An Outlook on Hunger

A Scenario Analysis on the Drivers of Hunger Through 2030

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Executive Summary

The following report was written at the request of Action Against Hunger's technical and advocacy groups. It is intended to support AAH directional strategy. The objective is to provide foresight into the factors that drive hunger and their trajectories through 2030, using structured analysis techniques that help to unravel their complex web of interactions.

The report discusses the heavy trends that predictably shape hunger over the reference period, including: natural disasters, population density, economic inequality, agricultural systems and agricultural productivity. It also identifies the following key drivers with uncertain trajectories that can be more successfully redirected through interventions to affect positive change, including: conflict, women's empowerment, food policy, energy policy, climate change policy and adaptation, purchasing power, commodity prices and trade. Additionally, the report outlines scenarios, based on the possible courses these drivers of hunger can take, to assist decision makers in strategic planning.

The report begins by providing an introduction to the topic of hunger. It includes Action Against Hunger's definition of hunger along with other key terms related to the topic. It additionally discusses the major international commitments to combatting hunger and methods of quantifying the state of hunger around the world. The next section begins the report's analysis, where the drivers of hunger are classified. It continues with the analysis of the critical uncertainties along with discussing its the central drivers of which. Lastly, it presents five scenarios for hunger through 2030 developed for this report. The annex contains additional material including a description of all the identified heavy trends, and an appendix provides a quantitative analysis of hunger using indicators assigned to the drivers in relation to five measures of hunger.

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Introduction

Defining Hunger

In order to analyze the causes and prevalence of hunger, it is first necessary to understand what hunger is. Simply put, hunger is a physiological condition resulting from a lack of sufficient food that results in weakness and discomfort. Though there are many terms that describe specific aspects or consequences of hunger, and many indicators used to measure them.

Undernourishment, the lack of sufficient energy (kilocalories) intake, has been the primary measure of hunger. It was used to track the progress of the World Food Summit and Millennium Development Goals. The major international agencies that address hunger continue to institutionally define hunger as a caloric deficiency[1], while addressing nutrient deficiencies as a related but distinct issue. However, there is wide criticism of the use of undernourishment alone to define hunger[2].

For this report, Action Against Hunger defines hunger as a "state of deprivation according to which an individual cannot satisfy his/her basic food needs (quantity and quality), required for a healthy and active life." Defining hunger as undernourishment overlooks many of its aspects such as the nutritional quality of food and periods of acute hunger lasting less than one year. Our definition is intended to take a more holistic approach to this pressing issue — One that encompasses the physiological toll on an individual resulting from the inadequate intake of energy and nutrients including macronutrients like protein and micronutrients like vitamins and minerals. It is also intended to include a range of time scales from periodic hunger that could last only days or weeks to chronic hunger lasting years. It should also be noted that the number of people experiencing hunger is far greater when using this definition than a very restricted one like undernourishment. We hope that our definition of hunger will help to provide a unified approach to protecting human health and wellness in a manner fitting with our organizational mission.

The following definitions are a reference to help illustrate the different components of hunger:

- **Hunger** – Action Against Hunger defines hunger as a state of deprivation according to which an individual cannot satisfy his/her basic food needs (quantity and quality), required for a healthy and active life. FAO, WFP, and other international bodies define hunger as undernourishment[3,4].

- **Food insecurity** – A condition where food is inadequate or uncertain. A broad term reflecting the condition of not having sufficiently safe and nutritious food to live a healthy and active life. The four pillars of food security are: availability, accessibility, utilization, and stability. Individuals can be food insecure without being hungry if they are at risk of hunger.

- **Malnutrition –** A broad term that includes a range of negative health outcomes resulting from being underweight due to insufficient nutrient intake or absorption

> Action Against Hunger defines hunger as a "state of deprivation according to which an individual cannot satisfy his/her basic food needs (quantity and quality), required for a healthy and active life."

(undernutrition), being overweight due to excessive food intake (overnutrition), or suffering from micronutrient deficiencies.[5]

- **Undernutrition** – The result of prolonged insufficient food intake and/or nutrient absorption, that which results from disease, which can include stunting, wasting, and micronutrient deficiencies[6].

- **Undernourishment** – Insufficient dietary energy intake. FAO specifically defines it as a state lasting over one year where less kilocalories are consumed than are necessary to meet one's Minimum Dietary Energy Requirement (MDER). Also referred to as Chronic Hunger[7].

- **Micronutrient deficiency** – Insufficient intake or absorption of vitamins and/or minerals necessary for good health. Also, referred to as Hidden Hunger as it can result in poor health outcome even though the individual is consuming a sufficient number of calories[8].

- **Stunting or Chronic Undernutrition** – The result of inadequate dietary intake or frequent illness during early childhood or while in the womb. It can permanently impede a child from realizing their full developmental potential of physical growth and cognitive abilities. Often measured by height-to-age ratios[9].

- **Wasting or Acute Undernutrition** – Rapid weight loss or failure to gain weight. Often measured by weight-to-height ratios or mid-upper arm circumferences (MUAC). Used as a measure of the severity of a crisis as it highlights food shortages and/or disease outbreaks. It is strongly correlated with mortality[10].

- **Chronic hunger** – Hunger that occurs over a prolonged timeframe and is most often a result of poverty where people are unable to access sufficient food.

- **Seasonal hunger** – A reoccurring and predictable pattern of hunger such as from the hunger gap, when the food from last year's harvest has run out but the next year's crop is not yet ready to harvest.

- **Transitory hunger** – A temporary, short term, and often unpredictable occurrence that can result from war, natural disasters or price fluctuations. Understanding the temporal character of hunger is important for designing effective solutions to it, such as whether a short-term relief or long-tern structural development is necessary to remedy it.

