Congo and Haiti, do not rely heavily on wheat in the diet, but the vulnerability index is high because almost all wheat is imported and a large share of the population is food insecure.

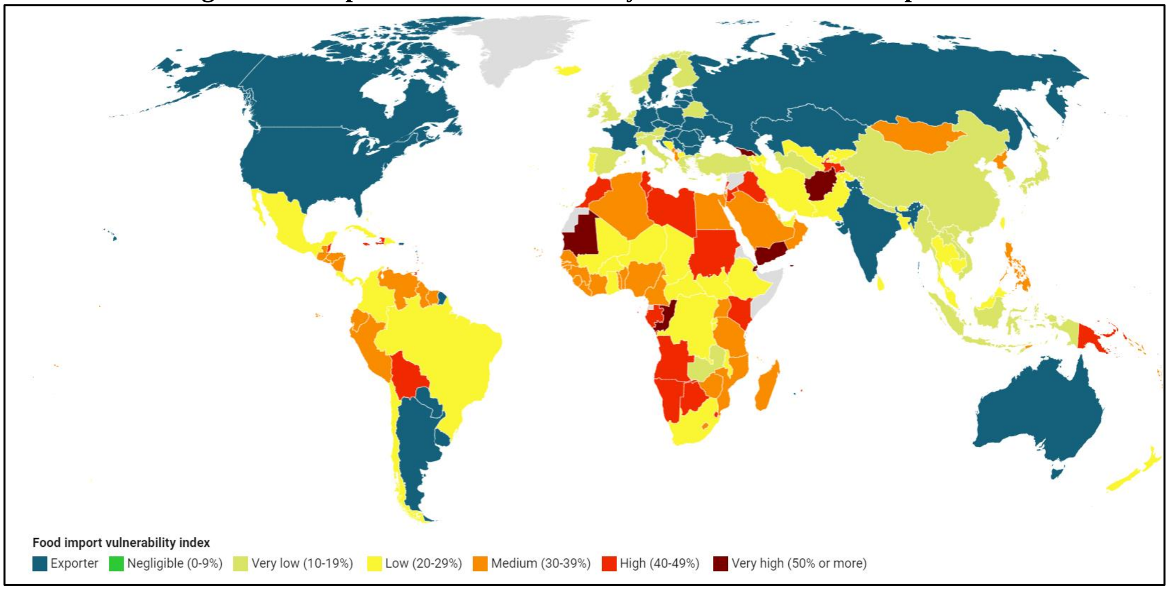
Table 11. Fifteen countries with highest index of vulnerability to wheat price increases

Country	Share of wheat in total calories (%)	Import dependency ratio for wheat (%)	Share of population that is food insecure (%)	Wheat import vulnerability index
Yemen	46	99	73	70
Djibouti	33	100	49	54
Afghanistan	62	37	70	54
Mauritania	32	100	45	53
Georgia	40	84	39	51
Congo	15	97	89	51
Libya	36	86	39	50
Jordan	29	97	43	50
Sao Tome and Principe	21	100	55	48
Haiti	13	100	82	47
Trinidad and Tobago	25	95	43	47
Tajikistan	44	56	39	46
Namibia	18	89	58	46
Sudan	23	80	51	45
Botswana	17	100	56	45

Source: Authors' calculations based on data from FAO (2023a) and World Bank (2023).

Figure 13 shows the global patterns in vulnerability to higher world prices of wheat. The countries shaded in blue are exporters, so they are not vulnerable and may benefit from higher wheat prices, at least in the aggregate. These countries are mainly in the northern and southern high latitudes where wheat grows well. The green, yellow, and orange-shaded countries are low or moderate vulnerability to spikes in world wheat prices. The countries marked in red and dark red are those with high vulnerability, that is, a FIVI score of 40% or more. These include Bolivia, several countries in North Africa and southwest Africa, Sudan, Yemen, Georgia, Afghanistan, and Papua New Guinea.

Figure 12. Map of index of vulnerability to international wheat price increases



4.4.3. Vulnerability to higher rice prices

Turning our attention to vulnerability to higher rice prices, Table 12 shows the fifteen countries with the highest FIVI score. Liberia is the most vulnerable as a result of the fact that rice is an important component in the diet (contributing almost half of caloric intake), the country depends on imports for most of its supply (61%), and a large proportion of the population is food insecure (81%). Among the top ten most vulnerable countries are four other West African nations: the Gambia, Guinea-Bissau, Sierra Leone, and Benin. Others on the list include Mozambique, Haiti, Djibouti, Bhutan, and six small island nations.

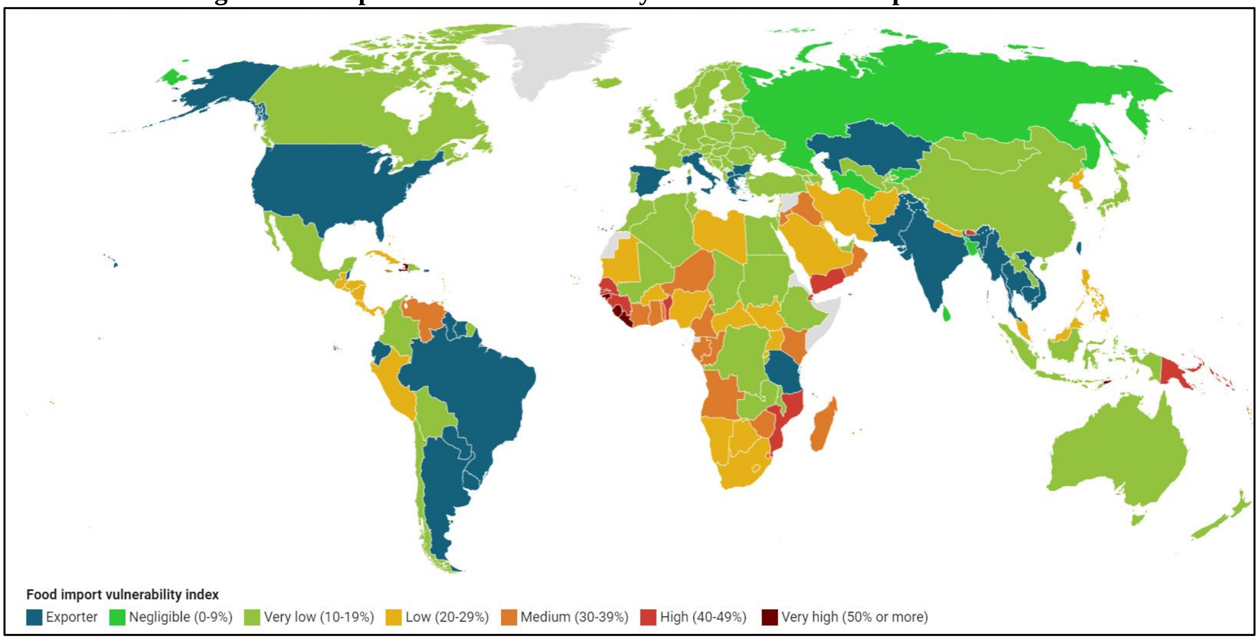
Table 12. Fifteen countries with highest index of vulnerability to rice price increases

