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The **FACT** Alliance research model offers a collaborative, stakeholder-driven approach to drive innovation and support food systems transformations at the global scale. The **FACT** model develops direct linkages between research and action and supports mechanisms for engaging with government, industry, civil society, and other food systems stakeholders. The MIT-led convergence research network will set the standard for developing the skills that tomorrow's leaders will need for solving critical food and climate challenges.

— Gregory N. Sixt,
FACT Alliance Director

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The Jameel Index for Food Trade and Vulnerability: Methodological Framework

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Abstract: To date, there has existed no index that offers a holistic understanding of the current dynamics of food trade and how different global change scenarios are likely to impact food trade in the future. While indices on different individual elements do exist, we present a new composite index integrating several existing metrics for both current and future scenarios. This new index, the Jameel Index for Food Trade and Vulnerability (Jameel Index), will serve as a useful tool by synthesizing these previously isolated metrics in a novel and meaningful manner. The Index is designed to gain understanding of historic behavior, forecast near-term vulnerabilities, and project future vulnerabilities using models to project how future global change scenarios will impact global food production and trade. Such a tool could, optimistically, guide policies and investments that support the causes of international development and food security.

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1. Introduction

International trade and food security are intrinsically linked. The quantity of crops traded among countries has more than doubled in the last 20 years (Falsetti et al., 2022), and nearly a quarter of food produced enters the international market (D'Odorico et al., 2014). As the food system has globalized, trade has emerged a key determinate of food security (Grassia et al., 2022). Of the six dimensions of food security outlined by the UN's High Level Panel on Food Security and Nutrition (HLPE) (Table 1), trade directly intersects with four dimensions (availability, access, stability, and sustainability), and indirectly with the remaining two (utilization and agency) (HLPE, 2020).

Table 1 The Six Dimensions of Food Security

The Six Dimensions of Food Security (adapted from: (HLPE, 2020))	
Availability	Having sufficient quantity and quality of food to safely meet the dietary needs of individuals within acceptable cultural norms.
Access (economic, social, and physical)	Having personal and/or household means to acquire food for an adequate diet at a level that ensures satisfaction of other basic needs are not compromised or threatened. Adequate food must also be accessible to everyone, including vulnerable individuals and groups.
Utilization	Having adequate diet, clean water, sanitation, and health care to ensure nutritional well-being and that all physiological needs are met.
Stability	Having the ability to ensure food security in the event of sudden shocks (e.g. conflict, climate crisis, economic crisis, etc.) or cyclical events (e.g. seasonal food insecurity)
Agency	Individuals or groups are able to act independently to make choices about what they eat, the foods they produce, and how that food is produced, processed, prepared, and distributed. Individuals or groups are also able to engage in the policy processes that shape their food system through socio-political systems that uphold governance structures.
Sustainability	Resilient food systems that contribute to long-term regeneration of natural, social, and economic systems ensure the food needs of current generations without compromising the food needs of future generations.

Trade can buffer shocks, both natural and manmade, allowing countries to decouple food demand and consumption from domestic production (Grassia et al., 2022). For example, the Arab Gulf Countries of the Gulf Cooperation Council (GCC) are some of the most food secure in the world, despite severe constraints on domestic food production from climate and water scarcity (The Economist Intelligence Unit Ltd., 2019). Their vast oil and gas reserves (30 percent of the proven oil and 22 percent of the proven natural gas reserves in the world), and relatively small populations have made the region one of the wealthiest in the world (Hassen & Bilali, 2019). Their fiscal strength allows them to bridge limited capacity for domestic food production with food imports, providing them considerable buying power in international food markets and reducing their vulnerability to price risk when compared with other food importers (Efron et al., 2018; Hassen & Bilali, 2019).

On the other hand, interconnected global trade networks can facilitate the transmission of shocks and increase the vulnerability of countries to climatic, environmental, economic, and geopolitical risks from abroad (Grassia et al., 2022). Low- and middle-income countries (LMICs) account for approximately one-third of global food and agricultural trade (FAO, 2023). Low-income, high food-importing countries are particularly vulnerable to the transmission of external shocks through global food trade networks and often are unable to shield themselves from such shocks with domestic production (Grassia et al., 2022).

While these risks are most acute for low-income countries, wealthy countries that are highly dependent on food imports to meet demand may also find themselves vulnerable in an increasingly unstable world. It is widely accepted that a country's food security increases with economic development, but national wealth alone cannot guarantee food security as the effects of climate change and other global change ripple through the complex and interconnected global food system—especially in those countries highly reliant on food imports.

To demonstrate this point, we continue with the example of the GCC countries. The Council on Foreign Relations reports that countries at the greatest risk for food insecurity are those that rely heavily on food imports; lack diversity in food suppliers; and/or are already facing risks from climate change, conflict, or economic troubles (Cheatham & Felter, 2020). The GCC states meet most of these conditions: domestic food production is capable of meeting only a small portion of food needs, a situation that will intensify with climate change; they are some of the most food import-dependent countries in the world, leaving them vulnerable to import price volatility and supply disruption; regional instability and geopolitical tensions increase the price and supply risk and have the potential to cause domestic unrest; and the ability of governments to continue to mitigate price risk is dependent on successful economic diversification away from oil and gas (Bailey & Willoughby, 2013; Lehne & Wellesley, 2017).

Regional Trade Agreements (RTAs) and bilateral food trade between countries increased almost six-fold between 1995 (when implementation of the World Trade Organization Uruguay Round Agreement on Agriculture began) and 2019 (FAO, 2023). RTAs increase bilateral food trade and have significant impacts on agricultural and food exports (Falsetti et al., 2022). Because of the growth in regional and bilateral trade and increasing complexity of the interactions between climate change, economic and population change, and geopolitical instability, there is a need to understand the dynamics of how food is traded among these countries. While there exist databases on different components of these complex interactions (e.g. food trade and climate change impacts on crops), there is a pressing need for a more holistic understanding of the dynamics of food trade and how global change will impact food trade and security. Put simply, there is a need for a comprehensive understanding of who is trading with whom and what factors will impact the availability, access, stability, and sustainability of that food trade.

To date, there has existed no index that offers a holistic understanding of the current dynamics of food trade and how different global change scenarios are likely to impact food trade in the future. While indices on different individual elements do exist, we present a new composite index integrating several existing metrics for both current and future scenarios. This new index, the Jameel Index for Food Trade and Vulnerability (Jameel Index), will serve as a useful tool by synthesizing these previously isolated metrics in a novel and meaningful manner. Based on an understanding how future scenarios impact global production and trade, such a tool could, optimistically, guide policies and investments that support the causes of international development and food security.

2. Methodology

2.1 Background

The Jameel Index measures food security in the context of trade. The goal of the Index is to provide policy- and decision-makers with insights concerning the threats posed by climatic and other global changes to food trade as well as the potential, resultant impacts to national food security. Thus, it does not represent an index of food security *per se*, but rather serves as a measure of food security risk as it relates to trade. This focus provides a lens through which policy- and decision-makers can better understand how varied factors affect and will affect the ability to import food and how these factors combine to impact key dimensions of food security.

The intent was to draw on readily available data but compile and organize it in a novel and transparent way that adds richness to the multidimensional question of what constitutes vulnerability to dependence on food imports.

The Jameel Index seeks to capture a broad spectrum of the vulnerabilities to a nation's food imports. Therefore, it cannot be described by any single indicator, but rather as a *composite index*. As Adger et al. (2004) suggest:
"[T]he most common, quantitative vulnerability assessment method is the employment of a composite index comprising a set of indicators. These indicators represent the vulnerability of a studied system and are mathematically combined into a single composite index".

Given that the Jameel Index will combine both biophysical and socioeconomic dimensions of food trade to assess current vulnerability and future global change scenarios, a composite index is suggested. Composite indices are commonly used for assessing climate change vulnerability (Eakin & Luers, 2006; Füssel & Klein, 2006; Soares et al., 2012; Wiréhn et al., 2015).

In developing the Jameel Index, the experience and guidance of the UNDP in *Measuring human development: A primer* (UN DESA, 2007, p.20) has been applied:

> *Composite indices have their limitations, but they can still be used with care to advocate policies and promote accountability. They should be simple to interpret, transparent in methodology, able to display complex and multidimensional issues, and useful in benchmarking performance and assessing policies. In general, a composite index is a unit-less number that combines various indicators or statistics to convey a larger picture. A composite index is formed when individual indicators are compiled into a single index on the basis of some underlying model. Ideally, a composite index should measure a multidimensional concept that cannot be captured by a single indicator alone—such as poverty, competitiveness, sustainability, market integration, etc. For human development, the main composite index is the HDI, which combines attributes of health, education and income.*

Composite indices should not be seen as an end in themselves, rather they should be seen as opportunities to initiate discussion and debate on policy, bearing in mind their inherently limited scope and inability to show causality (UN DESA, 2007).

2.2 Enhanced Framework for the Jameel Index

For the Jameel Index we have expanded the classic taxonomy of composite indices of where "individual indicators are compiled into a single index" (Greco et al., 2019) to a recursive framework where meta-indicators are assimilated into a single index. The meta-indicators are themselves composite indices focused on a single component related to food imports formed from summation across commodities of weighted indicators and normalized as illustrated in Figure 1.