International commitments to ending hunger

Since the 1990s, the international community has set forth three principal commitments to combating hunger. The World Food Summit (1996) and Millennium Development Goals (2000) concluded in 2015, at which point the Sustainable Development Goals began its fifteen-year initiative.

World Food Summit (WFS)

In November 1996, the Food and Agriculture Organization (FAO) organized the World Food Summit in Rome. Attended by representatives from 186 governments, the summit was concluded with the signature of the Rome Declaration. The declaration set numerous measurable objectives to combat hunger and promote global access to safe and nutritious food. Among these objectives, one aims at "eradicating hunger in all countries, with an immediate view to reducing the number of undernourished people to half their present level no later than 2015"[11]. In 1996, there were an estimated 960 million undernourished people in the world, so this would have required reducing the number to around 430 million by 2015[12]. This objective, based on an absolute number reduction, was overly ambitious given the international commitment to reaching the goal. The difficulty lay in having to end hunger for everyone alive in 1996 while also feeding over 1.5 billion more people born during the following twenty years of the reference period. This was particularly challenging as many of the regions with the greatest hunger also had the highest population growth rates. Indeed, the target was missed by a wide margin globally. By 2015, the target year, the number of undernourished people stood at 795 million, far above the goal of roughly 430 million[13]. Though 29 countries have met the WFS target[14], it is unlikely the world will reach it before 2040[15].

Millennium Development Goals (MDGs)

The 2000 Millennium Summit gathered 189 member states at the United Nations headquarters and was concluded by the adoption of the Millennium Declaration. The declaration contains eight chapters referring to new development goals to be achieved by the year 2015. The first development goal of the declaration (MDG1) was to eradicate extreme poverty and hunger. To do so, the declaration set a clear target 1.c: "halve, between 1990 and 2015, the proportion of people who suffer from hunger"[16].

The MDG goal was based on reducing the proportion of undernourished people in the developing world rather than the total number. As such, this goal was less ambitious but more likely to be achieved than the WFS goal. The MDG target on reduction was nearly reached — a far greater success than the WFS goal. The global proportion of undernourished people fell from 23.3% in 1990-1992 to 12.9% in 2014-2016[17]. The greatest progress was made in South and Southeast Asia, with slower progress occurring in Sub-Saharan Africa. The FAO estimates that in the next ten years, the the global proportion of undernutrition will fall to 8%, corresponding to less than 550 million people. So, while the share of undernourished people continues to decline, the total numbers are doing so at a much slower rate because of continued population growth in the developing world[18]. The effects of climate change may also limit continued progress[19].

FAO's Assessment of the WFS and MDG goals of reducing undernourishment[20]
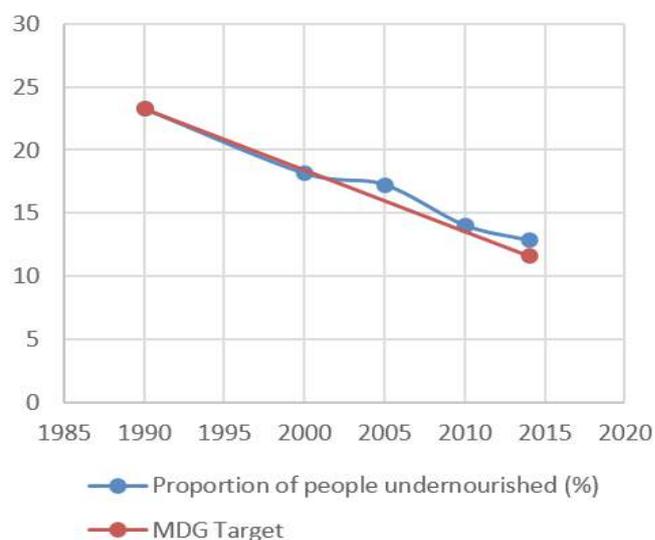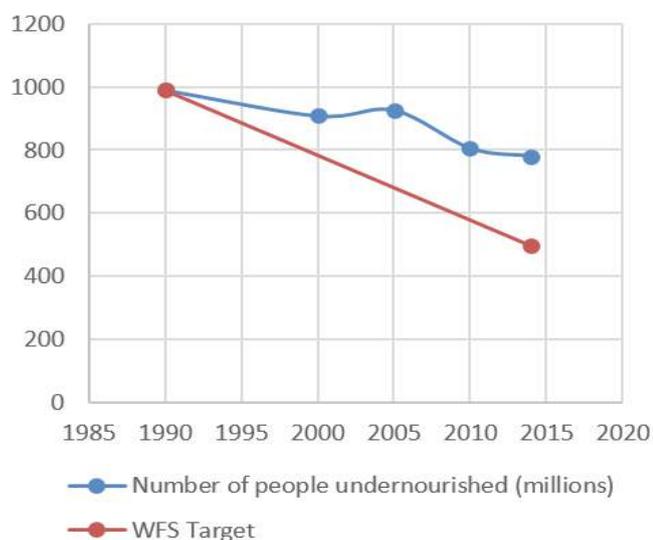
Undernourishment by country: Share of the population[21]

Legend

Share of undernourished persons (2015)