Country	Share of rice in total calories (%)	Import dependency ratio for rice (%)	Share of population that is food insecure (%)	Rice import vulnerability index
Liberia	47	61	81	61
Gambia	36	100	58	59
Guinea-Bissau	46	60	75	59
Comoros	35	70	80	58
Haiti	27	82	82	57
Timor-Leste	33	79	65	56
Sierra Leone	42	43	87	54
Benin	20	80	68	47
Bhutan	37	78	37	47
Solomon Islands	21	83	56	46
Kiribati	23	100	41	46
Sao Tome and Principe	17	100	55	46
Djibouti	19	100	49	45
Mozambique	12	100	74	44
Micronesia	18	100	48	44

Source: Authors' calculations based on data from FAO (2023a) and World Bank (2023).

The global patterns in vulnerability to higher rice prices are shown in Figure 13. The Western Hemisphere has a number of exporters, including the United States, Brazil, and Argentina, and countries with negligible vulnerability, including Canada, Mexico, Colombia, and Chile. Haiti is the only country in this region with very high or high FIVI score. In sub-Saharan Africa, the vulnerability to rice price shocks is high or very high in Mozambique and five West African nations. In Asia, there are some major exporters, including India, Vietnam, and some other Southeast Asian countries. At the same time, the region has some highly vulnerable rice importers including Yemen, Bhutan, Papua New Guinea, and Timor Leste. Rice plays a large role in the diets in China, South Korea, Indonesia, Malaysia, and the Philippines, but the vulnerability to international price shocks is very low or low because the import dependency of these countries is modest.

Figure 13. Map of index of vulnerability to international rice price increases



4.4.4. Vulnerability to higher maize prices

In this section, we examine vulnerability to higher international prices of maize. According to the FIVI score, the country most vulnerable to higher maize prices in Zimbabwe, where maize accounts for about one-third of caloric intake, import dependence is 72%, and food insecurity affects an estimated 73% of the population. It should be noted that maize trade in Zimbabwe and elsewhere in southern Africa fluctuates from year to year. For example, over 2016-20 Zimbabwe's import dependency for maize varied between 6 and 72%, averaging 34% (FAO, 2023a).

Southern African countries account for six of the 15 countries most vulnerable to higher world maize prices, and Central American nations represent another four. Others on the list include Mexico, Colombia, and Venezuela.

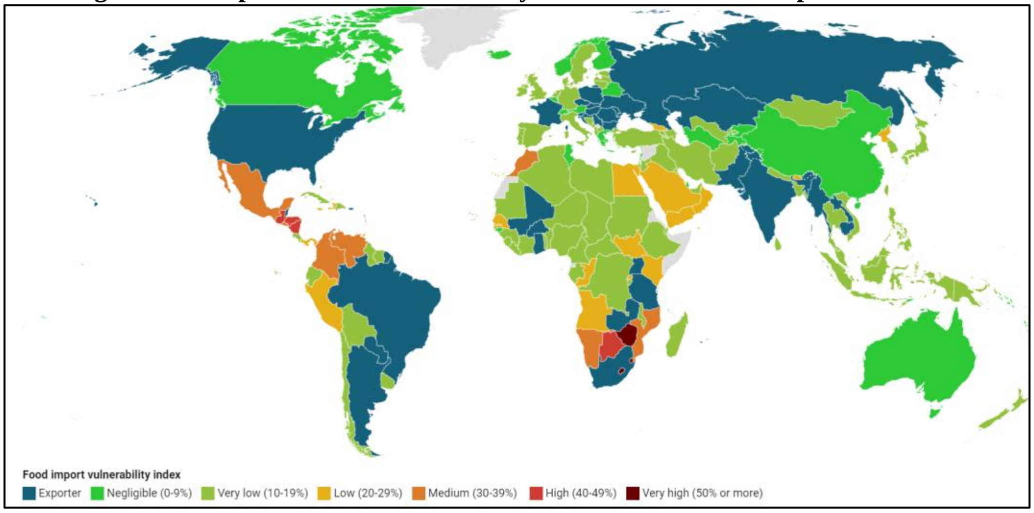
Table 13. Fifteen countries with highest index of vulnerability to maize price increases

Country	Share of maize in total calories (%)	Import dependency ratio for maize (%)	Share of population that is food insecure (%)	Maize import vulnerability index
Zimbabwe	34	72	73	57
Lesotho	47	70	54	56
Eswatini	27	85	67	54
Botswana	26	82	56	49
Guatemala	32	43	56	43
Honduras	28	54	50	42
Nicaragua	22	60	55	42
Cabo Verde	17	100	35	39
Namibia	15	64	58	39
El Salvador	30	41	46	38
Venezuela	14	47	65	35
Mozambique	24	21	74	34
Morocco	11	100	32	32
Colombia	10	80	33	30
Mexico	32	33	26	30

Source: Authors' calculations based on data from FAO (2023a) and World Bank (2023).

The global pattern of vulnerability to higher maize prices is shown in Figure 14. Exporters are not vulnerable to higher maize prices and may benefit. These include the United States, Brazil, Argentina, Russia, Ukraine, South Africa, Zambia, Tanzania, Uganda, and India. China, Canada, and Australia have negligible vulnerability, either because they are close to self-sufficiency, have modest consumption of maize, or import only a small share of domestic requirements. Most of sub-Saharan Africa (outside southern Africa) has very low or low vulnerability to maize price spikes. Although food insecurity is relatively high, most of these countries are close to self-sufficient in maize production. Similarly, much of Southeast Asia has very low vulnerability because maize is a modest part of the diet.

Figure 14. Map of index of vulnerability to international maize price increases



4.4.5. Vulnerability to higher cassava prices

The countries with the greatest vulnerability to higher cassava prices are shown in Table 14. As mentioned in Section 4.4.1, the vulnerability scores for cassava are quite low. For wheat, rice, and maize, the FIVI scores for the top 15 countries ranged between 30 and 70. However, in the case of cassava, the import vulnerability scores of the top 15 countries ranges between 5 and 24. Although many countries on the list have a large share of food insecure people, cassava is much less important in the diet (0-32%) and just five countries on the list import more than 20% of their domestic consumption needs. Rwanda and the Lao P.D.R are the only countries with a vulnerability index of more than 20. Although the diet in Burundi is dependent on cassava, imports represent less than 1% of domestic supply.