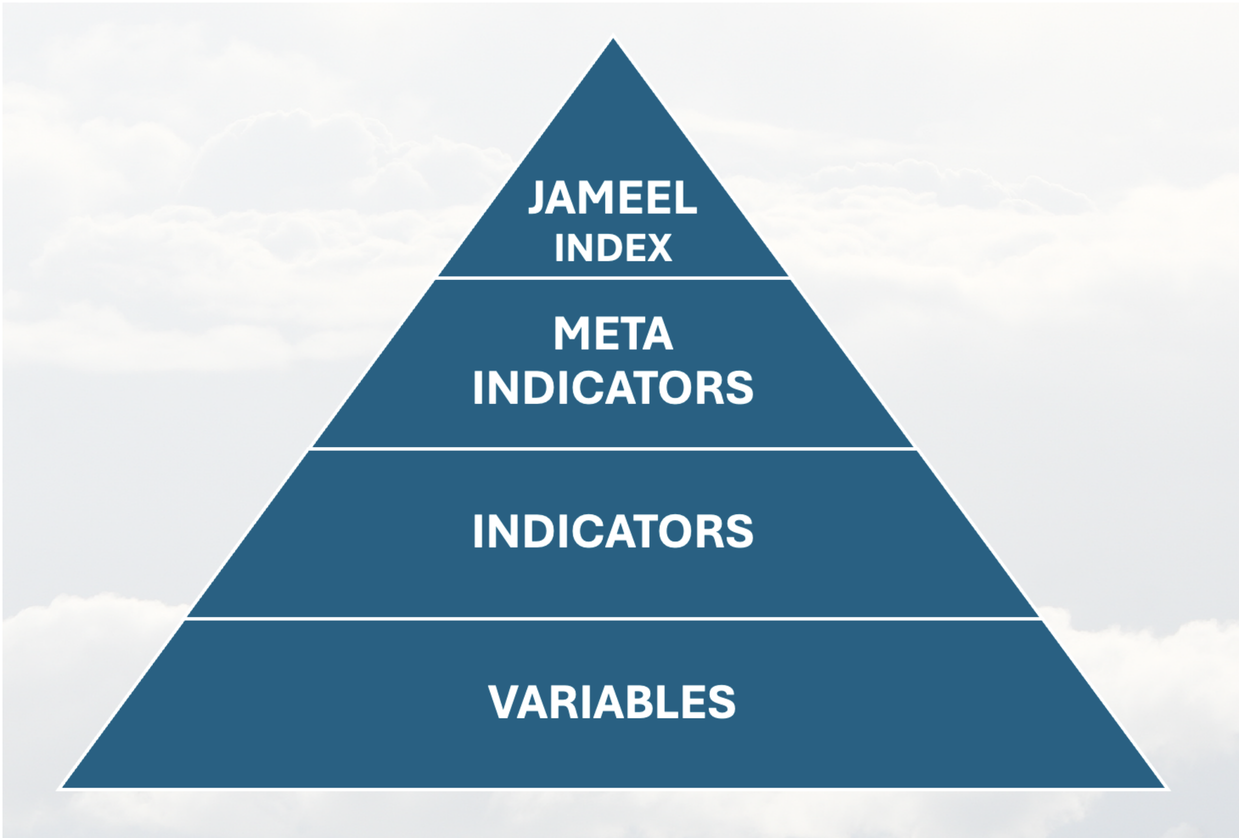


Figure 1 The Jameel Index Framework

To avoid a concern expressed in the literature that "[c]omposite indices may, however, invite simplistic policy conclusions if they address only the 'big picture' and ignore specific indicators" (Saisana & Tarantola, 2002, p.5), the Jameel Index output will present not only the final single composite index, but will also provide all the meta-indicator values that went into the Index. This will allow users to explore or investigate indicators specific to their own use cases.

2.2.1 The Five Meta-Indicators

The five meta-indicators are introduced below and are described in detail in the next section.

The criteria for selecting meta-indicators was to have a few as possible that cover the major elements that impact the food trade aspects of food security. The Five meta-indicators selected map directly to three of the six dimensions of food security (Table 2). The five meta-indicators were vetted by a panel of twelve food policy and trade experts in a series of three virtual and one in-person workshops.

Meta-indicators are developed based on five trade related Topical Indicators listed in Table 2. They will be described in detail in the next section.

Table 2 Mapping Meta Indicators to Food Security

	Topical Indicator	Food Security Dimension
1	Food Import Dependency Ratio	Availability, Access
2	Feed Import Dependency Ratio	Availability, Access
3	Food Import to Foreign Exchange Ratio	Stability
4	Exporter Reliability	Stability
5	Supply chain Robustness	Stability

2.3 From Meta-Indicators to the Jameel Index

The topical indicators are first calculated for each of eight key traded agricultural commodities chosen for the Index. The eight commodities included in the Jameel Index are:

1. Wheat
2. Maize
3. Rice
4. Soy
5. Dairy
6. Meat
7. Sugar
8. Oils

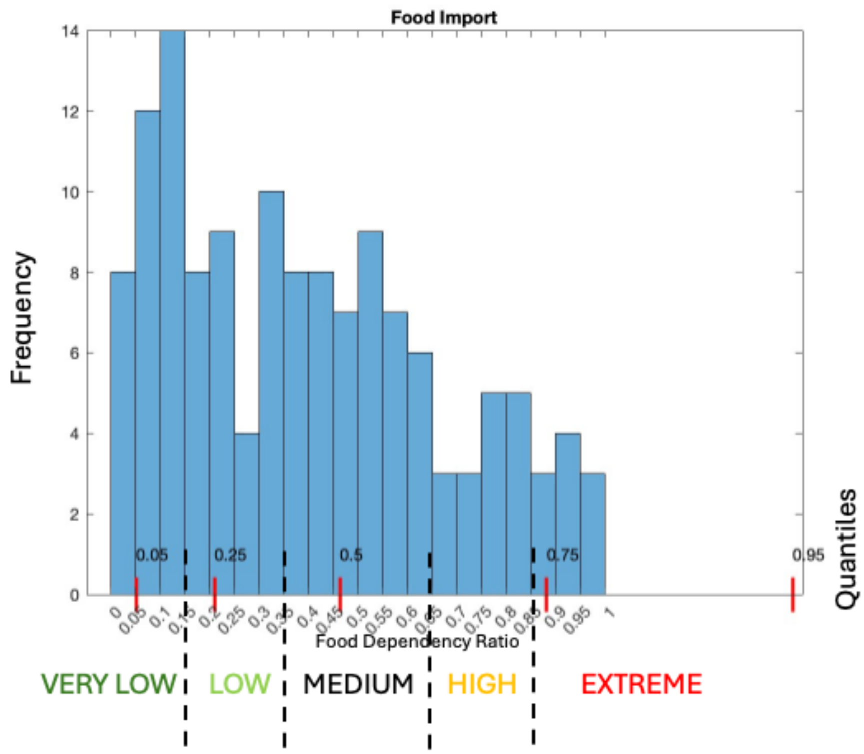
These eight are in the top ten of the key traded agricultural commodities related to nutrition and hunger as defined by the Food Consumption Score (WFP, 2008) and in the top ten in value and/or volume (WTO, 2023).

The primary data sources for the indicators come from FAOSTAT and the UN Comtrade databases. Some indicators use modeled data and will be presented in the discussion on each indicator. The indicators for each of the eight commodities are calculated from the raw data. For example, import dependency ratio for wheat for a country takes the import quantity and divides it by the total demand in the country to produce a ratio. The ratio for each commodity is then weighted and summed to produce the *meta-indicator* for the country. The details of weighting for each indicator are presented in the next section.

2.3.1 From Continuous to Categorical Meta -Indicator

The meta-indicators have different units of measurement, which require normalization before aggregation into a composite index. For the Jameel Index, the normalization process involves mapping the meta-indicators into a five-tier vulnerability classification system, illustrated below in Figure 2. The classification is meant to reflect how vulnerable a country's food security might be for a given level of the meta-indicator. For example, a score of .9 on the Food Dependency Import Ratio would translate to an EXTREME vulnerability while a score of .1 would be a VERY LOW vulnerability.

Figure 2 Mapping of Food Import Dependency Ratio to Vulnerability Classification



The determination of the levels of meta-indicator scores to the five-vulnerability classification was a complex and comprehensive process:

- Step 1: A review of the food security and trade literature was conducted to glean any quantitative ranks or threshold of risks or vulnerability. Little information or knowledge was obtained from this step.
- Step 2: A statistical analysis of each of the six meta-indicators raw scores from historical data from 2014 to 2020 was performed and 5%, 25%, 50%, 75% and 95% quantiles were produced.
- Step 3: The Jameel Index development team combined the information gathered from the literature, qualitative information about country import vulnerability, personal experience, and indicator development theory to produce a set of pilot values of two thresholds defining the three major levels of vulnerability for each of the six meta indicators, Low to Medium, Medium to High.
- Step 4: An expert elicitation was undertaken by an email survey using Google Forms. The pilot values along with the statistical analysis was shared with the experts. Thirty-seven experts were requested to take the survey and 25 responded. This is a 67% response rate, much greater than average academic survey response of 30 to 40%. The 25 respondents represented agricultural economist, development economists, food policy analysts, and trade analysts. There were about 30% academics, 30% researchers, 20% policymakers, and 20% consultants and private sector analysts.
- Step 5: The Jameel Index development team gathered the survey responses and performed a statistical analysis and, jointly with team expertise, established low to medium and medium to high thresholds. Using a method from indicator theory[6] the threshold between VERY LOW and LOW was set at 50% of the range between the minimum score and LOW to MEDIUM score and threshold

[6] Hoag, Dana, 2024. Personal Communication.

between HIGH and EXTREME was set at 50% of the range between score MEDIUM to HIGH score and maximum score. A set of five threshold values for each of the six meta-indicators was established—referred to as the Jameel-1 Thresholds.

Using the Jameel-1 thresholds, the meta-indicators were mapped from continuous raw scores to categorical classes in two forms: Text: Very Low, Low, Medium, High and Extreme and Ordinal where they are mapped from Text to a score of 1 to 5. : 1 -Very Low, 2 - Low, 3- Medium, 4- High and 5- Extreme. The greater the score, the greater the vulnerability.

The Meta Indicators as stand-alone indicators are valuable pieces of information for users of the Jameel Index and will be presented in the tables, maps and graphs of the visualization platform.

2.4 Theoretical Background to Composite Indicators

The literature classified methods for aggregation into three categories: arithmetic, geometric, and multi-criteria. Arithmetic and geometric aggregation are referred to as compensatory while multi-criteria is referred to as non-compensatory.

- Arithmetic or Linear aggregation is the process of combining multiple numerical values into a single value using the Arithmetic mean. This implies full compensability. According to OECD et al., (2008, p.103):

  An additive aggregation function permits the assessment of the marginal contribution of each variable separately. These marginal contributions can then be added together to yield a total value. If, for example, environmental dimensions are involved, the use of a linear aggregation procedure implies that among the different aspects of an ecosystem there are not phenomena of synergy or conflict. This appears to be quite an unrealistic assumption for certain index topics, (Funtowicz et al., 1990). For example, 'laboratory experiments made clear that the combined impact of the acidifying substances SO_2, NOX, NH_3 and O_3 on plant growth is substantially more severe that the (linear) addition of the impacts of each of these substances alone would be' (Dietz & Straaten, 1992).

  Additionally, arithmetic aggregation assumes preference independence which implies trade-off ratio between two indicators is independent of the rest of the indicators (OECD et al., 2008).

- "Geometric aggregation" in the context of composite indices refers to a method of combining multiple indicators into a single value by calculating the geometric mean, which means taking the n^{th} root of the product of all the indicators raised to their respective weights—essentially penalizing low values in any single indicator and giving more weight to achieving high scores across all dimensions, making it a less compensatory approach compared to simple averaging (arithmetic mean). Geometric aggregation implies partial compensability. The marginal utility from an increase in a low absolute score is much higher than for an increase in a high absolute score compared to arithmetic, which effectively incentivizes improvement on the worst indicators first.

The difference between the two are important when dealing with:

- Impact of extreme values: Geometric aggregation is more sensitive to low values, meaning a single very low score can significantly drag down the overall index value, whereas arithmetic aggregation allows for more "trade-off" between high and low values on different indicators.
- Compensatory nature: Arithmetic aggregation is considered more compensatory, meaning a high value on one indicator can offset a low value on another, while geometric aggregation is less compensatory.

Arithmetic aggregation is recommended for indices when:

- The preference is to give equal weight to all indicators and a simple average is sufficient, and/or
- The preference is to be less sensitive to outliers or extreme values on individual indicators.

Geometric aggregation is recommended for indices when:

- The indicators in the composite index are highly correlated and a low value on one indicator is likely to be accompanied by a low value on others, geometric aggregation can be more appropriate and/or
- A single very low value on an indicator should significantly impact the overall index score, even if other indicators are high, use geometric aggregation.