- >30%
- 20-30%
- 10-20%
- 5-10%
- No Data
- Undernourished population below 5%
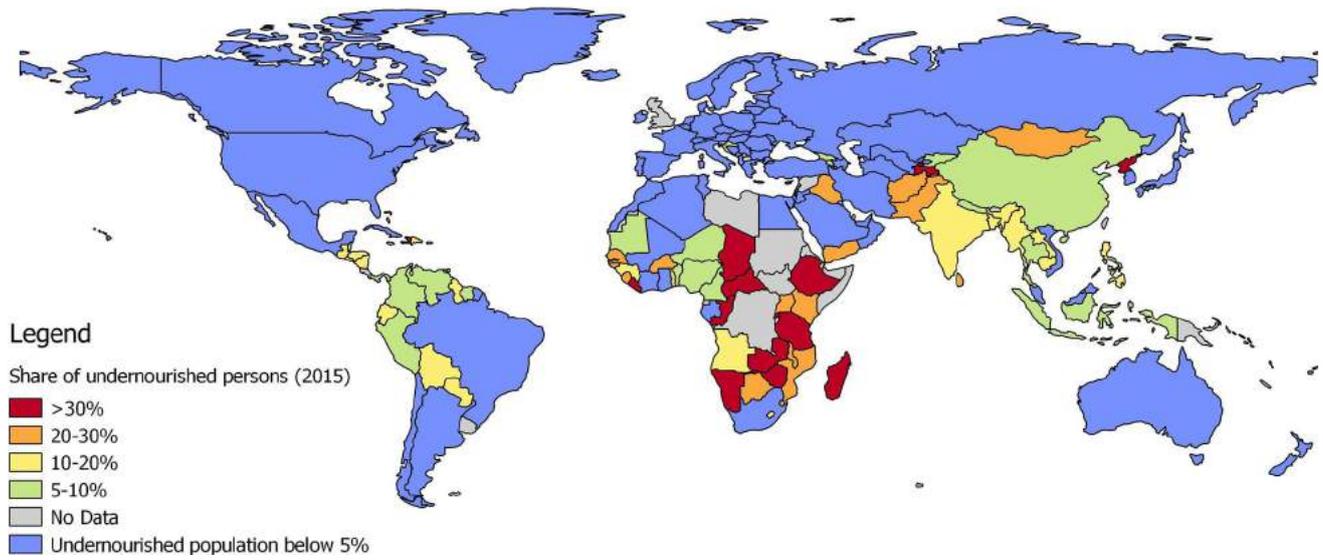
MDG: Halving the proportion[21]

Legend

Change in share of undernourished persons

- Increase
- Decrease of 0-25%
- Decrease of 25-50%
- Decrease of >50%.
- No Data
- Undernourished population below 5%
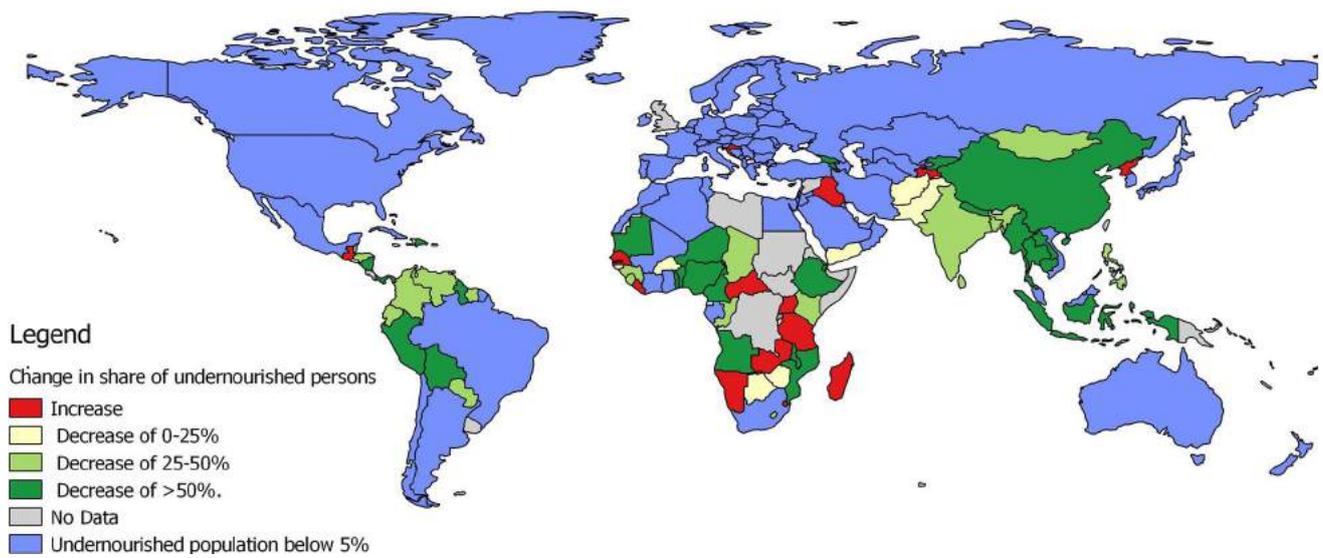
WFS: Halving the numbers[21]

Legend

Change in number of undernourished persons

- Increase
- Decrease of 0-25%
- Decrease of 25-50%
- Decrease of >50%.
- No Data
- Undernourished population below 5%
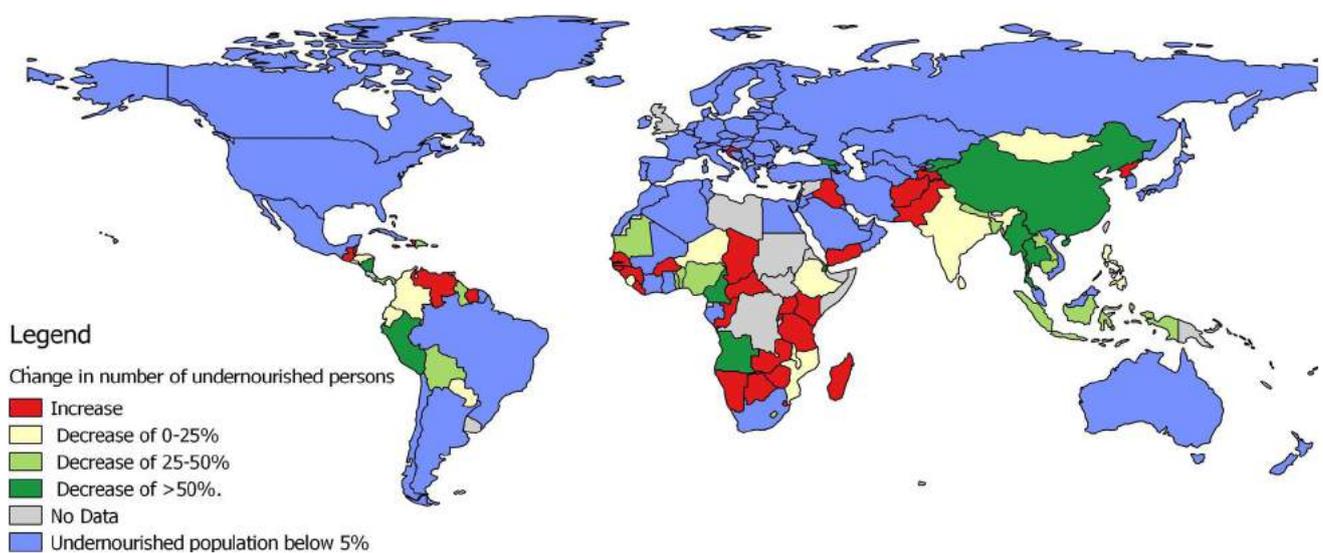
Reflections on the progress that has been made