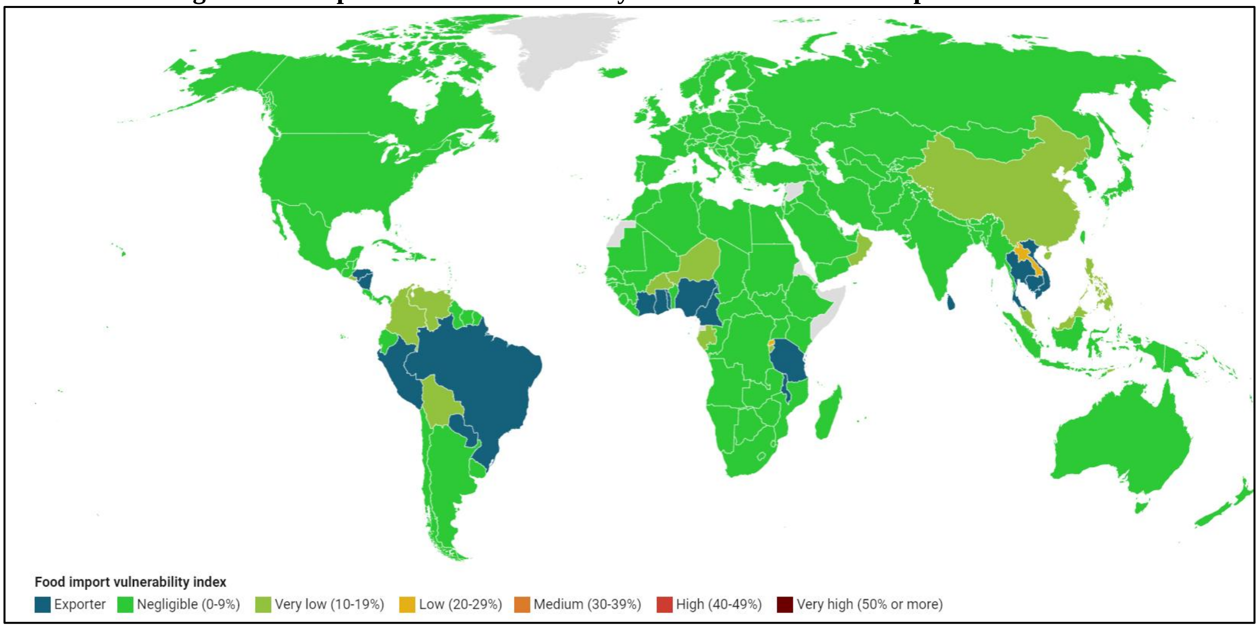
Table 14. Fifteen countries with highest index of vulnerability to cassava price increases

Country	Share of cassava in total calories (%)	Import dependency ratio for cassava (%)	Share of population that is food insecure (%)	Cassava import vulnerability index
Rwanda	14	14	73	24
Lao P.D.R.	3	100	32	20
Bolivia	1	14	47	9
Burundi	32	0	52	9
Philippines	1	17	44	8
Timor-Leste	2	4	65	8
Gabon	8	1	48	8
Niger	2	3	59	7
Venezuela	1	5	65	7
Burkina Faso	0	74	53	6
Colombia	1	5	33	6
Malaysia	0	85	15	6
Oman	0	100	29	5
China	0	84	11	5
El Salvador	0	10	46	5

Source: Authors' calculations based on data from FAO (2023a) and World Bank (2023).

The map in Figure 15 shows the international pattern in vulnerability to higher cassava prices. Given the results presented in the table above, it is not surprising that most of the countries in the world are either exporters (blue) or face only negligible vulnerability to higher cassava prices (light green). Rwanda and the Lao P.D.R. are the only countries facing even low vulnerability to higher international prices (an index of 20 or higher). No country faces medium or higher levels of vulnerability to higher cassava prices.

Figure 15. Map of index of vulnerability to international cassava price increases



4.4.6. Vulnerability to higher sugar prices

There is not much cross-country variation in the share of calories derived from sugar – in over three-quarters of the countries, sugar accounts for between 5 and 15% of caloric intake. As a result, the level of vulnerability depends largely on import dependence and the prevalence of food insecurity. Gambia, Yemen, and Haiti have the highest FIVI scores for sugar. However, the index does not vary much across countries, ranging from 36 to 45 across the 15 most vulnerable countries (see Table 15).

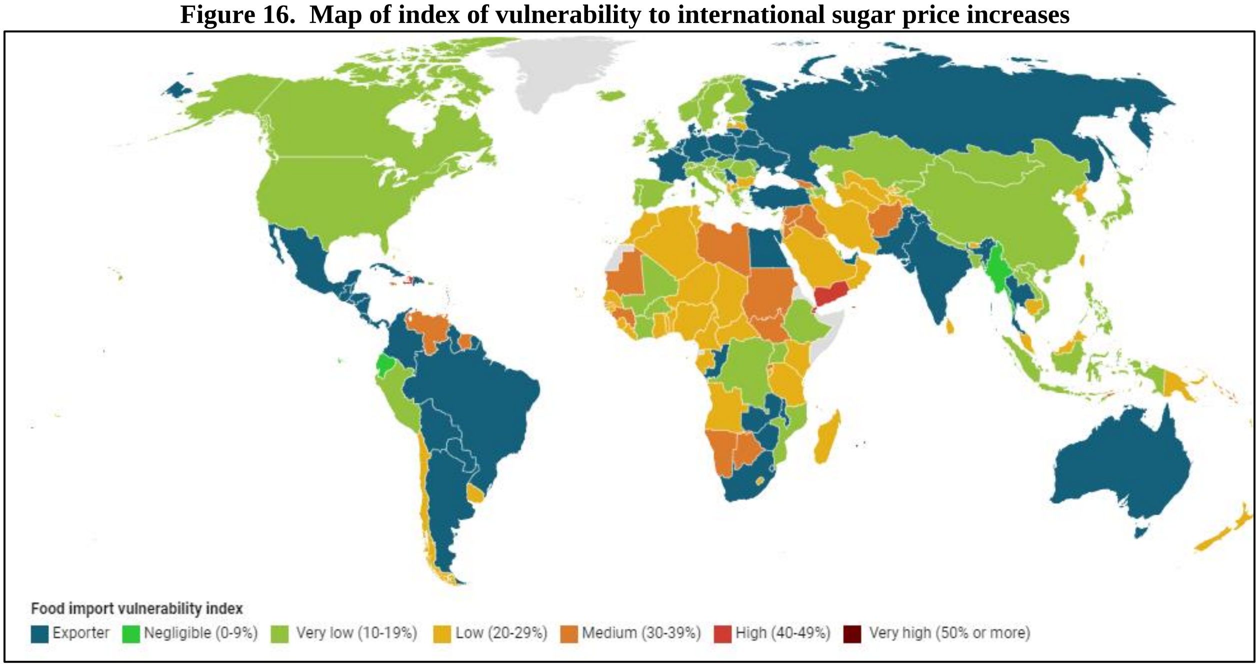
The international pattern is shown in Figure 16. Exporters include most of Latin America, much of Europe, Russia, India, and Australia, as well as Egypt and three countries in southern Africa. Countries with low and medium vulnerability are concentrated in sub-Saharan Africa, North Africa, and Southwest Asia. Five countries have high vulnerability to sugar price spikes (a FIVI score of 40 to 49), as shown in the table, but no country experiences very high vulnerability (a score over 50), largely because the caloric contribution of sugar is always less than 20%.