2.4.1 Lessons from practice

The Human Development Index (HDI) was first published in 1990 by the United Nations Development Programme (UNDP) to provide a more comprehensive measure of human development than economic measures alone (UNDP, 2025). The HDI is a metric that measures a country's development in three areas: health, education, and standard of living. The HDI initially used arithmetic aggregation but switched from linear to geometric in 2010, addressing one of the main methodological criticisms (Greco et al., 2019). By employing a geometric aggregation, the HDI ensures that a country cannot achieve a high score by excelling in only one area, while lagging in others.

2.5 The Composite Jameel Index

Geometric aggregation was selected for the Jameel Index over an arithmetic aggregation because

1. The development team desired to penalize extreme values more severely, meaning a low performance in any single area should significantly impact the overall score, and
2. The development team wanted to emphasize the need for balanced performance across multiple indicators.

Implementation of Composite Index using Geometric Aggregation requires that the indicators be normalized and equal mathematically before being combined. The process is:

1. Develop standardized indicators: Before aggregation, each individual indicator is usually standardized to a comparable scale. The meta-indicators are all standardized from 1 to 5.
2. Assign weights: Each indicator is assigned a weight reflecting its relative importance in the overall composite index. For the Jameel Index this is done by a two-step process
   - 2.1. Indicator Scaling to reflect the inversely correlated nature of some indicators. Discuss in detail below
   - 2.2. User establishment of weights for each of the 5 meta-indicators. This will allow user to develop a customized index to meet their needs. However, the canonical Jameel Index is based on each meta-indicator being equally weighted as 1.0.

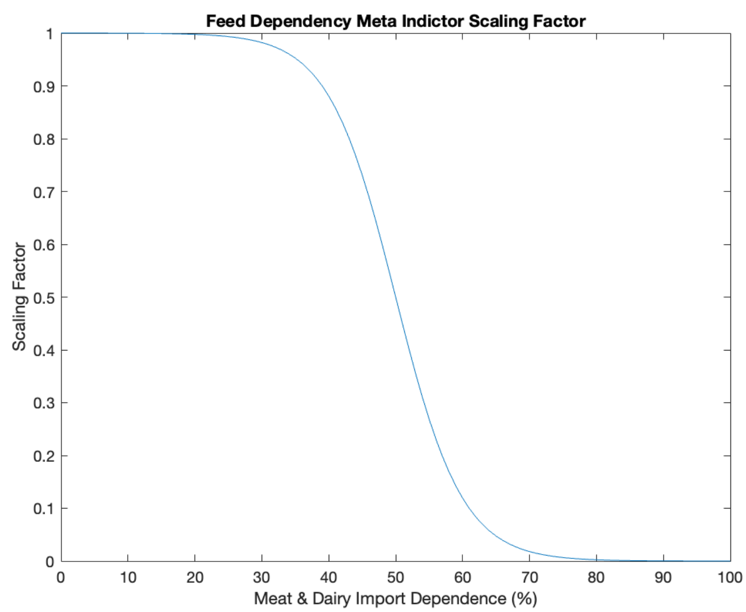
3. Calculate geometric mean: The geometric mean is calculated by taking the n^{th} root of the product of each indicator raised to its corresponding weight.

2.5.1 The Scaling Factors

The Scaling factors for the Feed Import Dependency Ratio, the Food Import Foreign Exchange, and Climate Policy meta-indicators are set to 1, as they represent independent topical indicators. For the other two meta-indicators, the scaling factor is determined by an S-Curve from 0 to 1 as a function of key data variables or another meta-indicator.

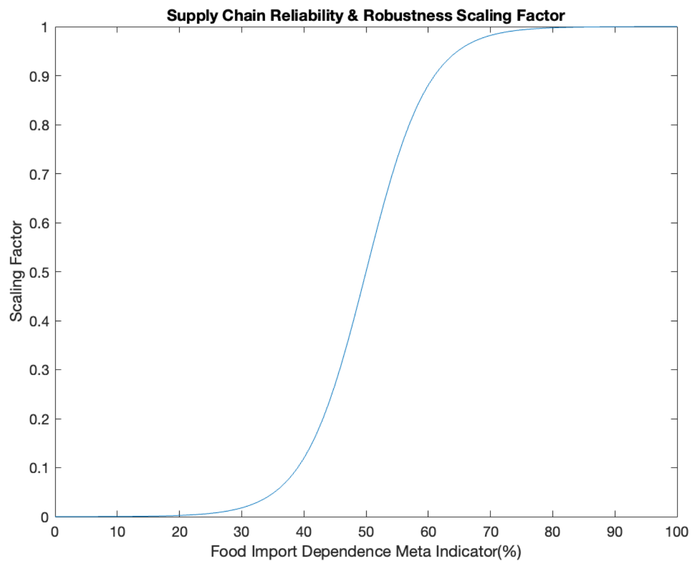
Feed Import Dependency Ratio: If meat and dairy are primarily produced locally (less than 25% imported), the Feed Import Dependency Ratio can be important to food security vulnerability. While, if meat and dairy are primarily imported (greater than 75%), then little feed is needed, and feed dependency does not impact the food security vulnerability. So, the scaling factor is a function of the % of Meat and Dairy demand imported as presented in Figure 3.

Figure 3 Feed Import Dependency Ratio: Scaling Curve



Supply Chain Reliability and Robustness: If the Food Import Dependency meta-indicator for a nation is low (less than 25% imported), the import supply chain reliability and robustness are not factors in food import security vulnerability. If the Food Import Dependency meta-indicator for a nation is high (greater than 75%), the import supply chain reliability and robustness are important factors in food import security vulnerability. So, the scaling factor is a function of the Food Import Dependency meta-indicator as presented in Figure 4.

Figure 4 Supply Chain Reliability and Robustness: Scaling Curve



2.5.2 Developing the Composite Jameel Index

The five meta-indicators, and the method to classify their vulnerability classification were presented above. The vulnerability classification is assigned a numeric score $VUL_{M.}$ between 1 to 5 per the mapping below.

Vulnerability Classification	Very Low	Low	Medium	High	Extreme
VUL_M	**1**	**2**	**3**	**4**	**5**

The task now is to take these five meta-indicators and develop a Composite Index. As presented above we have selected a geometric aggregation (mean) to combine the five meta-indicators into a single composite index and classification for each nation.

This is done by a three-step process:

1. Calculate a Raw Index
2. Calculate a Normalized Index
3. Classify the Composite Vulnerability

Step 1 Calculate the Raw Index: A set of weights are provided by the user. WM_M is the weight for each meta indicator M.

The raw index in calculate by taking the product of all five meta vulnerability scores times their weight, WM_M , and then taking the 1/M root of the product as presented in the equation below

$$\mathrm{RAWJx} = \left(\prod_{M} \mathrm{WM_M} * \mathrm{VUL_M}\right)^{1/M}$$

Using weights of 1 for all meta indicators, the RawJx score will be between 1, if all meta indicators vulnerabilities Very Low and 5, if all meta indicators are Extreme. Most scores will be between these extremes.

Step 2 Calculate the Normalized Index: For the case with all weights set to1, the minimum score possible RawJx is 1 so MinJx = 1. The maximum score possible RawJx is 5 so MaxJx = 5. The JxRange = MaxJx-MinJx or 4. The normalize Jx is a measure of where a nation's score falls within the range of possible value as a ratio of the range and then multiplied by 100 to reflect the percentage of maximum vulnerability the nation is facing, per the equation below

Jx = (RawJx-1) /RangeJx * 100

This results in scores ranging from 0 to 100. So, if RawJx is 2.5, the Jx = (2.5/4) * 100 or 62.5.

An example of a case with unequal weights could be if there is a user from the Central Bank that is greatly concerned about balance of payments and considers, the meta indicator -Food Import to Foreign Exchange Ratio, to be 3 times as important as each of the other indicators. She would set that weight to 3 and MinJx is 1.25 MaxJx is 6.23. The JxRange = MaxJx- MinJx is 4.98. So if RawJx is 2.0, the Jx = (2.0/4.98) * 100 or 40.2.

Step 3 Classify the Composite Vulnerability: The Jameel Index is not intended to be a relative ranking but an absolute measure of a nation's food vulnerability. The goal is to classify a nation's vulnerability into one of the 5 vulnerability classifications: Very Low, Low, Medium, High, or Extreme.

The procedure for the classification of the meta-indicators was done by an extensive consultative and Delphi process. The composite Jameel Index has taken a hybrid approach based on insights and examples from wide-applied composite indices and theoretical foundations.

2.6 Theoretical Foundation of Index Classification

The theoretical foundation is drawn from the fact that the composite index uses a geometric aggregation, which suggest multiplicative scaling for classification of a continuous variable into discrete categories

By scaling features multiplicatively, the classification becomes more sensitive to proportional changes between features, which can be beneficial when the absolute values of features are not as important as their relative magnitudes. There are two approaches to scaling:

1. **Direct multiplication:** Simply multiply each feature by a scaling factor before feeding it into the classification model.

2. **Logarithmic or exponential transformation:** Sometimes, taking the logarithm or exponential of the features before scaling can further enhance the impact of multiplicative relationships.

Example scenarios where multiplicative scaling might be beneficial is analyzing financial data, e.g. when comparing stock prices, the relative change in price is often more important than the absolute price, so scaling prices multiplicatively could be beneficial.

Since we used a geometric aggregation, we want our classification bins to grow geometrically. The goal is to set thresholds for the bins to transform the Jx score to the 5 discrete classifications: Very Low, Low, Medium, High, Extreme

The procedure to develop the thresholds is developed below:

In order to have 5 bins we need 6 Bin threshold Ti with i ranging from 1 to 6, and T_1 being much greater than 0 with a scaling factor S.

$T_{i+1} = T_i * S$ so $T_6=T_1*S^5$. Since we want if we set (T_6= 1.0 and T_1 = .1)[7] we can solve for S

$1.0= 0.1 * S^5$. ➔ $S = 10^{0.2}= 1.58$

Expanding this for all 6 threshold produces the T_i for i = 1 to 6:

T_1	T_2	T_3	T_4	T_5	T_6
.10	.158	.251	.398	.631	1.00

This procedure produced thresholds such that the size of the classification bins that increase monotonically from 0.058 to 0.369. This result is appropriate for a geometric aggregation composite index. The next section will examine a range of classification for similar composite indices.

2.6.1 Examples from Practice

The most widely used and scrutinized composite index is the Human Development Index. A composite geometric mean of four component indicators, the HDI categories of human development achievements into four levels calculated using the quartiles *(q)* from the distributions of the component indicators averaged over 2004–2013. This results in a non-uniform mapping of the normalized HDI score to the four levels shown below (UNDP, 2025).

[7] T6 set to maximum value 1.0 and T1 determines by trial and error to a value greater than 0.0 that produce a set of bins that fit desired risk classification to be biased toward type I error and classify a nation to higher class than they may actually be rather than a lower class.

Table 3 HDI Classification Levels

Very high human development	0.800 and above
High human development	0.700–0.799
Medium human development	0.550–0.699
Low human development	Below 0.550

The sequence of bin sizes is 0.200, 0.099,0.149.0.550 and the bins are non-uniform and non-monotonic.