The 2015 SOFI (State of Food Insecurity) report written by FAO addresses some of the leading issues that have contributed to reducing hunger around the world such as "economic growth, agricultural productivity growth, markets (including international trade) and social protection"[22]. Economic growth is a necessary condition but the gains generated must be distributed equally to be effective. Agricultural productivity must target "family farming and smallholder agriculture"[23] as it is the prevailing mode of agriculture in rural areas where people suffering from hunger are concentrated. Food markets are a strong determinant of food accessibility, nevertheless it is a highly complex one with multiple impacts and so must be addressed with precautions. Finally, FAO enhances the role of social protection in developing countries to achieve the MDG 1c target. More than each factor taken separately, it is their combination which proves to be the more effective.

Conversely, FAO underlines the negative impacts of crises, particularly protracted conflicts, on the progress of hunger reduction. Indeed, food insecurity is often induced by conflicts and civil strife. In the meantime, it can also be a cause of deepening of crises. Added to this, other political and economic factors such as good governance, political stability and the management of food prices volatility are required to ensure food security. Another factor, that FAO calls "weather-related shocks"[24] is also mentioned. This factor related to climate change and naturel disasters impacts, highlights the need of emergency and anticipatory measures from governments.

Controversies

The setting and use of the WFS and MDG targets were not without controversy. First, the initiatives to eliminate hunger have been progressively weaker. Starting with the World Food Conference in 1974 to end childhood hunger by 1984, the international community lowered their ambition down to the WFS goal of halving the total number of people who were hungry, and then once more, the MDG of halving the share of people who were hungry. Eliminating hunger certainly has been more challenging than originally thought. Lowering the hunger reduction targets to make them achievable can reduce expectations, public and political will, and create a false sense of success when concerted action needs to be maintained.

Secondly, there has been an emphasis on global numbers that can conceal worrying regional trends[25]. China accounts for nearly half the total reduction during the MDG reference period. Also, while nearly 300 million people were lifted out of hunger, about 85 million became hungry during the 1990-2015 reference period. 19 countries saw over one million more hungry people. So, while there have been great successes, the tendency to aggregate to the global level can conceal the many failures.

Lastly, there has been widespread criticism of the use of Prevalence of Undernourishment (PoU) to measure hunger, which will be discussed in the following section. Besides, as the FAO sought to recalibrate this metric they have changed their figures. The FAO does provide very detailed explanations of how they calculate PoU and their motivation for the updated methodology[26]. However, some have still been critical of how the data changed after the major 2012 revisions[27]. One point was that the revisions reversed an increasing trend in global hunger. The revised data also increased past hunger values, thereby making for a greater reduction in the share of hunger and the near-achievement of MDG target 1c. While the FAO is very transparent and there has been no evidence of data manipulation for political purposes, such instances illustrate the need for more accurate metrics to monitor hunger and how announcements of success in the fight against hunger must be considered with great caution.

Prevalence of undernourishment in developing regions (millions)

Revised — Old
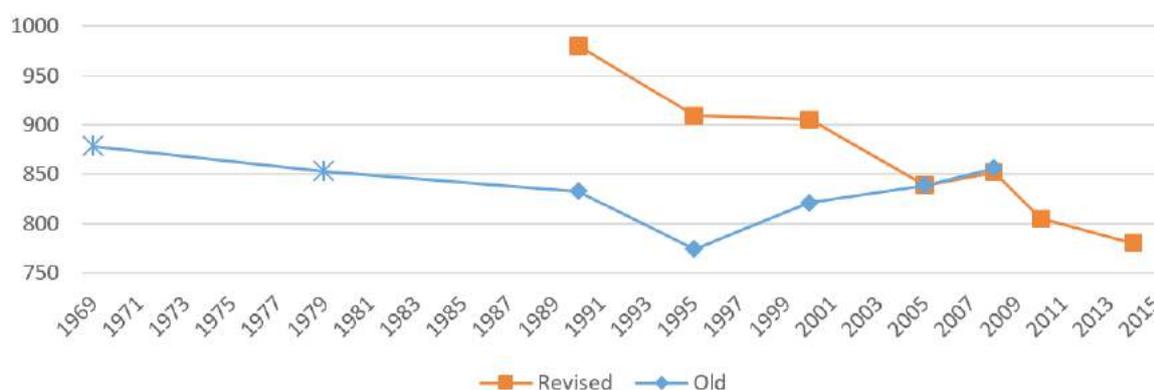
Sustainable Development Goals (SDGs)

In September 2015, the 2030 Agenda for Sustainable Development was adopted by member countries, during the United Nations conference on sustainable development. This agenda comprises 17 Sustainable Development Goals. In comparison to the MDGs, nine new goals have been added while the others have been updated to face new challenges. Goal 2 is specifically dedicated to "end hunger, achieve food security and improved nutrition and promote sustainable agriculture" by 2030[28]. This new goal enhances the role of a sustainable agricultural system for the progress of food security. Moreover, it underlines the complexity of the subject as it is not only a matter of hunger and accessibility but also of nutrition (with a specific target). This new goal addresses calorie and nutrient deficiencies, whereas the previous WFS and MDG targets were based only on undernourishment. The new SDG includes the broader burden of malnutrition that is increasingly impacting developing countries. Thereby, according to the FAO[29], several developing countries have large shares of their population facing the double burden of malnutrition: a growing prevalence of obesity while at the same time undernourishment is still pervasive in much of the rest of the population.