Table 15. Fifteen countries with highest index of vulnerability to sugar price increases

Country	Share of sugar in total calories (%)	Import dependency ratio for sugar (%)	Share of population that is food insecure (%)	Sugar import vulnerability index
Gambia	16	100	58	45
Yemen	12	100	73	44
Haiti	10	91	82	43
Djibouti	13	100	49	40
Trinidad and Tobago	15	97	43	40
Jordan	15	100	43	40
Mauritania	13	100	45	39
Kiribati	16	83	41	38
Saint Lucia	15	100	35	38
Namibia	9	100	58	38
Sudan	10	100	51	37
Botswana	9	100	56	37
Timor-Leste	8	100	65	37
Venezuela	14	56	65	37
Suriname	14	92	36	36

Source: Authors' calculations based on data from FAO (2023a) and World Bank (2023).

Figure 16. Map of index of vulnerability to international sugar price increases



4.4.7. Vulnerability to higher vegetable oil prices

The degree of vulnerability to higher vegetable oil prices is considerably higher than for cassava and almost as high as maize. As shown in Table 16, vegetable oil rarely accounts for more than 20% of caloric intake, but many countries are highly dependent on imports. According to the FIVI scores, Congo is the most vulnerable to higher world prices of vegetable oil. However, the difference in vulnerability among the top 15 countries is quite modest: the vulnerability score ranges between 37 and 45. About half the countries on the list are in sub-Saharan Africa. The others are split between Asia (e.g. Yemen and Timor-Leste) and Latin America and the Caribbean (e.g. Venezuela and Haiti).

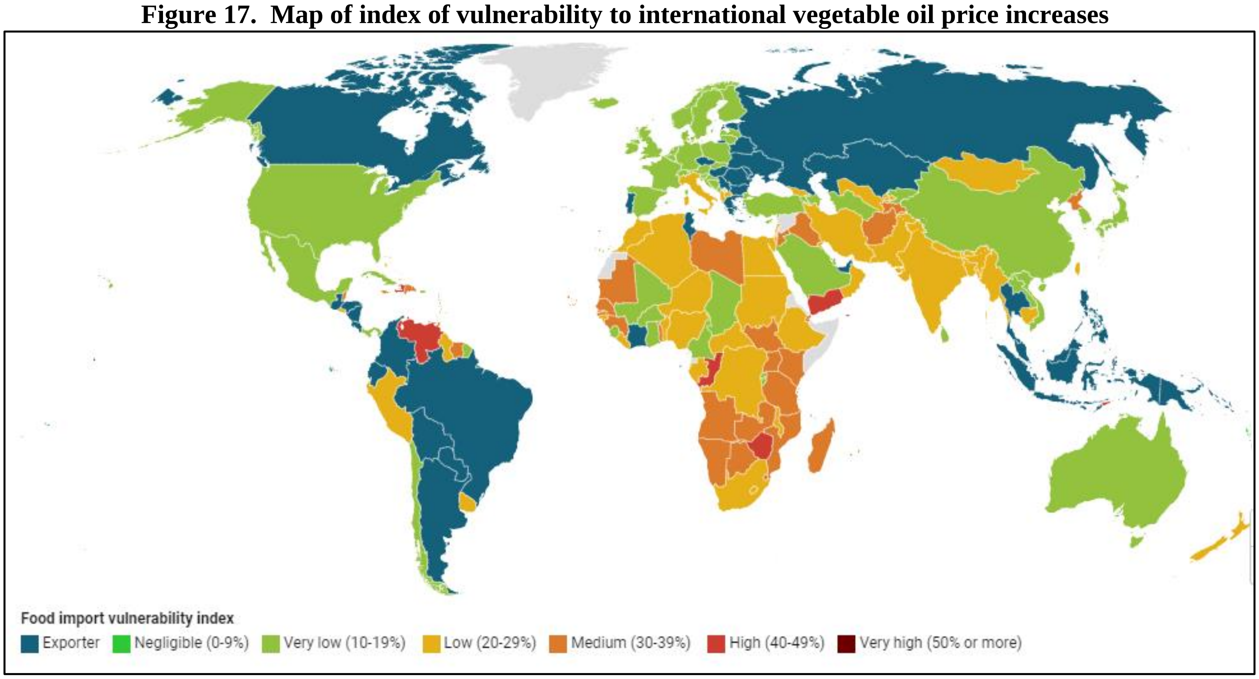
The international pattern in vulnerability to higher vegetable oil prices is shown in Figure 17. As discussed earlier, vegetable oil exporters are concentrated in Canada (mostly rapeseed oil), South America (mostly soybean oil), Russia (mostly sunflower oil), and Southeast Asia (mostly palm oil). Vulnerability to higher prices is very low in the United States, western Europe, China, and Australia. The highest vulnerability is concentrated in Africa, Southwest Asia, and South Asia.

Table 16. Fifteen countries with highest index of vulnerability to vegetable oil price increases

Country	Share of vegetable oil in total calories (%)	Import dependency ratio for vegetable oil (%)	Share of population that is food insecure (%)	Vegetable oil import vulnerability index
Congo	14	74	89	45
Zimbabwe	14	79	73	43
Yemen	10	100	73	42
Timor-Leste	11	100	65	41
Venezuela	19	55	65	41
Haiti	8	99	82	41
Comoros	11	71	80	40
Jordan	19	77	43	40
Djibouti	13	100	49	40
Botswana	11	100	56	39
Iraq	12	100	49	39
Mozambique	10	82	74	39
Uganda	9	86	72	38
Angola	12	55	78	37
Kenya	9	82	70	37

Source: Authors' calculations based on data from FAO (2023a) and World Bank (2023).