The Global Food Security Index (GFSI) (Economist Impact, 2022), a highly regarded tool developed by The Economist Impact and supported by Corteva, produces a Composite Index- the Food Security Environment, that is the composite of four meta-indicators: 1) Affordability, 2) Availably, 3) Quality and Safety, and 4) Sustainability & Adaptation. These four meta-indicators are constructed from 68 unique indicators that measure the drivers of food security across both developing and developed countries. The Food Security Environment is calculated as a weighted arithmetic mean of the 4 meta-indicators. (Economist Impact, 2022). A Food Security Classification is produced for the 113 nations using The Food Security Environment score which ranges from 0 to 100:

Table 4 GDSI Classifications Level

VERY GOOD	GOOD	MODERATE	WEAK	VERY WEAK
≥ 80	70-79.9	55-69.9	40-54.9	0-39.9

The sequence of bin sizes is 20, 9.9,14.9.14.9, 39.90 and the bins are non-uniform and non-monotonic.

The Water Quality Index (WQI) is one of the most used tools to describe water quality. It is based on the aggregation of physical, chemical, and biological subindex values into a single value that ranges from 0 to 100. Chidiac, et al 2022, surveyed the most prominent water quality indices found in the literature and found that most used a non-uniform, non-monotonic classification system to the classify water quality state of a waterbody. Most were found like that of the WQI developed for the Susquehanna River Basin (Berry et al., 2020).

Table 5 Susquehanna WQI Classifications Level

EXCELLENT	GOOD	FAIR	POOR	VERY POOR
≥ 85	62-85	43-62	31-43	<31

The sequence of bin sizes is 15, 23,19,12, 31 and the bins are non-uniform and non-monotonic.

2.7 The Classification for the Jameel Index

The theoretical formulation suggests a multiplicative scaled classification that produces a monotonic and non- uniformed classification. Our observation from the HDI, GFSI, and most water quality indicators is that they use a non-uniform and non-monotonic classification. In addition, these composite indices classification have two common features

1) The bin size of the worst classification that index is targeted to warn users to try to avoid, is always the largest, up to 4 times the size of the smallest bin size.
2) The bin size of the best classification is smaller than the worst classification but larger than size of the middle classifications.

Based on the synthesis of our theoretical and empirical research we have established the following thresholds and mapping from the Jx raw score 0-100 in the five vulnerability classifications in Table 6.

Table 6 Jameel Index Jx Mapping to Vulnerability Classifications

Very Low	Low	Medium	High	Extreme
<15.8	15.8 - <25.1	25.1- <39.8	39.8- <63.1	≥ 63.1

2.8 Meta-Indicator 1: Food Import Dependency

The food dependency ratio is a standard indicator developed by FAO and provided in FAOSTAT (FAO, 2024) by commodity. The Food Import Dependency meta-indicator is the ratio the nation's commodity demand that is import to the total commodity demand. It is a measure of how dependent a nation's food supply across all commodities is dependent on imports.

1. Variables

The variables by commodity C are:

- Total National Demand: TD_c
- Total National Import: IM_c (negative imports or exports are set to 0)

2. Indicator

The indicator for each commodity is the ratio of the amount of food imported over the total national food demand express below

$$IDR_c = IM_c/TD_c$$

3. Weighted Indicator

In measuring achievement of food security, not all commodities play the same roll in each country due to diet and cultural norms, and not all foods have the same nutritional value per unit.

For this sub-index we weight each commodity by two multiplicative weights

1. The percent of total calories in the diet
2. Food Consumption Score
   - % of Total Calories: PC_c
   - Food Consumption Score: FCS_c

1. The percent of total calories in the diet for each commodity is determined by multiplying the total commodity consumption by weight by the caloric value per unit wight and then dividing by the total calories consumed over all commodities

2. The Food Consumption Score (FCS) is an index that was developed by the World Food Programme (WFP) in 1996 (WFP, 2008). The FCS provides a score for the relative nutritional value of the consumed food groups as presented in Table 7. For instance, food groups containing nutritionally dense foods, such as animal products, are given greater weight than those containing less nutritionally dense foods, such as tubers. The FCS is a proxy indicator of household caloric availability.

Table 7 Food Consumption Score (FCS) [WFP 2008]

	Food items	Food groups	Weight
1	Maize , maize porridge, rice, sorghum, millet pasta, bread and other cereals Cassava, potatoes and sweet potatoes, other tubers, plantains	Main staples	2
2	Beans, peas, groundnuts and cashew nuts	Pulses	3
3	Vegetables, leaves	Vegetables	1
4	Fruits	Fruits	1
5	Beef, goat, poultry, pork, eggs and fish	Meat and fish	4
6	Milk yoghurt and other diary	Milk	4
7	Sugar and sugar products, honey	Sugar	0.5
8	Oils, fats and butter	Oil	0.5
9	Spices, tea, coffee, salt, fishpowder, small amounts of milk for tea.	Condiments	0

The calculation for weighted Food Supply Import dependency indicator is:

$$WIDR_c = IDR_c * PC_c * FCS_c$$

1. Raw meta-indicator

The raw Food Import Dependency score RIDS is calculated by summing the weighted Food Supply Import dependency indicator over all commodities

- RIDS = $\sum_{c} \text{WIDR}_c$

An example of the steps from indicator to sub-index for UAE is found in Table 8.

Table 8 Example Food Import Dependency Ratio Meta-Indicator for UAE

UAE	Import Dependency Ratio	Dietary Contribution	FCS	Commodity Score
Commodity				
dairy	0.66	0.06	4	0.15
maize	0.98	0	2	0
meat	0.79	0.05	4	0.16
oil	0.08	0.2	0.5	0.01
rice	1	0.12	2	0.24
soy	1	0	2	0
sugar	1	0.11	0.5	0.06
wheat	1	0.26	2	0.52
TOTAL		**0.8**		**1.14**

2. Normalized Meta-Indicator

The raw Food Import Dependency score RIDS for the six representative nations are listed in Table 9.

Table 9 Representative RIDS

Nation	Food Import Dep
United Arab Emirates	1.34
Argentina	0.00
Bangladesh	0.27
Egypt	0.62
Ethiopia	0.14
Philippines	0.45

Using rules developed to map RIDS to vulnerability shown below:

Classification	Upper Bound <
VERY LOW	0.15
LOW	0.3
MEDIUM	0.75
HIGH	0.875
EXTREME	2

Table 9 is transformed to Table 10.

Table 10 Jameel Index by Categorization

Nation	Food Import Dep
United Arab Emirates	Extreme
Argentina	Very Low
Bangladesh	Low
Egypt	Medium
Ethiopia	Very Low
Philippines	Medium

2.9 Meta-Indicator 2: Feed Import Dependency

The Feed Supply Dependency Ratio is analogous to the Food Supply Dependency. The Feed Import Dependency meta-indicator measures the dependent a nation's feed supply on imports from the 8 major commodities considered in this analysis.

1. Variables

The variables for the grain commodities are :

- Total Demand: TD_{gc}
- Total Feed Use : FU_{gc}
- GC = grain commodities: Maize, Rice, Sorghum, Wheat

2. Indicator

There are two sub-indicators used to calculate the Feed Import Dependency Indicator

Sub-Indicator A – The import dependency ratio for each of the grain commodities, gc
Sub-Indicator B – The percent of commodity demand for feed for each of the grain commodities, gc

- Sub Indicator A : $IDR_{gc} = IM_{gc}/TD_{gc}$
- Sub Indicator B : $FR_{gc}=FU_{gc}/TD_{gc}$

The two sub-indicators are multiplied to produce the indicator of feed import dependency

Indicator: $FIDR_{gc} = IDR_{gc} * FR_{gc}$

3. Weighted Indicator

For this sub-indicator each commodity is weighted by the percentage of feed calories supplied by each grain commodity to total feed calories:

% FEED CAL of Total FEED Calories: PC_c

The calculation for weighted Feed Supply Import dependency indicator is:

$WFIDR_c = FIDR_c * PC_c$

1. Raw Meta-Indicator

The raw continuous value meta-indicator is calculated by summing the weighted Feed Supply Import dependency indicator over all grain commodities

- $RIDS = \sum_{gc} WFIDR_{c\,gc}$

An example of the steps from indicator to sub-index for UAE is found in Table 11

Table 11 Example Import Dependency Ratio Sub-Indicator for UAE

	IDR	FEED Metric	% of Feed Calories	Commodity Score
UAE				
dairy	0.66			
maize	0.98	0.88	64%	55%
meat	0.79			0%
oil	0.08			0%
rice	1	0.09	10%	1%
soy	1	0.21	2%	0%
sugar	1			0%
wheat	1	0.13	25%	3%
TOTAL	0.80			59%

2. Normalized Meta-Indicator

The Raw Feed Import Dependency Ratio for the six representative nations are listed in Table 12.

Table 12 Representative Raw Feed Import Dependency Scores

Nation	Feed Import Dep
United Arab Emirates	0.95
Argentina	0.00
Bangladesh	0.34
Egypt	0.55
Ethiopia	0.07
Philippines	0.42

Using rules developed to map RIDS to vulnerability shown below:

Classification	Upper Bound <
VERY LOW	0.15
LOW	0.3
MEDIUM	0.75
HIGH	0.85
EXTREME	2

Table 12 is transformed to Table 13.

Table 13 Representative Jameel Index

Nation	Feed Import Dep
United Arab Emirates	Extreme
Argentina	Very Low
Bangladesh	Medium
Egypt	Medium
Ethiopia	Very Low
Philippines	Medium

2.10 Meta-Indicator 3: Food Import Foreign Exchange Ratio

Food Import Foreign Exchange Ratio is an original indicator developed for the Jameel Index using data from FAOSTAT and Comtrade by all commodities, the meta-indicator is the ratio of the value of all food imports to the total value of ALL exports including agricultural, minerals, industrial product, etc. The lower the ratio, the less vulnerable a nation will be to economic shocks and the internal competition for foreign to pay for food imports.

1. Variables

The variables by commodity C are:

- Value of Food Import : FIM_c
- Value of Total Exports : EX

2. Indicator

The indicator is the ratio of the value of food imported over the total national exports by commodity C expressed below

$$FFXR_c = FIM_c / EX$$

3. Weighted Indicator

Since the indicator is a monetary value there is no weighting by commodity.

4. Raw Meta-Indicator

The raw continuous value meta-indicator is calculated by summing the Food Import Foreign Exchange indicator over all commodities

$$\mathrm{RFXR} = \sum_{c} \mathrm{FFXRc}$$

An example of the steps from commodity indicator raw meta-indicator for Ethiopia is found in Table 14.

Table 14 Example Food Import Foreign Exchange Sub-Indicator for Ethiopia

Ethiopia	
dairy	0.01
maize	0.01
meat	0.00
oil	0.00
rice	0.09
soy	0.00
sugar	0.12
wheat	0.22
TOTAL	0.44

5. Normalized Meta-Indicator

The raw Food Import Foreign Exchange for the six representative nations are listed in Table 15.

Table 15 Representative Raw Food Import Foreign Exchange

Nation	Food Import FX Ratio
United Arab Emirates	0.02
Argentina	0.00
Bangladesh	0.00
Egypt	0.33
Ethiopia	0.50
Philippines	0.09

Using rules developed to map RIDS to vulnerability shown below:

Classification	Upper Bound <
VERY LOW	0.01
LOW	0.035
MEDIUM	0.25
HIGH	0.575
EXTREME	1

Table 15 is transformed to Table 16.