Goal 2 contains several targets, the most stringent being ending hunger by 2030. Additionally it includes Goal 2.2: "end[ing] all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons"[30]. Other targets more related to food systems aim to ensure sustainable food production systems, maintain the genetic diversity of seeds and biodiversity in general, increase investment in implementation, prevent trade restrictions and distortions to decrease price volatility and ensure the proper functioning of the food system.

> **Sustainable Development Goal 2 is specifically dedicated to "end hunger, achieve food security and improved nutrition and promote sustainable agriculture" by 2030.**

Current estimates and projections of hunger

FAO's Prevalence of Undernourishment (PoU)

The FAO estimates hunger based on their measures of undernourishment. This estimate measures deficiencies in food energy intake and does not reflect food nutrition. Undernourishment is the same measure that has been used to track the World Food Summit (WFS) and Millennium Development Goals (MDG). While some have criticized, quantifying hunger based solely on caloric intake as for neglecting the importance of nutrition, maintaining a consistent indicator of hunger was important for the monitoring of progress for the period of the WFS and MDG initiatives and other longitudinal analyses[31].

The FAO calculates the Prevalence of Undernourishment (PoU) as "the probability that an individual from a reference population consumes less than the minimum calorie requirement for an active and healthy life[32]." For every country, the FAO calculates a Minimum Dietary Energy Requirement (MDER) based on its population characteristic. This is based on a frequency distribution of the mean level of dietary energy consumption of the population, accounting for inequality in food consumption and asymmetry. In most of the least developed countries it runs around 1,650-1,900 kilocalories per day for a person engaging in light activity[33]. This cut-off point, defined as the MDER, is proportioned for age, sex, body mass, and physical activity level. Anyone consuming less kilocalories then the MDER is then considered to be undernourished. The PoU is then the share of the population who fall below this cut off point for a period of one year or more. For analysis at the national level, FAO uses data based on national food balance sheets that reflect food availability based on production and trade. For subnational analysis, they use household survey data, though this is not extensive enough to perform analysis of wider areas[34].

FAO's 2015 estimates found that 795 million people were undernourished around the world[35]. While still a considerable number, this is in fact a decrease of 167 million over the past ten years and 216 million since 1990-1992. The majority of the undernourished remain in the least developed regions where they account for 12.9% of the population[36].

USDA-ERS International Food Security Assessment (IFSA)

The Economic Research Service (ERS) of USDA has two models for estimating global hunger. The first is a supply-oriented model that was developed for the World Food Summit in 1996. It is based on the availability of food within a country, determined by the sum of agricultural production, imports, and aid of cereals and roots minus exports and non-food uses. Access to this available food is calculated as a function of income deciles. This model estimates that food security will slightly worsen over the coming decade with a 32% increase in the number of people

food insecure and the share rising from 12% in 2016 to 13.6% in 2026 for the 76 low and middle income countries included in it. Most of this deterioration is expected to occur in only a few countries while the majority remains at the same level. The results for this supply-oriented model appear to be largely under- or over-estimating the prevalence of hunger, as can be seen in the following table.

Their new model is demand-orientated. It is more focused on food accessibility than availability, incorporating measures of price, food quality, and consumer behavioral responses to changing economic conditions. It is not based on deciles, rather continually along the range of income, which provides for more accurate modeling particularly of the lowest decile where people are the most likely food insecure. It estimates that food security is expected to improve between 2016 to 2026. The model projects a 59% decrease in the number of food insecure people from a share of 17% in 2016 to 6% in 2026 for the 76 low and middle income countries included in it. However, it is also noted that the income and price data used were from the end of 2015 and early 2016, and that even by mid-2016 these projections had grown more pessimistic.

IFPRI's Global Hunger Index (GHI)

In 2006, IFPRI developed the Global Hunger Index (GHI). Unlike other estimates that rely solely on undernourishment data as a proxy for hunger, they developed a broader index in an attempt to produce more accurate figures. The GHI is based on three dimensions. The first is inadequate food supply, based on FAO data on the percentage of the population that consumes less than the average minimum energy requirement. The second dimension is child undernutrition, which is composed of two sub-indicators[37]. Child wasting is the percentage of children under five who are below the prescribe weight to height ratio that reflects acute undernutrition. Child stunting is the percentage of children under five who are below the prescribed height to age ratio reflects chronic undernutrition. These two indicators touch on the quality of food, and not just the quantity. Additionally, children are very vulnerable to hunger and will quickly show observable symptoms. The third dimension is child mortality, which reflects the mortality risk of acute and/or chronic hunger. However, this indicator also reflects more strongly than the others the prevalence of micronutrient deficiencies. The indicators are standardized and aggregated into the final index of zero for the absence of hunger to fifty for extremely alarming conditions. This final score, however, does not provide a numerical estimate of the number of people suffering from hunger, rather an evaluation of a country's situation as a whole.