Figure 17. Map of index of vulnerability to international vegetable oil price increases



4.4.8. Vulnerability to staple food price increases

Thus far, we have focused on the vulnerability to world price increases in individual commodities. In this section, we examine vulnerability to all 15 key staple foods. As discussed in Section 3, the national food import vulnerability index (FIVI) is the geometric mean of a) the share of calories from the 15 staple foods that is imported and b) the share of the population that experiences moderate or severe food insecurity. Thus, it takes into consideration all three components in the commodity index: the importance of each commodity in the diet, the import vulnerability of each commodity, and the prevalence of food insecurity in the country.

Table 17 shows the 15 countries facing the highest vulnerability to spikes in international food prices according to our national FIVI score. Yemen is the most vulnerable with a national FIVI score of 84. This reflects the fact that almost all (96%) of the calories derived from the 15 key staple foods are imported and the prevalence of food insecurity is high (73%). Nine of the 15 countries are in sub-Saharan Africa. Others include Haiti, Venezuela, Trinidad and Tobago, Jordan, and Timor-Leste. All these countries are heavily dependent on imports for their food supply: only Liberia has an import dependence under 50%. And most of them have a high prevalence of food insecurity: only in Djibouti and Jordan is less than half the population facing food insecurity.

Table 17. Fifteen countries with highest index of vulnerability to staple food price increases

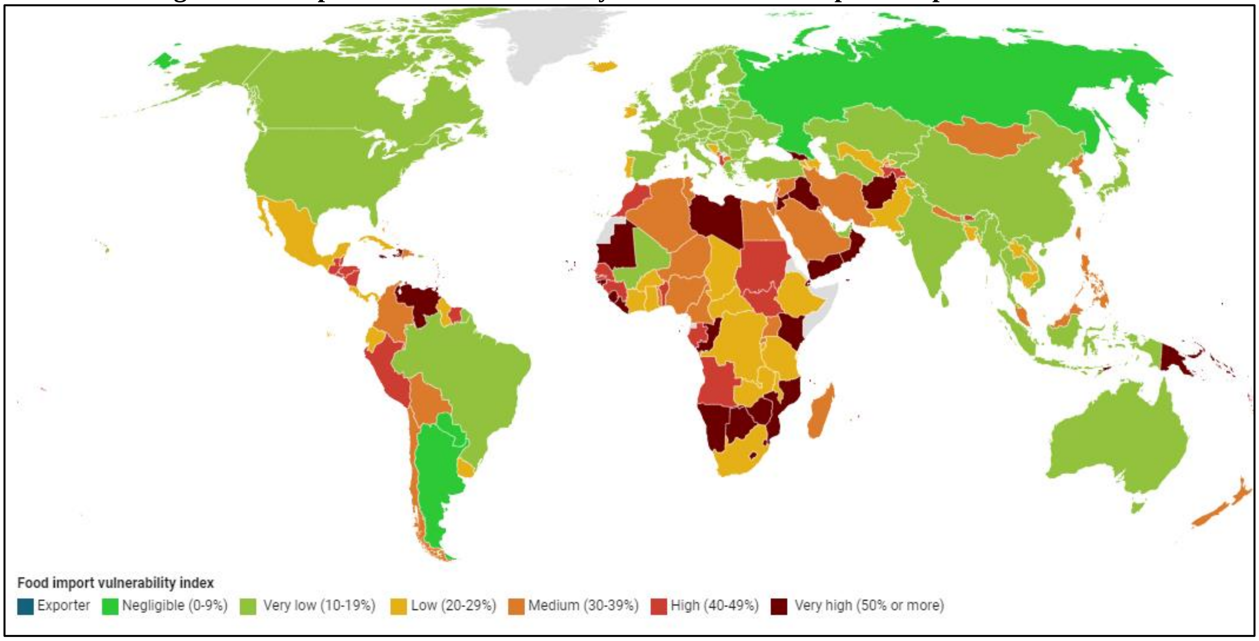
Country	Share of staple calories imported (%)	Share of population that is food insecure (%)	National food import vulnerability index
Yemen	96	73	84
Haiti	71	82	76
Eswatini	76	67	71
Botswana	91	56	71
Comoros	63	80	71
Djibouti	99	49	70
Zimbabwe	65	73	69
Namibia	76	58	67
Gambia	74	58	66
Trinidad and Tobago	96	43	65
Timor-Leste	63	65	64
Jordan	91	43	63
Lesotho	69	54	61
Venezuela	57	65	61
Liberia	44	81	59

Source: Authors' calculation based on FAO (2023a) and World Bank (2023)

The map of the global patterns in the national food import vulnerability index (FIVI) is shown in Figure 18. It is worth noting that it is not possible to calculate the national vulnerability index with negative numbers, so exporters of a commodity are considered to have zero import dependence in that commodity for the purpose of this index. This explains why none of the countries on the map is classified as an exporter.

Food import vulnerability is negligible or very low (an index less than 20) in the United States, Canada, Brazil, Argentina, most of Europe, Russia, China, India, much of Southeast Asia, and Australia. In the high-income countries, this is because of the small percentage of the population that is food insecure. In Argentina, Brazil, India, China, and Southeast Asia, it is due to the fact that their dependence on food imports is low. For example, India and China are close to self-sufficient and occasional exporters of wheat and rice, the main components of their diet. Thailand and Vietnam are exporters of rice, the main staple food. The countries that face high and very high vulnerability to food price increases (an index over 40) are concentrated in Central America, the Andrean nations of South America, Africa, and Southwest Asia. In addition, some countries outside these regions have similar levels of food import vulnerability, including Venezuela, Jamaica, Haiti, Albania, Papua New Guinea, Timor-Leste, and Bhutan. Within Africa, there are more than a dozen countries with very high food import vulnerability including most of southern Africa, Congo, several countries in West Africa, Mauritania, Libya, Djibouti, and Kenya. In some cases, reliance on food imports may be related to the semi-arid conditions that make food production difficult. This is the case in Botswana, Namibia, Gambia, Libya, Yemen, Jordan, and Oman. In some cases, conflict and/or economic crisis has contributed to food insecurity and disruption of domestic food production, examples being Venezuela, Libya, Zimbabwe, Yemen, and Afghanistan. Regardless of the cause, these countries are most at risk of food insecurity when world prices of staple foods increase.

Figure 18. Map of index of vulnerability to international staple food price increases



5. Summary and discussion

5.1. Summary

Recent spikes in staple food prices resulting from the invasion of Ukraine have once again highlighted the difficulty faced by low-income countries that rely on imports for a substantial portion of their food supply. In order to better understand which countries are most affected by higher world food prices, we propose a food import vulnerability index (FIVI).