Table 16 Representative Jameel Index

Nation	Food Import FX Ratio
United Arab Emirates	Low
Argentina	Very Low
Bangladesh	Very Low
Egypt	High
Ethiopia	High
Philippines	Medium

2.11 Meta-Indicator 4: Supply Chain Reliability

Food Supply Chain Reliability is a original indicator developed for the Jameel Index using data from the Oxford Programme for Sustainable Infrastructure Systems. The Food Supply Chain Reliability meta-indicator is designed to measure the reliability in commodity production due to climate variability in the exporting nations that make up 80 percent of a nation's imports by commodity C. High variability is likely to make export supplies vulnerable in low production years thus reducing the reliability of supply from the exporting nation.,

1. Variables

The variables by commodity C and exporter X are:

- Coefficient of Variation of Commodity C by Exporter X : COV_{cx}
- % of Commodity supplied by Export X: PX_{cx}

2. Indicator

The indicator for each commodity is the sum of the weighted Coefficient of Variation of Commodity C by Exporter exporting nations that make up 80 percent of a nations imports.

- $COV_c = \sum_{x} PX_{cx} * COV_{cx}$

3. Weighted Indicator

In measuring achievement of food security, not all commodities play the same role in each country due to diet and cultural norms, and not all foods have the same nutritional value per unit of

For this sub-index we weight each commodity by two multiplicative weights

1. The percent of total calories in the Diet
2. Food Consumption Score

    - % of Total Calories: PC_c
    - Food Consumption Score: FCS_c

3. The percent of total calories in the diet for each commodity is determined by multiplying the total commodity consumption by weight by the caloric value per unit weight and then dividing by the total calories consumed over the all commodities.

4. The Food Consumption Score (FCS) is a measure that was developed by the World Food Programme (WFP, 2008). The FCS provides a gauge of the relative nutritional value of the consumed food groups. For instance, food groups containing nutritionally dense foods, such as animal products, are given greater weight than those containing less nutritionally dense foods, such as tubers. The food consumption score is a proxy indicator of household caloric availability.

The calculation for weighted Food Supply Import Dependency indicator is:

$$WCOV_c = COV_c * PC_c * FCS_c$$

4. Raw Meta-Indicator

The raw continuous value meta-indicator is calculated by summing the weighted Food Supply Chain Reliability indicator over all commodities

$$RCOV = \sum_{c} WCOVP_c$$

An example of the steps from indicator to meta-indicator for UAE is found in Table 17.

Table 17 Example Supply Chain Reliability Sub-Indicator for UAE

UAE	Partner's COV	Dietary Contribution	FCS	Commodity Score
dairy	0.09	0.06	4	0.02
maize	0.04	0.00	2	0.00
meat	0.05	0.05	4	0.01
oil	0.03	0.20	0.5	0.00
rice	0.03	0.12	2	0.01
soy	0.05	0.00	2	0.00
sugar	0.06	0.11	0.5	0.00
wheat	0.04	0.26	2	0.02
TOTAL		0.80		0.06

5. Normalized Meta-Indicator

The raw Supply Chain Reliability score for the six representative nations is listed in Table 18.

Table 18 Representative Raw Food Supply Chain Reliability Scores

Nation	Supply Chain Reliab...
United Arab Emirates	0.10
Argentina	0.00
Bangladesh	0.08
Egypt	0.08
Ethiopia	0.05
Philippines	0.06

Using rules developed to map RFSCR to vulnerability show below Table 18 is transformed to Table 19.

Classification	Upper Bound <
VERY LOW	0.025
LOW	0.05
MEDIUM	0.075
HIGH	0.15
EXTREME	0.5

Table 19 Representative Normalized Categorization

Nation	Supply Chain Reliab...
United Arab Emirates	High
Argentina	Very Low
Bangladesh	High
Egypt	High
Ethiopia	Low
Philippines	Medium

2.9 Meta-Indicator 5: Food Supply Chain Robustness

Food Supply Chain Robustness is an original indicator developed for the Jameel Index using data from FAOSTAT and Comtrade by commodity, the Supply Chain Robustness meta-indicator is the number of exporting nations that make up 80 percent of a nations import by commodity C. The higher the number the less vulnerable a nation will be to shocks in the supply chain, from drought, shipping bottle necks, geopolitics or other conflicts. the ratio the more likely the food imports will compete with other key imports such as energy or raw materials for limited foreign exchange. It also indicates that funds for food imports might be vulnerable when foreign exchange is short supply.

1. Variables

The variables by commodity C are:

- # of exporters supplying 80% of Commodity C imports : NP_c

2. Indicator

The indicator for each commodity is the number of exporting nations that make up 80 percent of a nation's imports.

- NP_c

3. Weighted Indicator

In measuring achievement of food security, not all commodities play the same roll in each country due to diet and cultural norms, and not all foods have the same nutritional value per unit of

For this sub-index we weight each commodity by two multiplicative weights:

1. The percent of total calories in the Diet
2. Food Consumption Score
   - % of Total Calories: PC_c
   - Food Consumption Score: FCS_c

5. The percent of total calories in the diet for each commodity is determined by multiplying the total commodity consumption by weight by the caloric value per unit wight and then dividing by the total calories consumed over the all commodities

6. The Food Consumption Score (FCS) is an index that was developed by the World Food Programme (WFP, 2008). The FCS provide a score for the relative nutritional value of the consumed food groups. For instance, food groups containing nutritionally dense foods, such as animal products, are given greater weight than those containing less nutritionally dense foods, such as tubers. The food consumption score is a proxy indicator of household caloric availability.

The calculation for weighted Food Supply Import dependency indicator is

$$WNP_c = NP_c * PC_c * FCS_c$$

6. Raw Meta-Indicator

The raw continuous value Meta-Indicator is calculated by summing the weighted Food Supply Chain Robustness indicator over all commodities

$$RFSCR = \sum_{c} WNP_c$$

An example of the steps from indicator to meta-indicator for UAE is found in table 20.

Table 20 Example Supply Chain Robustness Sub-Indicator for UAE

UAE	Number of Partners	Dietary Contribution	FCS	Commodity Score
dairy	8	0.06	4	1.80
maize	3	0.00	2	0.01
meat	4	0.05	4	0.83
oil	5	0.20	0.5	0.50
rice	2	0.12	2	0.49
soy	4	0.00	2	0.00
sugar	2	0.11	0.5	0.11
wheat	9	0.26	2	4.65
TOTAL		0.80		8.40

7. Normalized Meta-Indicator

The raw Supply Chain Robustness scores for the six representative nations are listed in Table 21.

Table 21 Representative Raw Supply Chain Robustness Scores

Nation	**Supply Chain Robust**
United Arab Emirates	9.13
Argentina	15
Bangladesh	2.66
Egypt	4.39
Ethiopia	3.57
Philippines	4.73

Using rules developed to map Raw Supply Chain Robustness Scores to vulnerability shown below Table 21 is transformed to Table 22.

Classification	Upper Bound <
VERY LOW	7.5
LOW	5
MEDIUM	3
HIGH	1.5
EXTREME	0

Table 22 Representative Normalized Categorization

Nation	Supply Chain Robust
United Arab Emirates	Very Low
Argentina	Very Low
Bangladesh	High
Egypt	Medium
Ethiopia	Medium
Philippines	Medium

3. THE JAMEEL INDEX FOR FOOD TRADE AND VULNERABILITY

With the five meta-indicators defined and evaluated for six representative nations, the composite index that comprises the Jameel Index for Food Trade and Vulnerability can be developed. Following the guidelines for the UN DESA primer (UN DESA, 2007) to ensure transparency, a linear multi-criterion weighting model was used to combine the five meta-indicators into the Jameel Index

The Index Formulation

There are five meta-indicators developed:

1. Food Import Dependency
2. Feed Import Dependency
3. Foreign Exchange
4. Supply Chain Reliability
5. Supply Chain Robustness

For each of the meta-indicators, M, the normalized vulnerability was assessed and is presented in Table 23

Table 23 Meta-Indicator Vulnerability Assessment for Representative Nations

Nation	Food Import Dependency	Feed Import Dependency	Foreign Exchange	Supply Chain Reliability	Supply Chain Robustness
United Arab Emirates	Extreme	Extreme	Low	High	Very Low
Argentina	Very Low	Very Low	Medium	Very Low	Extreme
Bangladesh	Low	Medium	Very Low	Medium	High
Egypt	Medium	Medium	High	Medium	Medium
Ethiopia	Very Low	Very Low	High	Low	High
Philippines	Medium	Low	Medium	Medium	Medium

To perform the multi-criterion aggregation to a single index, each of the normalized vulnerabilities are mapped to an intermediate value and are stored in the single variable VUL_M .

Table 24 Jameel Classification Mapping

Vulnerability Classification	Very Low	Low	Medium	High	Extreme
VUL_M	1	2	3	4	5

The mapping from is found in Table 24. Using Table 24, each of the six representative nations in Table 23 is mapped to VUL_M and presented in Table 25.

Table 25 Meta Indicator Vulnerability Assessment

Nation	Food Import Dependency	Feed Import Dependency	Foreign Exchange	Supply Chain Reliability	Supply Chain Robustness
United Arab Emirates	5	5	2	4	1
Argentina	1	1	3	1	5
Bangladesh	2	3	1	3	4
Egypt	3	3	4	3	3
Ethiopia	1	1	4	2	4
Philippines	3	2	3	3	3

For each of the meta-indicators, M, a weight is assigned WM_M. The weight is set to default of 1 for each Meta-Indicator. However, via the Index's user interface the user can modify the weight to 0, 0.5, 1, 2, and 3.. WM_M is the weight for each meta indicator M.

The raw index in calculate by taking the product of all five meta vulnerability scores times their weight, WM_M , and then taking the 1/M root of the product as presented in the equation below

$$\mathrm{RAWJx} = \left(\prod_{M} \mathrm{WM_M} * \mathrm{VUL_M}\right)^{1/M}$$

Step 2 Calculating the Normalized Index

For the case with all weights set to1, the minimum score possible RawJx is 1 so MinJx = 1. The maximum score possible RawJx is 5 so MaxJx = 5. The JxRange = MaxJx- MinJx or 4. The normalized Jx is a measure of where a nation's score falls within the range of possible value as a ratio of the range and then multiplied by 100 to reflect the percentage of maximum vulnerability the nation is facing, per the equation below

Jx = (RawJx-1) /RangeJx * 100

Extreme based on the mapping in the Table 26 below.

Table 26 Jameel Score Mapping

Very Low	Low	Medium	High	Extreme
<15.8	15.8 - <25.1	25.1- <39.8	39.8- <63.1	≥ 63.1

Mapping the score in Table 27 using the rules from Table 26 results in the Jameel Index for the representative nations presented in Table 27.