Estimates of Global Hunger for Select Countries

Country	FAO's Prevalence of Under-nourishment 2015 (%)	USDA Supply-oriented model 2016 (%)	USDA Demand-oriented model 2016 (%)	IFPRI's Global Hunger Index 2016 Rank	
Afghanistan	26.8	10	38.1	Serious	
Algeria	<5	0	2.5	Low	
Angola	14.2	0	21.8	Serious	
Armenia	5.8	0	5.3	Low	
Azerbaijan	<5	0	1.6	Low	
Bangladesh	16.4	0	17.5	Serious	
Benin	7.5	0	14.2	Serious	
Bolivia	15.9	40	28.1	Moderate	
Burkina Faso	20.7	0	19.2	Serious	
Burundi	..	100	60.1	Extremely Alarming	
Cambodia	14.2	0	17.7	Serious	
Cameroon	9.9	0	9.1	Serious	
Central African Rep.	47.7	100	38.0	Alarming	
Chad	34.4	90	41.4	Alarming	
Colombia	8.8	10	4.8	Low	
Congo, Dem. Rep.	..	100	86.8	Extremely Alarming	
Congo, Rep.	30.5	30	21.3	Serious	
Côte d'Ivoire	13.3	0	14.1	Serious	
Dominican Republic	12.3	10	8.0	Moderate	
Ecuador	10.9	50	15.1	Moderate	
Egypt	<5	0	1.6	Moderate	
El Salvador	12.4	0	17.4	Moderate	
Eritrea	..	100	75.1	Extremely Alarming	
Ethiopia	32.0	10	35.2	Serious	
Gambia	5.3	20	3.4	Serious	
Georgia	7.4	0	7.7	Low	
Ghana	<5	0	4.4	Moderate	
Guatemala	15.6	30	25.3	Serious	
Guinea	16.4	0	26.1	Serious	
Guinea-Bissau	20.7	20	19.7	Serious	
Haiti	53.4	80	50.3	Alarming	
Honduras	12.2	40	18.1	Moderate	
India	15.2	10	11.1	Serious	
Indonesia	7.6	0	6.8	Serious	
Jamaica	8.1	0	7.1	Low	
Kenya	21.2	30	21.2	Serious	
Kyrgyzstan	6.0	0	4.3	Low	
Laos	18.5	0	19.1	Serious	
Lesotho	11.2	90	11.0	Serious	
Liberia	31.9	10	41.0	Serious	
Madagascar	33.0	30	41.4	Alarming	
Malawi	20.7	0	32.0	Serious	
Mali	<5	0	6.2	Serious	
Mauritania	5.6	0	7.4	Serious	
Moldova	<5	0	3.6	Low	
Mongolia	20.5	10	14.8	Moderate	
Morocco	<5	0	3.4	Low	
Mozambique	25.3	30	25.7	Serious	
Namibia	42.3	40	33.2	Serious	

Estimates of Global Hunger for Select Countries

Country	FAO's Prevalence of Under-nourishment 2015 (%)	USDA Supply-oriented model 2016 (%)	USDA Demand-oriented model 2016 (%)	IFPRI's Global Hunger Index 2016 Rank	
Nepal	7.8	0	11.6	Serious
Nicaragua	16.6	10	17.8	Moderate
Niger	9.5	0	11.7	Serious
Nigeria	7.0	0	8.9	Serious
North Korea	41.6	50	39.2	Serious
Pakistan	22.0	0	20.6	Serious
Peru	7.5	0	8.3	Low
Philippines	13.5	0	18.3	Moderate
Rwanda	31.6	50	31.7	Serious
Senegal	10.0	0	13.3	Moderate
Sierra Leone	22.3	0	38.1	Alarming
Somalia	..	100	64.7	Extremely Alarming
Sri Lanka	22.0	0	19.0	Serious
Sudan (former)	..	0	36.2	Extremely Alarming
Swaziland	26.8	80	27.1	Serious
Tajikistan	33.2	20	35.3	Serious
Tanzania	32.1	10	31.0	Serious
Togo	11.4	20	20.2	Serious
Tunisia	<5	0	0.6	Low
Turkmenistan	<5	0	3.5	Moderate
Uganda	25.5	50	30.5	Serious
Uzbekistan	<5	0	4.5	Moderate
Viet Nam	11.0	0	7.4	Moderate
Yemen	26.1	90	40.5	Alarming
Zambia	47.8	80	40.5	Alarming
Zimbabwe	33.4	70	39.2	Serious

Structured Analysis of the Drivers of Hunger

Structured analysis techniques are a way to break complex issues down into their components, allowing an analyst to follow a structured procedure that is transparent, and allows for contributions from external subject matter experts. Following these procedures also reduces the risk of error from perceptual bias, groupthink, and other errors. The report uses a series of these techniques to identify the central drivers of hunger and then develop scenarios for global hunger in 2030[38]. It is intended to provide an overview of the issue today and provide insight into how it could develop over the next fifteen years. The scenarios can serve as the basis for further strategic planning on the issue. Through a better understanding of the network of factors that drive hunger and the courses by which it may evolve, we can make more informed decisions on how to end global hunger.

Impact-uncertainty matrix

The structured analysis began with the creation of an architecture: the compilation of a list of the drivers of hunger using our definition presented above, based on our definition presented above, based on existing literature and discussions with our technical team and extremal experts. Each driver contained a definition of what specifically it referred to, to avoid misunderstanding between contributors. The list was then ordered based on the scale of its influence.

The next technique was the creation of an Impact-Uncertainty Matrix[39]. This entailed ranking each driver based on how much it affected, for better or worse, the prevalence of hunger and how predictable it was over the next fifteen years. The ranking scale

was from one to nine. The results were then graphed to create the matrix shown below. Based on the location of the driver in the matrix, we then divided this large list into three categories. The first category — heavy trends — included drivers strongly influencing hunger with a clear trajectory over the coming years.These typically have held a consistent trend for decades and so will presumably continue to maintain their course over the next fifteen years barring a major systemic change to the international system. A summary of all the heavy trends is detailed in the annex of the report. The persistence of these factors will make the elimination of hunger over the next fifteen years very challenging. However, other entry points to the system could allow for significant progress to be made.