One version of the index describes the vulnerability to higher world prices for each of 15 major staple foods: wheat, rice, maize, sorghum, millet, beans, groundnuts, soybeans, cassava, potatoes, sweet potatoes, yams, sugar, and vegetable oil. The commodity-level FIVI is calculated as the geometric mean of three components: the share of caloric intake from the commodity, the share of imports in the domestic supply of the commodity, and the share of the population that experiences moderate or severe food insecurity.

Another version of the FIVI is a national index, aggregating across the 15 commodities. The national FIVI is the geometric mean of two components: the share of calories from staple foods that are imported and the share of the population that faces moderate or severe food insecurity. The former component is calculated as the weighted average of import dependence ratio across the 15 staple foods, where the weights are the caloric contribution of each staple food to the diet.

The data for the calculation of caloric intake and import dependence come from the FAO Food Balance Sheets and the FAO estimates of moderate and severe food insecurity, which is based on surveys using the Food Insecurity Experience Scale (FIES). Data on the composition of the diet and import dependence are available for 183 countries in 2020, while data on food insecurity are available for 142. We impute an estimate of the prevalence of food insecurity for the other 41 countries using regression analysis of food insecurity as a function of per capita gross domestic product and the prevalence of undernourishment from the World Bank and the FAO, respectively.

The first component of the food import vulnerability index is the importance of each staple food as a source of calories in the national diet. The results show that wheat is the most important staple food, ranking first in global caloric intake (18% of the total), first in the number of countries where it is the main staple (95), and tied for first in the number of countries for which it is among the top five sources of calories (163). It is particularly important in the diets in North Africa and Southwest Asia. Rice is ranked second in caloric intake and the number of countries where it is the main staple food. Its role in the diet is dominant in Southeast Asia, Madagascar, and several countries in West Africa. India and China are large producers and consumers of rice, but rice accounts for about one quarter of the caloric intake, with wheat playing an important secondary role. Maize is less important globally, but represents a major source of calories in Mexico, Central America, East Africa, and southern Africa. Cassava plays a modest role globally but is important in the Democratic Republic of Congo and nearby African countries. Sugar and vegetable oil are rarely the main source of calories, but they are among the top five in most countries (144 for sugar and 163 for vegetable oil). Sorghum, millet, pulses, other root crops, and plantains are important in selected countries but are less important at the global level.

The second component in the index is the import dependence of each commodity. The usual pattern is that there is a small number of exporters, a much larger number of importers, and some countries that are close to self-sufficient, neither importing nor exporting large volumes. But there is a wide variation in the degree to which staple foods are traded and the number of self-sufficient countries. Wheat, rice, maize, sugar, and vegetable oils are widely traded, while other cereals, pulses, and root crops are not. For example, 84% of countries are wheat importers and, on average, they rely on imports for almost four-fifths of their domestic supply. Similarly, the average import dependence ratio among importers is also high for sugar (78%), rice (72%), vegetable oil (62%), groundnuts (54%), and maize (51%). In contrast, sorghum, millet, beans, and all the root crops are much less traded. For most of these commodities, a majority of countries are close to self-sufficient in these commodities, and the average import dependence ratio is below 30%.

The third component of the food import vulnerability index is the prevalence of food insecurity. We use estimates of moderate or severe food insecurity as measured by the FAO (2023a), supplemented by interpolation in countries where an estimate was not available. Nine of the ten countries with the highest prevalence of food insecurity are in sub-Saharan Africa. Countries with over half the population experiencing food insecurity include Haiti, Venezuela, Peru, several Central American countries, most countries in sub-Saharan Africa, Yemen, North Korea, Afghanistan, India, Papua New Guinea, and Cambodia.

The results for the commodity-level food import vulnerability index (FIVI) show that countries are much more adversely affected by increases in the world price of wheat, rice, maize, sugar, and vegetable oil than by price increases in sorghum, millet, pulses, and root crops. This is because the five commodities listed are both major contributors to the diet in many countries and because many countries depend on imports for a large share of the domestic requirements of these staple foods. In the case of wheat, almost half of all countries are at least moderately vulnerable to higher prices (FIVI score of at least 30%). The countries most vulnerable to a spike in wheat prices are Yemen, Djibouti, Afghanistan, and Mauritania. Similarly, one quarter of the countries are at least moderately vulnerable to higher rice prices, the most adversely affected being the West African nations of Liberia, Gambia, Guinea-Bissau, and Comoros. About 8% of the countries are at least moderately vulnerable to higher maize prices, the most vulnerable being four southern African countries: Zimbabwe, Lesotho, Eswatini, and Botswana. For both sugar and vegetable oil, the caloric contribution to the diet does not vary much across countries. As a result, the vulnerability depends largely on import dependence and food insecurity. According to our index, the countries that are most vulnerable to sugar price spikes are Gambia, Yemen, Haiti, and Djibouti, though FIVI scores of the top 15 countries are similar, ranging from 36% to 45%. Similarly, the countries most adversely affected by increases in vegetable oil prices are Congo, Zimbabwe, Yemen, and Timor-Leste. As in the case of sugar, the top 15 countries in terms of vulnerability to higher vegetable oil prices have similar FIVI scores, ranging from 37% to 45%. Very few countries have moderate or even low vulnerability to the other commodities in the analysis: sorghum, millet, beans, groundnuts, soybeans, cassava, potatoes, sweet potatoes, yams, and plantains.

According to the national food import vulnerability index, the countries that face high and very high vulnerability to food price increases (an index over 40) are concentrated in Central America, the Andrean nations of South America, Africa, and Southwest Asia. In addition, some countries outside these regions have similar levels of food import vulnerability, including Venezuela, Jamaica, Haiti, Albania, Papua New Guinea, Timor-Leste, and Bhutan. These countries import a large share of their staple foods and have a relatively large share of the population facing moderate or severe food insecurity.

5.2. Discussion

The food import vulnerability index can help identify the countries that are most vulnerable to a spike in staple food prices on the world market, either for a specific commodity or for food prices in general. However, it has some limitations that need to be recognized in interpreting the results. First, it is an index rather than a quantitative assessment of the income or poverty impact of a given price increase. Second, the link between import dependence and vulnerability is not perfect. For example, even in a rice-exporting country like Vietnam, higher world prices of rice will have an adverse effect on the income and possibly food security of households that are net buyers of rice. In the case of Vietnam, the benefits of higher prices to surplus farmers appear to offset the losses to net buyers, but this may not be the case for other exporters (Minot and Goletti, 1998). And third, the actual impact of higher world food prices on poverty and food security in a country depends on the income and consumption patterns of households, particularly low-income households, as well as general equilibrium considerations such as the impact of higher food prices on wages, interest rates, and the exchange rate. To address these issues, the analysis would need to make use of survey data on household budgets and possibly a national computable general equilibrium model. Such a measure could take into account a wider range of factors, but it would be limited to countries that have suitable household survey data and/or an economy-wide model. The food import vulnerability index sacrifices some precision in the interest of greater transparency and wider country coverage.