Table 27 Generic Jameel Index

Nation	Raw Score	Normalize	Classification
United Arab Emirates	2.99	35.1	Medium
Argentina	1.43	3.5	Very Low
Bangladesh	1.78	10.7	Very Low
Egypt	4.19	59.1	High
Ethiopia	1.63	7.9	Very Low
Philippines	2.22	19.6	low

3.2 A User Adjustable Jameel Index on the Website

The Jameel Index development team having chosen the Canonical or scaled formulation of the Jameel index to best addresses all the factors of food trade potential vulnerability to food security, understands that a weighting of each meta indicator to develop a user appropriate Jameel index is a key feature of the Index. However, the default data weights on the website and for the following case study are set to one.

The UN DESA (2007) reminds us of two key points about composite indicators:

1) *"Composite indices should not be seen as an end in themselves. ...., they should be seen as opportunities to initiate discussion and debate on policy." (p.21)*
2) *"Given that many are easier to interpret than a set of indicators,"* they employ weights and *"Weights reflect value judgments. ..they need to be explicitly explained and justified in all cases."(p.23)*

However, the development team acknowledges that many users or stakeholder may feel certain meta indicators should not be included or weighted less than others for their application. Therefore, when the Index is presented, the users will be able to modify the weights for each of the six meta indicators from the default 1 to 0, 0.5,1, 2, or 3.

3.3 The Adaptive Jameel Index to address the questions being asked.

The Jameel Index Platform (jameelindex.mit.edu) provides a wide range of information for the user. It provides the classification of the five meta indicators, as well as a user-defined scaled weighted composite index.

In future analyses, the Index will be used to examine three eras of data:

1. Historical Analysis 2014 to 2024
2. Immediate Future 2025 to 2030
3. Mid-Term Future 2035 & 2050

As the Jameel Index matures, it is hoped that the existing meta indicators maybe modified and new ones added, but we believe that these six—with the ability to customize—the composite Jameel Index is an excellent starting point.

4. A Case Study Use of the Jameel Index

Section 3 provided a detailed description of the meta-indicators and the Jameel Index and provided example calculations for a set of representative countries. This was to provide the reader with a presentation of the conceptual framework, the implementation logic, and data as well at the assumptions used.

This section is to provide an illustration of a basic global analysis of the five meta-indicators and the Jameel Index. This analysis will provide national results as well as global and regional statistics on the six meta-indicators and the Jameel Index vulnerability for historical data from 2014 to 2020.

4.1 Country Scale Analysis

The Jameel Index framework was run for the historical data from 2014 to 2021. Only subset of the results will be presented in this document, the full results can be found at the Jameel Index Website (https://jameelindex.mit.edu/). The full global analysis for 2020 for the 163 countries with data is found in Appendix B.

Table 28 presents the results for 2020 for the first 13 countries in the global database. It is a mock-up of the how the data will be presented in tabular form on the website. It presents the vulnerability classification of the six meta indicators and the Jameel Index. These first 13 countries exhibit the full range of The Jameel Index from Very Low to Extreme.

Table 28 Jameel Index for 2020

Nation	Food Import Depend	Feed Import Depnd	Foreign Exch	Supply Chain Reliab	Supply Chain Robust	Jameel Index
Afghanistan	Medium	Medium	Very Low	Medium	Medium	Medium
Angola	Medium	Low	Medium	Medium	Medium	Medium
Albania	Medium	Low	Medium	High	Very Low	Low
United Arab Emirates	Extreme	Extreme	Low	High	Very Low	Medium
Argentina	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
Armenia	High	Medium	Medium	Medium	High	High
Antigua and Barbuda	Extreme	Very Low	Very Low	Medium	Low	Medium
Australia	Very Low	Very Low	Very Low	Very Low	Extreme	Very Low
Austria	Low	Low	Very Low	Low	High	Very Low
Azerbaijan	Medium	Low	Medium	High	Medium	Medium
Burundi	Very Low	Very Low	High	Very Low	High	Low
Belgium	Medium	High	Low	Medium	Medium	Low
Benin	Medium	Very Low	Extreme	Low	Medium	Medium

Table 29 presents the 2018 results for the first 13 countries in the global database. It demonstrates that Food Trade and Vulnerability is not static but is dynamic from year to year due to many climate, economic, and political factors. The Jameel Index changed classification for 4 of the 13 countries between 2018 and 2020. Afghanistan, Antigua, Belgium, and Benin all showed a decrease of vulnerability in 2020 compared to 2018.

Table 29 Jameel Index for 2018

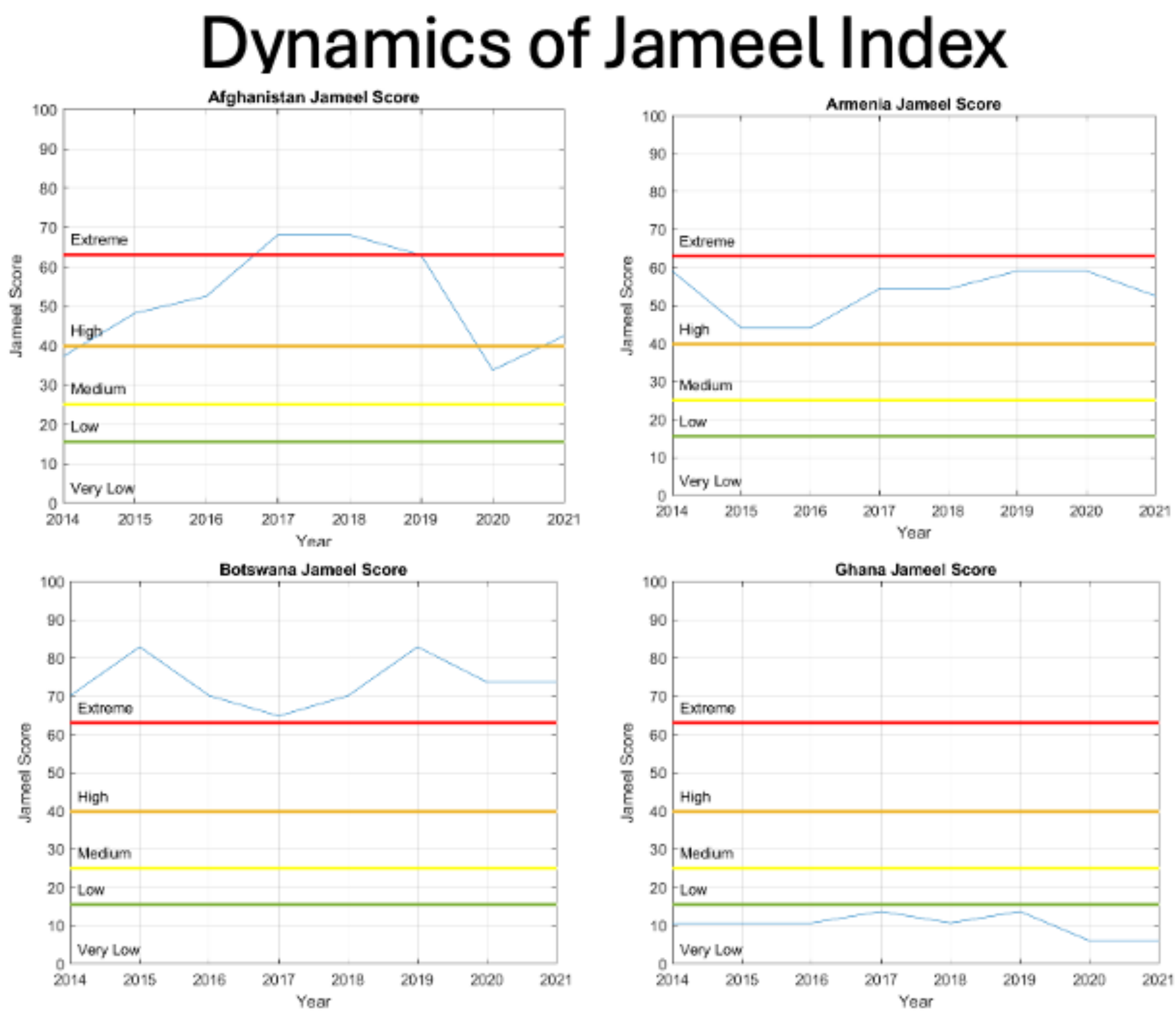
Country	Food Import Dependency	Feed Import Dependency	Foreign Exchange	Supply Chain Reliability	Supply Chain Robustness	Jameel Index
Afghanistan	High	Medium	Extreme	High	Medium	High
Angola	Medium	Low	Medium	Medium	High	Medium
Albania	Medium	Low	Medium	High	Low	Low
United Arab Emirates	Extreme	Extreme	Low	High	Very Low	Medium
Argentina	Very Low	Very Low	Medium	Very Low	Extreme	Very Low
Armenia	Medium	Medium	Medium	Medium	High	High
Antigua and Barbuda	Extreme	Medium	Extreme	Medium	Low	High
Australia	Very Low	Very Low	Very Low	Very Low	Extreme	Very Low
Austria	Very Low	Low	Very Low	Very Low	High	Very Low
Azerbaijan	Medium	Low	Low	High	Medium	Medium
Burundi	Very Low	Very Low	High	High	High	Low
Belgium	Medium	High	Low	Medium	High	Medium
Benin	Medium	Low	Extreme	Medium	High	High

4.2 Country Dynamic Analysis

Presenting time series of the full global 163 country dataset is problematic in a document but presenting country-level dynamic Jameel Index results for select countries is possible. Figure 5 present the results for four countries for the years 2014 to 2020. The bars in the figure presents the “raw” Jameel Index scores. The colored lines are the threshold for the vulnerability classification which are presented in Tables 28 and 29. The figure reveals the two interesting insights:

1. There can be significant yearly variation and trends. Afghanistan shows a trend from lower Medium Vulnerability in 2014 to upper High Vulnerability only 3 years later in 2017
2. There can be slight variation around a trend that remains in the same vulnerability classification, Botswana and Ghana, or this variation can stratal a classification threshold like Armenia such that discrete classification can overstate the variability of vulnerability for a country.

Figure 5 Jameel Index for 2020



4.3 Global Analysis

When averaging the results of the Jameel Index over geographical regions there are two variations:

- By Population – to determine the percentage of the region's population in each class, the countries are sorted by classification and population of each country in the class is summed, then divided by the total population in the region.

- By Countries - to determine the percentage of the region's countries in each class, the countries are sorted by classification and the number countries in the class is summed, then divided by the total population in the region.

Presenting results of the full global 163 country for 2020 is presented in Table 30 Global Jameel Analysis 2020for both population and countries.

The results are quite interesting as it show most of the globe's population,70.5% are in the Very Low classification while only 10.3% are High or Extreme. While the only 33% of the globe's countries are classified Very Low and 32.5 % are High or Extreme

This reflects the findings that the large highly populated countries have very low vulnerabilities while it is the same nations that face food trade vulnerability and generally less resources to overcome this vulnerability.

To investigate these global findings, we present a series of deep-dive analyses presenting the Jameel Index results by income classes and by a variety of regional disaggregation used by the UN, the World Bank, and the ISO 3166 standard regions.