The second category was light trends. These drivers were also found to have consistent trends but were less influential on hunger. While the report does not focus on these drivers, they should be considered for the greater importance they may have in specific local contexts. For example, post-harvest loss may not be as comparatively influential globally, yet there may likely be many local communities where it is the largest driver of hunger. The third category was critical uncertainties. These are the drivers impacting hunger, for better or worse, whose trajectory over time is not clearly defined. As such they are issues to consider when planning hunger initiatives because they are more susceptible to change. The following section analyses the critical uncertainties drivers.

> **Through a better understanding of the network of factors that drive hunger and the courses by which it may evolve, we can make more informed decisions on how to end global hunger.**
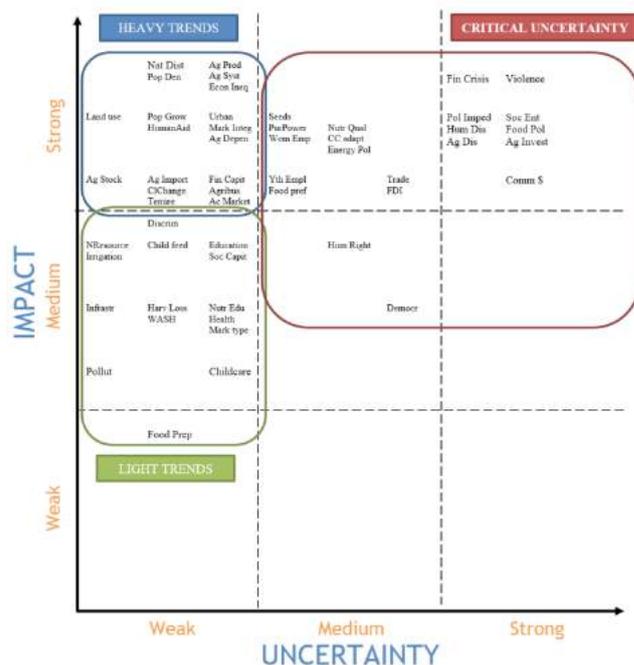
MICMAC analysis

The heavy trends — drivers with a strong and predictable influence on hunger at the global level — are largely set in their course over the next fifteen years and are difficult to influence through action or advocacy in a business as usual scenario. The critical uncertainties, though, are the drivers whose future course is not clearly set. That is not to say that their unpredictability can be easily influenced, nor what the determinants of their occurrence are. As such their course is more easily diverted in a direction that will reduce or increase global hunger. An analysis of these drivers was then warranted to examine the structure of their system of interactions and to identify the key drivers at its center. In so doing, we can know which drivers should be targeted through advocacy or research to influence the system. As these drivers are central to the network, affecting them will induce change in connected drivers, creating a cascade effect. By designing programming for one of these central drivers we can then affect many, all of which can then contribute to reducing hunger.

A structural analysis matrix technique was used, known as the Impact Matrix Cross-Reference Multiplication Applied to a Classification or MICMAC for short[40]. The drivers having been previously classified as critical uncertainties were entered into a double input chart where they were listed along both the x- and y-axes. Our working group[41] then determined the degree of influence (from 0-3) each driver had on every other. The resulting table of values was then used to calculate the web of interactions and to classify each driver based on its net influence (the sum of its influence on all other drivers) and dependence (the sum of all other drivers' influence on it).

The figure on the following page is a graphical representation of the complex network of interactions between critical uncertainties. While at first it appears that all drivers are related to one another, there are underlying patterns of influence. Using a quantitative analysis[42], the relative influence and dependence each had on the sum of the others was calculated. The results where then presented as an influence-dependence map, also shown on page 16. The critical uncertainties could then be defined into five categories based on these values. The first are Determinant Variables located in the upper-left quadrant. They have a high level of influence over and a low level of dependence on the other drivers. They are often entry points to the system whose direction will shape the rest of the system. As such they are crucial elements in determining its structure. Often they can take the form of environmental variables that shape the system but are not in turn influenced by it. In our analysis, there was only one Determinant Variable: Financial Crises. It will have strong impacts on the other drivers of hunger and yet there are few ways in which the others can cause or prevent financial crises. Similarly, this driver is important to watch for as it will have a considerable direct and indirect impact on hunger. The presence of only one Determinant Variable can be viewed positively since they are difficult for actors to control. Optimistically, more of the system is within our ability to leverage towards the eradication of hunger.

List of heavy trends

Climate Change: Increasing extreme weather events; reduces agricultural productivity for arid and glacial runoff areas while increased productivity for high latitude regions leading to deepening disparities and dependence;

Natural disasters: Increasing occurrence of natural disasters due to climate change but slightly decreasing numbers of people affected due to greater resilience; increasing regional disparities in occurrence

Urbanization: Increasingly urban populations; growth of shantytowns; increasing global dietary convergence; food becomes cheaper in cities than in rural communities.

Population growth and structure: Addition of one billion people by 2030; populations doubling in less developed countries by 2050; ageing populations.

Economic inequality: Inequality will remain high despite a decline in extreme poverty and growth of a middle class in the emerging markets.

Market integration: Markets will continue to integrate making consumers and small scale producers more vulnerable to price fluctuations.

Access to markets: Will slowly increase for small scale producers who are more restricted by lack of infrastructure and in meeting international standards, while markets will continue to be dominated by large scale producers.

Financial capital: Access to financial capital is important to reducing hunger and poverty. However, the poor still have the least access to financial credit. While some progress has been made, most still do not access to this means of breaking the cycle of poverty.

Humanitarian and development assistance: Slowly widening funding gap; decentralization of NGOs; growth of non-DAC donors.