Regarding the policy implications of the food import vulnerability index, it is important to recognize that international prices are just one type of shock to food security. It is true that reducing the food import dependency ratio with tariffs or other trade restrictions would reduce vulnerability to spikes in international food prices. However, a strategy of pursuing food self-sufficiency with trade restrictions has two negative side-effects. First, it raises the price of staple foods in the country, which is precisely the shock we are trying to avoid. Second, even if successful in reducing the impact of international price volatility, it makes local markets more vulnerable to domestic food supply shocks. Research indicates that the volatility of international prices of staple foods, such as wheat, rice, and maize, is significantly lower than the volatility of domestic prices of these commodities (Minot, 2014 and Martin and Minot, 2022).

These concerns are limited to the use of trade restrictions to achieve food self-sufficiency. Public and private investment in agricultural research, seed systems, and extension services to reduce import dependence would not raise domestic prices or increase local price volatility, though it is obviously a long-term strategy. Similarly, efforts to streamline trade procedures, improve transportation infrastructure, and make transport services more competitive could reduce the cost of imported food and facilitate distribution of food within the country, making markets more resilient to domestic and international shocks.

In addition, efforts to promote diversification of the diet, even within staple foods, would reduce vulnerability to shocks in international food prices. As discussed earlier, when the diet is heavily reliant on a single staple food, there is less flexibility to switch to alternatives when the price rises. Finally, a strong social safety net program will reduce the household-level impact of a spike in international food prices that is transmitted to domestic markets. A well-targeted social safety nets can help poor households cope with higher food prices at a lower fiscal cost than programs that provide universal subsidies on staple foods or trade policies that insulate local markets from international price volatility.

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APPENDIX A. INTERPOLATION OF MODERATE AND SEVERE FOOD INSECURITY

The FAO has estimated the share of the population experiencing moderate or severe food insecurity (MFI) in most countries, but not all. In cases where we have information for the other components of the vulnerability index (caloric intake and import dependence) but not MFI, we estimate the MFI using regression analysis and data on four other indicators of standard of living over the most recent five years for which data are available. The four indicators used to predict MFI are per capita GDP, the prevalence of undernourishment (PoU), the Gini coefficient of income inequality, and the rate of headcount poverty (FAO, 2023c and World Bank, 2023). However, not all four indicators are available for every country and year where we need to interpolate the MFI. Thus, when the MFI is not available from FAO, we estimate its value using as many of the four indicators as are available for that country and year.

The MFI, PoU, and other nutrition indicators from the FAO are available as three-year averages. We use the mid-point year of these variables to match them with per capita GDP, the Gini coefficient, and poverty, which are available on an annual basis.

Table A1 shows the number of countries by the source of the MFI estimate and by year, although the analysis in this report is limited to 2020. Of the 182 countries for which we have 2020 data on the composition of the diet and import dependence, FAO estimates of food insecurity in 2019-21 are available for 142 of them (78%). Among the 40 countries for which interpolation is needed, 23 can be estimated with data on per capita gross domestic product (GDP) and the prevalence of undernourishment. For another eight countries, we estimate MFI based on per capita GDP alone, and for the remaining nine countries, the interpolation is based on the prevalence of undernourishment.

The regression analysis is based on five years of data: 2016 through 2020 for per capita GDP, the Gini coefficient, and poverty and 2015-17 through 2019-21 for MFI and PoU. For each type of interpolation, we run a regression analysis of MFI as a function of the available indicators, using the countries and years for which MFI and the indicators are available. The estimated equations describe MFI as a function of the indicators and their quadratic terms. The equations are then applied to countries and years for which MFI is not available from the FAO, but some of the indicators of standard of living are available. More specifically, the predicted values of MFI in 2020 are calculated using the regression coefficients and the 2020 values of per capita GDP and/or the 2019-21 values of PoU. Estimates of headcount poverty and the Gini coefficient for 2020 were not available at the time of the analysis.

Table A1. Sources of estimates of moderate and severe food insecurity by year

		Year				
Source of MFI estimate		2016	2017	2018	2019	2020
Original FAO estimates		106	118	124	132	142
Interpolated using data on:						
1	GDP, PoU, Gini, and poverty	50	42	34	26	0
2	GDP and PoU	6	5	5	5	23
3	GDP, Gini, and poverty	6	5	7	7	0
4	PoU, Gini, and poverty	4	4	4	4	0
5	GDP per capita	5	4	4	4	8
6	Prev of undernourishment (PoU)	4	4	4	4	9
7	Gini coefficient & poverty	2	1	1	1	0
	Total	183	183	183	183	182

Note: For the nutrition indicators (MFI and PoU), the year refers to the mid-point of the three-year average. For example, 2020 refers to data for 2019-21.

Tables A2 and A3 give the results of regression analysis used to estimate the prevalence of moderate and severe food insecurity. Across the two tables, seven versions of the model are shown, each using a different combination of independent variables. The model number describes the order of priority in selecting a model. For example, if the data allow, we use model (1). If all but the Gini coefficient and poverty are available, we use model (2). The model numbers also correspond to the numbers in the first column of Table 1.

As shown in Tables A2 and A3, all the indicators of standard of living are statistically significant predictors of the dependent variable, MFI, at the 1% level with one exception: the squared Gini coefficient in model (4), which is significant at the 5% level. In addition, the signs of the coefficients follow expectations. For example, per capita GDP has a negative relationship with food insecurity in each model, while squared per capita GDP has a positive one. This suggests that MFI declines with higher per capita GDP but at a decreasing rate. In every model, MFI rises with the prevalence of undernourishment but at a declining rate. Moderate and severe food insecurity is positively associated with income inequality, represented by the Gini coefficient, though at a decreasing rate. Similarly, MFI is positively associated with poverty, though at a decreasing rate.