Table 30 Global Jameel Analysis 2020

World Population: *Percentage of the Globe's population in each Vulnerability Classification*

Very Low	Low	Medium	High	Extreme	kcal	GDP Per Capita
70.5	9.8	9.4	9.7	0.6	2974	12,592

World Countries: *Percentage of the Globe's Countries in each Vulnerability Classification*

Very Low	Low	Medium	High	Extreme	kcal	GDP Per Capita
33.1	12.9	21.5	28.2	4.3	2974	12,592

4.4 Global Income Level Analysis

The World Bank Group assigns the globe's economies to four income groups – low, lower-middle, upper-middle, and high. The income classification for 2024 are listed below:

Low Income	≤ 1,135
Lower-middle Income	1,136 – 4,466
Upper-middle Income	4,466-13,845
High Income	>13,845

Presenting results of the full global 163 country for 2020 is presented in Table 31 for both population and countries.

The results show that the approximately two-thirds of Low-Income population and countries fall into the Very Low or Low Vulnerable Classification. This is surprising, but when looks at the average per capita calories available to the Low-Income level you see it one-third lower than the Upper-middle and High-Income level. This suggests that the Low-Income countries do not have the resources to import. Thus, they that are not vulnerable to food trade disruption but *are* food insecure.

This finding is currently under investigation and a report is due out in mid-2025.

Table 31 Income Class Jameel Analysis 2020

Income Population *Percentage of the Income's class population in each Vulnerability Classification*

Income	Very Low	Low	Medium	High	Extreme	kcal	GDP Per Capita
Low	67.5	9.2	12.5	7.2	3.6	2300	704
Lower Middle	70.0	13.1	4.0	12.4	0.5	2693	2,596
Upper Middle	81.4	6.6	4.0	7.7	0.2	3262	11,038
High	51.4	7.6	33.4	7.5	0.0	3490	48,694

Income Countries *Percentage of the Income's countries in each Vulnerability Classification*

Income	Very Low	Low	Medium	High	Extreme	kcal	GDP Per Capita
Low	60.0	10.0	15.0	10.0	5.0	2300	704
Lower Middle	30.4	13.0	15.2	34.8	6.5	2693	2,596
Upper Middle	25.0	11.4	20.5	36.4	6.8	3262	11,038
High	32.1	15.1	30.2	22.6	0.0	3490	48,694

4.5 Regional Analysis

For this analysis, a series of regional statistical analyses were performed on the 2020 global Jameel Index outputs for the 163 countries for the UN, the World Bank, and the 14 regions as defined by the ISO 3166 standard. Appendix C provides the mapping of the 163 countries to the 14 regions.

The regional results for 2018 are reported in Table 32.   There are many interesting insights found in table 32 and we invite the reader to scan the table to investigate the regions of interest.

Table 32 Regional Jameel Analysis 2020

UN Region Population

UN Region	Very Low	Low	Medium	High	Extreme	kcal	GDP Per Capita
Africa	66.6	6.6	4.2	22.1	0.5	2606	2,096
Asia	74.4	11.0	8.9	4.9	0.8	2913	8,019
Europe	64.1	12.5	21.2	2.2	0.0	3415	32,290
Latin America and the Caribbean	46.2	11.4	7.5	34.9	0.0	3115	8,417
Northern America	89.7	0.0	10.3	0.0	0.0	3872	69,139
Oceania	59.7	0.0	36.9	1.2	2.1	3101	43,037

UN Region Countries

UN Region	Very Low	Low	Medium	High	Extreme	kcal	GDP Per Capita
Africa	42.2	11.1	13.3	26.7	6.7	2606	2,096
Asia	23.1	15.4	25.6	28.2	7.7	2913	8,019
Europe	48.7	17.9	20.5	12.8	0.0	3415	32,290
Latin America and the Caribbean	16.7	10.0	20.0	53.3	0.0	3115	8,417
Northern America	50.0	0.0	50.0	0.0	0.0	3872	69,139
Oceania	12.5	0.0	50.0	25.0	12.5	3101	43,037

UN Subregion Population

UN Subregion	Very Low	Low	Medium	High	Extreme	kcal	GDP Per Capita
Northern Africa	0.0	0.0	3.2	96.8	0.0	3367	4,034
Southern Africa	87.4	0.0	0.0	3.4	9.3	2819	6,745
Eastern Africa	69.1	10.5	7.5	12.9	0.0	2235	1,068
Western Africa	82.6	9.3	2.2	5.9	0.0	2700	1,785
Middle Africa	95.1	1.4	3.4	0.1	0.0	2291	1,195
Southern Asia	90.9	1.5	0.0	7.6	0.0	2585	2,228
South-eastern Asia	22.4	55.6	22.1	0.0	0.0	2897	4,400
Eastern Asia	86.9	0.5	12.6	0.0	0.0	3276	15,925
Western Asia	0.0	35.6	22.2	30.9	11.4	3196	12,910
Central Asia	53.7	19.0	0.0	0.0	27.3	3083	6,028
Northern Europe	19.3	11.8	68.9	0.0	0.0	3391	53,649
Southern Europe	8.6	31.7	48.6	11.1	0.0	3396	29,090
Eastern Europe	97.6	2.4	0.0	0.0	0.0	3328	12,905
Western Europe	80.6	13.2	6.2	0.0	0.0	3569	51,652
South America	69.5	17.1	8.4	5.0	0.0	3138	8,070
Central America	0.0	0.0	0.0	100.0	0.0	3062	9,061
Caribbean	0.0	0.3	42.1	57.6	0.0	3109	9,383
Northern America	89.7	0.0	10.3	0.0	0.0	3872	69,139
Australia and New Zealand	83.4	0.0	16.6	0.0	0.0	3398	58,859
Melanesia	0.0	0.0	92.0	0.0	8.0	2315	2,758
Micronesia	0.0	0.0	100.0	0.0	0.0	3103	2,244
Polynesia	0.0	0.0	0.0	100.0	0.0	3016	13,379

UN Subregion Countries

UN Subregion	Very Low	Low	Medium	High	Extreme	kcal	GDP Per Capita
Northern Africa	0.0	0.0	20.0	80.0	0.0	3367	4,034
Southern Africa	20.0	0.0	0.0	20.0	60.0	2819	6,745
Eastern Africa	50.0	14.3	14.3	21.4	0.0	2235	1,068
Western Africa	50.0	14.3	14.3	21.4	0.0	2700	1,785
Middle Africa	57.1	14.3	14.3	14.3	0.0	2291	1,195
Southern Asia	42.9	14.3	0.0	42.9	0.0	2585	2,228
South-eastern Asia	50.0	25.0	25.0	0.0	0.0	2897	4,400
Eastern Asia	14.3	14.3	71.4	0.0	0.0	3276	15,925
Western Asia	0.0	7.1	21.4	57.1	14.3	3196	12,910
Central Asia	33.3	33.3	0.0	0.0	33.3	3083	6,028
Northern Europe	40.0	30.0	30.0	0.0	0.0	3391	53,649
Southern Europe	25.0	8.3	25.0	41.7	0.0	3396	29,090
Eastern Europe	90.0	10.0	0.0	0.0	0.0	3328	12,905
Western Europe	42.9	28.6	28.6	0.0	0.0	3569	51,652
South America	45.5	18.2	18.2	18.2	0.0	3138	8,070
Central America	0.0	0.0	0.0	100.0	0.0	3062	9,061
Caribbean	0.0	9.1	36.4	54.5	0.0	3109	9,383
Northern America	50.0	0.0	50.0	0.0	0.0	3872	69,139
Australia and New Zealand	50.0	0.0	50.0	0.0	0.0	3398	58,859
Melanesia	0.0	0.0	66.7	0.0	33.3	2315	2,758
Micronesia	0.0	0.0	100.0	0.0	0.0	3103	2,244
Polynesia	0.0	0.0	0.0	100.0	0.0	3016	13,379

World Bank Region Population

World Bank Region	Very Low	Low	Medium	High	Extreme	kcal	GDP Per Capita
Sub-Saharan Africa	79.5	7.9	4.4	7.6	0.6	2458	1,720
Middle East & North Africa	0.0	0.0	11.3	82.4	6.2	3141	7,695
East Asia & Pacific	67.9	16.2	15.8	0.0	0.0	3165	13,129
South Asia	95.1	1.6	0.0	3.3	0.0	2564	2,142
Europe & Central Asia	56.3	20.9	19.0	2.7	1.1	3430	28,559
Latin America & Caribbean	46.2	11.4	7.5	34.9	0.0	3115	8,417
North America	89.7	0.0	10.3	0.0	0.0	3872	69,139

World Bank Region Countries

World Bank Region	Very Low	Low	Medium	High	Extreme	kcal	GDP Per Capita
Sub-Saharan Africa	47.5	12.5	12.5	20.0	7.5	2458	1,720
Middle East & North Africa	0.0	0.0	18.8	68.8	12.5	3141	7,695
East Asia & Pacific	26.1	13.0	47.8	8.7	4.3	3165	13,129
South Asia	50.0	16.7	0.0	33.3	0.0	2564	2,142
Europe & Central Asia	43.5	19.6	19.6	15.2	2.2	3430	28,559
Latin America & Caribbean	16.7	10.0	20.0	53.3	0.0	3115	8,417
North America	50.0	0.0	50.0	0.0	0.0	3872	69,139

ISO Region Population

ISO Region	Very Low	Low	Medium	High	Extreme	kcal	GDP Per Capita
Northern Africa	0.0	0.0	3.2	96.8	0.0	3367	4,034
Sub-Saharan Africa	79.5	7.9	4.4	7.6	0.6	2458	1,720
Middle East	0.0	0.0	31.5	48.5	20.0	2845	15,654
Southern Asia	90.9	1.5	0.0	7.6	0.0	2585	2,228
South-eastern Asia	22.4	55.6	22.1	0.0	0.0	2897	4,400
Eastern Asia	86.9	0.5	12.6	0.0	0.0	3276	15,925
Western Asia	0.0	82.5	9.9	7.6	0.0	3659	9,293
Central Asia	53.7	19.0	0.0	0.0	27.3	3083	6,028
Eastern Europe	97.6	2.4	0.0	0.0	0.0	3328	12,905
Western Europe	42.6	19.0	34.7	3.7	0.0	3470	44,685
Latin America and the Caribbean	46.2	11.4	7.5	34.9	0.0	3115	8,417
Northern America	89.7	0.0	10.3	0.0	0.0	3872	69,139
Australia and New Zealand	83.4	0.0	16.6	0.0	0.0	3398	58,859
Oceania	0.0	0.0	88.2	4.3	7.6	2354	3,206

ISO Region Countries

ISO Region	Very Low	Low	Medium	High	Extreme	kcal	GDP Per Capita
Northern Africa	0.0	0.0	20.0	80.0	0.0	3367	4,034
Sub-Saharan Africa	47.5	12.5	12.5	20.0	7.5	2458	1,720
Middle East	0.0	0.0	22.2	55.6	22.2	2845	15,654
Southern Asia	42.9	14.3	0.0	42.9	0.0	2585	2,228
South-eastern Asia	50.0	25.0	25.0	0.0	0.0	2897	4,400
Eastern Asia	14.3	14.3	71.4	0.0	0.0	3276	15,925
Western Asia	0.0	20.0	20.0	60.0	0.0	3659	9,293
Central Asia	33.3	33.3	0.0	0.0	33.3	3083	6,028
Eastern Europe	90.0	10.0	0.0	0.0	0.0	3328	12,905
Western Europe	34.5	20.7	27.6	17.2	0.0	3470	44,685
Latin America and the Caribbean	16.7	10.0	20.0	53.3	0.0	3115	8,417
Northern America	50.0	0.0	50.0	0.0	0.0	3872	69,139
Australia and New Zealand	50.0	0.0	50.0	0.0	0.0	3398	58,859
Oceania	0.0	0.0	50.0	33.3	16.7	2354	3,206

5. Summary and Conclusions

The goal of this paper is to present the theoretical and procedural background to the Jameel Index for Food Trade and Vulnerability. The introductory sections presented the framework methodology and data used, which was illustrated using six representative countries that spanned a range of geographic and economic conditions.