Table A2. Regression results for predicting food insecurity

	Dependent variable is the prevalence of moderate and severe food insecurity			
	(1)	(2)	(3)	(4)
GDPpc	-0.000	-0.001		-0.001
	(5.07)**	(9.29)**		(8.95)**
GDPpc2	0.000	0.000		0.000
	(2.89)**	(6.12)**		(5.38)**
PoU	1.695	2.479	2.331	
	(8.49)**	(15.26)**	(12.53)**	
PoU2	-0.022	-0.029	-0.034	
	(4.56)**	(7.62)**	(7.32)**	
Gini	167.457		223.728	146.969
	(3.73)**		(4.83)**	(2.90)**
Gini2	-181.166		-247.485	-143.916
	(3.28)**		(4.34)**	(2.32)*
poverty	69.415		83.721	122.530
	(6.51)**		(7.68)**	(11.60)**
poverty2	-54.052		-71.979	-96.257
	(3.23)**		(4.15)**	(5.83)**
Constant	-17.867	22.220	-39.120	-4.660
	(1.93)	(13.76)**	(4.30)**	(0.45)
R^2	0.84	0.80	0.82	0.81
N	428	578	428	452

Source: Regression analysis based on data from FAO (2023c) for the prevalence of moderate or severe food insecurity and the prevalence of undernourishment. World Bank (2023) for GDP per capita, headcount poverty, and the Gini coefficient of inequality.

Table A3. Regression results for predicting food insecurity

	Dependent variable is prevalence of moderate and severe food insecurity		
	(5)	(6)	(7)
GDPpc	-0.002		
	(25.53)**		
GDPpc2	0.000		
	(15.97)**		
PoU		3.709	
		(28.43)**	
PoU2		-0.050	
		(14.38)**	
Gini			286.553
			(5.07)**
Gini2			-298.117
			(4.29)**
poverty			171.199
			(17.63)**
poverty2			-140.019
			(9.06)**
_cons	53.681	6.273	-47.836
	(53.71)**	(8.69)**	(4.29)**
R^2	0.61	0.76	0.76
N	631	578	455

Source: Regression analysis based on FAO (2023c) for the prevalence of moderate or severe food insecurity and the prevalence of undernourishment. World Bank (2023) for GDP per capita, headcount poverty, and the Gini coefficient of inequality.

The coefficient of determination (R^2) ranges from 0.61 in model (5) to 0.84 in model (1). This implies that the indicators explain 61% to 84% of the variance in moderate and severe food insecurity across countries and years.

APPENDIX B: SENSITIVITY ANALYSIS

The commodity-level food import vulnerability index (FIVI) is a geometric mean of three indicators: the share of calories from the commodity, the import dependency ratio for the commodity, and the share of the population that is moderately or severely food insecure. The geometric mean gives equal weight to each of the three indicators. In this Appendix, we examine the sensitivity of the results to variation in the weights on each component of the index. More specifically, we calculate alternative value of the FIVI score using a weight geometric mean of the three components:

$$FIVI_{ic} = 100\left(\frac{C_{ic}}{\sum_i C_{ic}}\right)^a \left(\frac{M_{ic}}{Q_{ic}}\right)^b (MFI_c)^c$$

Where a, b, and c are weights such that a+b+c=1.0. Table B1 shows the six alternative weights that were tested.

Table B1. Alternative weights used for the sensitivity analysis

Label	Description	Calorie share weight (a)	Import dependence weight (b)	Food insecurity weight (c)
FIVI	Original index	0.33	0.33	0.33
FIVI_C	More weight on caloric share	0.50	0.25	0.25
FIVI_M	More weight on import dependence	0.25	0.50	0.25
FIVI_F	More weight on food insecurity	0.25	0.25	0.50
FIVI_CM	More weight on caloric share & import depend.	0.40	0.40	0.20
FIVI_CF	More weight on caloric share & food insecurity	0.40	0.20	0.40
FIVI_MF	More weight on import dep. & food insecurity	0.20	0.40	0.40

We calculate the FIVI and the six alternative versions of the FIVI for all 15 commodities and 183 countries, generating 2,745 observations for each indicator. Table B2 gives the correlation coefficient between the scores of each pair of FIVI alternatives. We focus on the first column, which gives the correlation coefficients between the main FIVI, with equal weights, and the alternative version, with different weights. The correlation coefficients in the first column range from 0.978 to 0.990. The lowest correlation is between FIVI and the alternative that gives greater weight (50%) to the importance of the commodity in the diet. Overall, these results suggest a close correlation between the scores in the original FIVI and those of the alternative versions.

Table B2. Correlation of FIVI scores across alternative weighting schemes

	FIVI	FIVI_C	FIVI_M	FIVI_F	FIVI_CM	FIVI_CF	FIVI_MF
FIVI	1.000						
FIVI_C	0.978	1.000					
FIVI_M	0.983	0.936	1.000				
FIVI_F	0.984	0.941	0.961	1.000			
FIVI_CM	0.990	0.985	0.978	0.949	1.000		
FIVI_CF	0.987	0.987	0.942	0.978	0.971	1.000	
FIVI_MF	0.979	0.918	0.987	0.985	0.952	0.947	1.000

Since we are often interested in the ranking of countries, it is useful to look at the correlation of the country rankings within each commodity. Table B3 shows the correlation of the country ranking. Looking at the first column, the correlation coefficient ranges from 0.975 to 0.985. Again, the lowest correlation is with the alternative that gives more weight to the caloric contribution to the diet. However, the results again suggest a close correlation between the original FIVI and the six alternatives.

Table B3. Correlation of FIVI ranks across alternative weighting schemes

	FIVI	FIVI_C	FIVI_M	FIVI_F	FIVI_CM	FIVI_CF	FIVI_MF
FIVI	1.000						
FIVI_C	0.975	1.000					
FIVI_M	0.981	0.936	1.000				
FIVI_F	0.981	0.938	0.954	1.000			
FIVI_CM	0.985	0.981	0.977	0.940	1.000		
FIVI_CF	0.984	0.983	0.938	0.977	0.961	1.000	
FIVI_MF	0.980	0.921	0.985	0.983	0.952	0.948	1.000

Finally, we present a somewhat more intuitive measure of the sensitivity of our results to different weights given to the three components. Table B4 gives the mean and median values of the absolute difference in the ranking of countries for each commodity. A mean absolute difference of zero means that both original FIVI and the alternative version of FIVI give the same rank to a country within a commodity. The first column shows that the mean absolute difference varies from 3.99 to 5.40. Although a smaller difference would be preferable, it is useful to recall that the country rankings range from 1 to 183, so a difference of 4-5 is relatively modest. Furthermore, the second column indicates that the median absolute difference in country rank is zero for all six alternative FIVI measures. In other words, for most country-commodity combinations, the original FIVI ranking is the same as the rank according to the alternative FIVI.

Table B4. Absolute different in FIVI ranks across alternative weighting schemes

	Mean absolute difference in rank from FIVI	Median absolute difference in rank from FIVI
FIVI_C	5.40	0.00
FIVI_M	4.67	0.00
FIVI_F	4.71	0.00
FIVI_CM	4.20	0.00
FIVI_CF	3.99	0.00
FIVI_MF	4.69	0.00

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