After the introduction of the methodology and its illustration, a global analysis for 2020 for the five meta-indicators and the composite Jameel Index for 163 countries were presented. The dynamic trends in the Jameel Index were presented for 4 countries. A statistical analysis global, by income levels and a series of global regional disaggregations were performed.

These case study analyses are intended to illustrate the potential regional differences that exist for food trade vulnerability and provide the reader with a sense of the potential for the use of the Index. It was not intended to be a policy analysis. This paper is intended to be a background documentation to the Jameel Index and the material on the Jameel Index website (jameelindex.mit.edu).

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Appendix A Country ISO3 Abbreviation

	IS03	Nation		IS03	Nation
1	'AFG'	'Afghanistan'	42	'DMA'	'Dominica'
2	'AGO'	'Angola'	43	'DNK'	'Denmark'
3	'ALB'	'Albania'	44	'DOM'	'Dominican Republic'
4	'ARE'	'United Arab Emirates'	45	'DZA'	'Algeria'
5	'ARG'	'Argentina'	46	'ECU'	'Ecuador'
6	'ARM'	'Armenia'	47	'EGY'	'Egypt'
7	'ATG'	'Antigua and Barbuda'	48	'ESP'	'Spain'
8	'AUS'	'Australia'	49	'EST'	'Estonia'
9	'AUT'	'Austria'	50	'ETH'	'Ethiopia'
10	'AZE'	'Azerbaijan'	51	'FIN'	'Finland'
11	'BDI'	'Burundi'	52	'FJI'	'Fiji'
12	'BEL'	'Belgium'	53	'FRA'	'France'
13	'BEN'	'Benin'	54	'GAB'	'Gabon'
14	'BFA'	'Burkina Faso'	55	'GBR'	United Kingdom
15	'BGD'	'Bangladesh'	56	'GEO'	'Georgia'
16	'BGR'	'Bulgaria'	57	'GHA'	'Ghana'
17	'BHS'	'Bahamas'	58	'GIN'	'Guinea'
18	'BIH'	'Bosnia and Herzegovina'	59	'GMB'	'Gambia'
19	'BLR'	'Belarus'	60	'GRC'	'Greece'
20	'BLZ'	'Belize'	61	'GRD'	'Grenada'
21	'BOL'	Bolivia '	62	'GTM'	'Guatemala'
22	'BRA'	'Brazil'	63	'GUY'	'Guyana'
23	'BRB'	'Barbados'	64	'HKG'	'Hong Kong'
24	'BWA'	'Botswana'	65	'HND'	'Honduras'
25	'CAF'	'Central African Republic'	66	'HRV'	'Croatia'
26	'CAN'	'Canada'	67	'HUN'	'Hungary'
27	'CHE'	'Switzerland'	68	'IDN'	'Indonesia'
28	'CHL'	'Chile'	69	'IND'	'India'
29	'CHN'	'China'	70	'IRL'	'Ireland'
30	'CIV'	'Côte d''Ivoire'	71	'IRN'	Iran '
31	'CMR'	'Cameroon'	72	'ISL'	'Iceland'
32	'COD'	Congo, DRC'	73	'ISR'	'Israel'
33	'COG'	'Congo'	74	'ITA'	'Italy'
34	'COL'	'Colombia'	75	'JAM'	'Jamaica'
35	'COM'	'Comoros'	76	'JOR'	'Jordan'
36	'CPV'	'Cabo Verde'	77	'JPN'	'Japan'
37	'CRI'	'Costa Rica'	78	'KAZ'	'Kazakhstan'
38	'CUB'	'Cuba'	79	'KEN'	'Kenya'
39	'CYP'	'Cyprus'	80	'KGZ'	'Kyrgyzstan'
40	'CZE'	'Czechia'	81	'KHM'	'Cambodia'
41	'DEU'	'Germany'	82	'KIR'	'Kiribati'

	IS03	Nation		IS03	Nation
83	'KOR'	'Korea, Republic of'	125	'PRT'	'Portugal'
84	'KWT'	'Kuwait'	126	'PRY'	'Paraguay'
85	'LAO'	Laos'	127	'PYF'	'French Polynesia'
86	'LBN'	'Lebanon'	128	'ROU'	'Romania'
87	'LBY'	'Libya'	129	'RUS'	'Russian Federation'
88	'LCA'	'Saint Lucia'	130	'RWA'	'Rwanda'
89	'LKA'	'Sri Lanka'	131	'SAU'	'Saudi Arabia'
90	'LSO'	'Lesotho'	132	'SEN'	'Senegal'
91	'LTU'	'Lithuania'	133	'SLB'	'Solomon Islands'
92	'LUX'	'Luxembourg'	134	'SLE'	'Sierra Leone'
93	'LVA'	'Latvia'	135	'SLV'	'El Salvador'
94	'MAC'	'Macao'	136	'SRB'	'Serbia'
95	'MAR'	'Morocco'	137	'STP'	'Sao Tome and Principe'
96	'MDA'	Moldova'	138	'SUR'	'Suriname'
97	'MDG'	'Madagascar'	139	'SVK'	'Slovakia'
98	'MEX'	'Mexico'	140	'SVN'	'Slovenia'
99	'MKD'	'North Macedonia'	141	'SWE'	'Sweden'
100	'MLI'	'Mali'	142	'SWZ'	'Eswatini'
101	'MLT'	'Malta'	143	'SYC'	'Seychelles'
102	'MMR'	'Myanmar'	144	'SYR'	'Syrian Arab Republic'
103	'MNE'	'Montenegro'	145	'TGO'	'Togo'
104	'MNG'	'Mongolia'	146	'THA'	'Thailand'
105	'MOZ'	'Mozambique'	147	'TJK'	'Tajikistan'
106	'MRT'	'Mauritania'	148	'TTO'	'Trinidad and Tobago'
107	'MUS'	'Mauritius'	149	'TUN'	'Tunisia'
108	'MWI'	'Malawi'	150	'TUR'	'Turkey'
109	'MYS'	'Malaysia'	151	'TWN'	'Taiwan, Province of China'
110	'NAM'	'Namibia'	152	'TZA'	Tanzaniaf'
111	'NER'	'Niger'	153	'UGA'	'Uganda'
112	'NGA'	'Nigeria'	154	'UKR'	'Ukraine'
113	'NIC'	'Nicaragua'	155	'URY'	'Uruguay'
114	'NLD'	'Netherlands'	156	'USA'	United States '
115	'NOR'	'Norway'	157	'VCT'	Saint Vincent '
116	'NPL'	'Nepal'	158	'VNM'	'Viet Nam'
117	'NZL'	'New Zealand'	159	'WSM'	'Samoa'
118	'OMN'	'Oman'	160	'YEM'	'Yemen'
119	'PAK'	'Pakistan'	161	'ZAF'	'South Africa'
121	'PER'	'Peru'	162	'ZMB'	'Zambia'
122	'PHL'	'Philippines'	163	'ZWE'	'Zimbabwe'
123	'PNG'	'Papua New Guinea'			
124	'POL'	'Poland'			

Appendix B Jameel Index 2020

The reader is referred to the Jameel Index website where detailed results can be found

Jameelindex.mit.edu

Appendix C ISO 3166 The Global Regions

The 163 countries in the Jameel Database are divided into 14 regions and listed in Table B.1 and B.2 b. using the the International Organization for Standardization (ISO) ISO 3166 standard – *Codes for the representation of names of countries and their subdivisions*.[1]

Table B-1Global Regions

Central Asia	Eastern Asia	Southern Asia	South-eastern Asia	Western Asia	Middle East
Kazakhstan	China	Afghanistan	Brunei Darussalam	Armenia	United Arab Emirates
Kyrgyzstan	Japan	Bangladesh	Indonesia	Azerbaijan	Iraq
Tajikistan	Korea, Republic of	Bhutan	Cambodia	Cyprus	Israel
Turkmenistan	Mongolia	India	Lao Peoples	Georgia	Jordan
Uzbekistan	Korea (Democratic)	Iran	Myanmar	Turkey	Kuwait
	Taiwan, Province of China	Sri Lanka	Malaysia		Lebanon
		Nepal	Philippines		Oman
		Pakistan	Thailand		Palestine, State of
			Timor-Leste		Qatar
			Viet Nam		Saudi Arabia
					Syrian Arab Republic
					Yemen

Table B-2 Global Regions

Northern Africa	Sub-Saharan Africa	Eastern Europe	Western Europe	Latin America & Caribbean	Northern America	Australia and New Zealand	Oceania
Algeria	Angola	Bulgaria	Albania	Argentina	Canada	Australia	Fiji
Egypt	French So. Territories	Belarus	Austria	Bahamas	Greenland	New Zealand	New Caledonia
Western Sahara	Burundi	Czechia	Belgium	Belize	USA		Papua New Guinea
Libya	Benin	Hungary	Bosnia &Herz.	Bolivia			Solomon Islands
Morocco	Burkina Faso	Moldova, Republic of	Switzerland	Brazil			Vanuatu
Sudan	Botswana	Poland	Germany	Chile			
Tunisia	Central African Republic	Romania	Denmark	Colombia			
	Côte dIvoire	Russian Federation	Spain	Costa Rica			
	Cameroon	Slovakia	Estonia	Cuba			
	Congo, DR	Ukraine	Finland	Dominican Republic			
	Congo		France	Ecuador			
	Djibouti		United Kingdom	Guatemala			
	Eritrea		Greece	Guyana			
	Ethiopia		Croatia	Honduras			
	Gabon		Ireland	Haiti			
	Ghana		Iceland	Jamaica			
	Guinea		Italy	Mexico			
	Gambia		Lithuania	Nicaragua			
	Guinea-Bissau		Luxembourg	Panama			
	Equatorial Guinea		Latvia	Peru			
	Kenya		North Macedonia	Puerto Rico			
	Liberia		Montenegro	Paraguay			
	Lesotho		Netherlands	El Salvador			
	Madagascar		Norway	Suriname			
	Mali		Portugal	Trinidad and Tobago			
	Mozambique		Serbia	Uruguay			
	Mauritania		Slovenia	Venezuela			
	Malawi		Sweden				
	Namibia						
	Niger						
	Nigeria						
	Rwanda						
	Senegal						
	Sierra Leone						
	Somalia						
	South Sudan						
	Eswatini						
	Chad						
	Togo						
	Tanzania						
	Uganda						
	South Africa						
	Zambia						
	Zimbabwe						

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