Social exclusion/discrimination: Continued improvements for marginalized groups.

Agricultural productivity: A half century of rapid increases in agricultural productivity has led to food becoming more plentiful and affordable. However, the sustainability of this advancement has been called into question, with many now calling for a shift from an industrial to agroecological model of farming.

The second category of drivers is Relay Variables, located in the upper-right quadrant. They have a high degree of influence and dependence on the other drivers. As a result, actions on them are transmitted throughout the system. This makes them sources of instability, but also areas to target to influence the system as a whole. This category can also be broken down into two subgroups: Stake Variables and Target Variables. Stake variables tend to fall along the diagonal division of the quadrant. They have the greatest degree of instability and therefore tend to be the primary target of actors wishing to influence the system. In our model these are: Trade, Climate Change Adaptation and Policy, Food Policy, and Commodity Prices. These five are recommended as drivers to focus on to influence the system of interactions driving hunger. The second sub-category is Target Variables located below the diagonal. These are shaped more by the system, but they can still serve as the next best target for actors seeking to reshape the system and its outcomes. In our model, these include: Purchasing Power, Women's Empowerment, Conflict, and Foreign Direct Investment.

The third category is Regulating Variables that fall in the center of the chart with a medium level of influence and dependence on the other drivers. This group, being in the center of the system's gravity, can behave like any of the other four though usually at a lower intensity. As such, they can serve as secondary targets for actors to still leverage the system to some degree. In the model the Regulating variables are: Energy Policy; Policy Impediments, Social Entitlements, Public Investment in Agriculture, Agricultural diseases and pests, Human Rights, Democratic Institutions, and Seeds.

The fourth category is Dependent Variables, located in the lower-right. They have a high level of dependence and low level of influence and as such are sensitive to changes in the system. As a result, these are not recommended as targets for actors. Instead attention should be focused on Relay and, to a lesser extent, Regulating Variables as they will in turn shape this category along with the rest of the system. The Dependent Variables in the model are: Youth Employment, Communicable Human Diseases, Nutritional Quality of Food.

Network of Interactions between Key Drivers

Direct influence graph

Weakest influences
Weak influences
Moderate influences
Relatively strong influences
Strongest influences
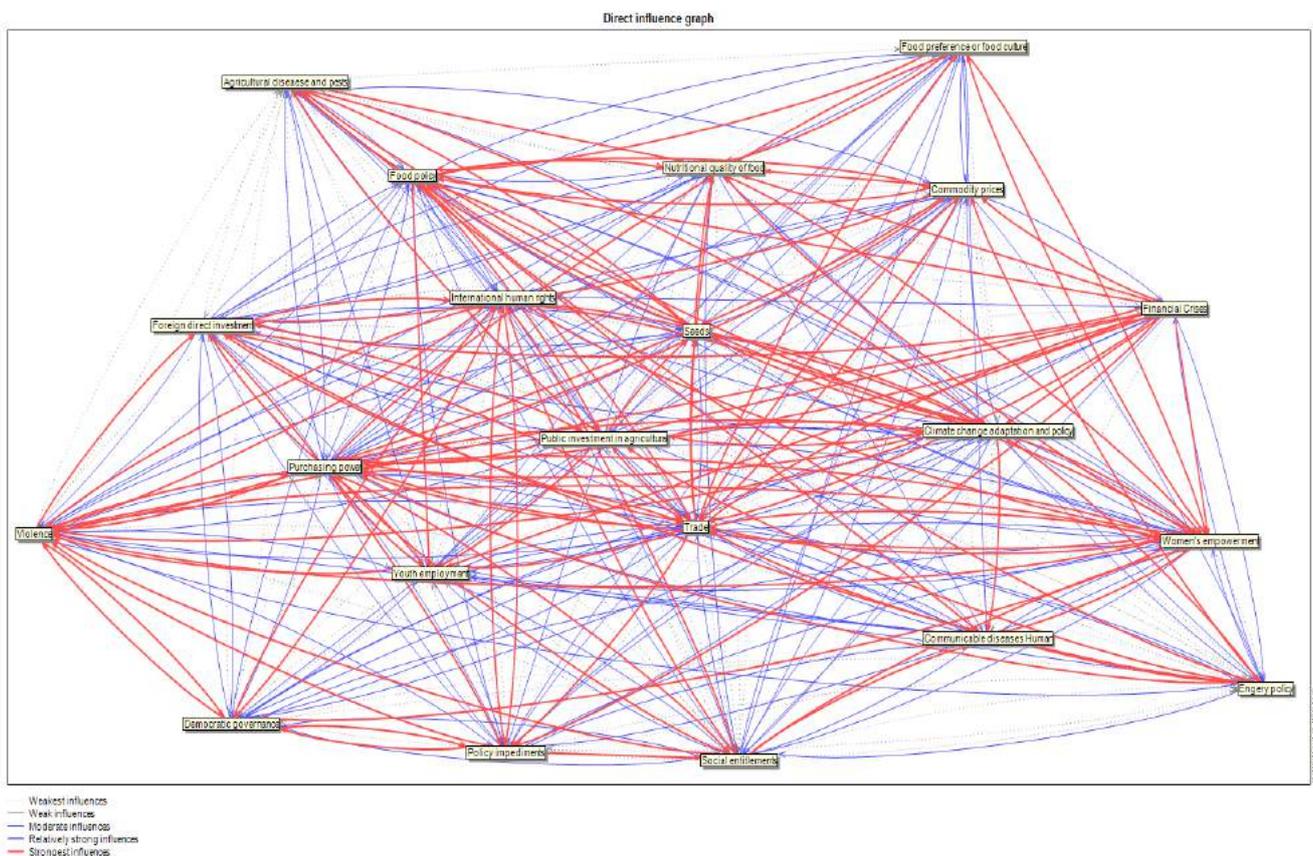
Influence/Dependence Map
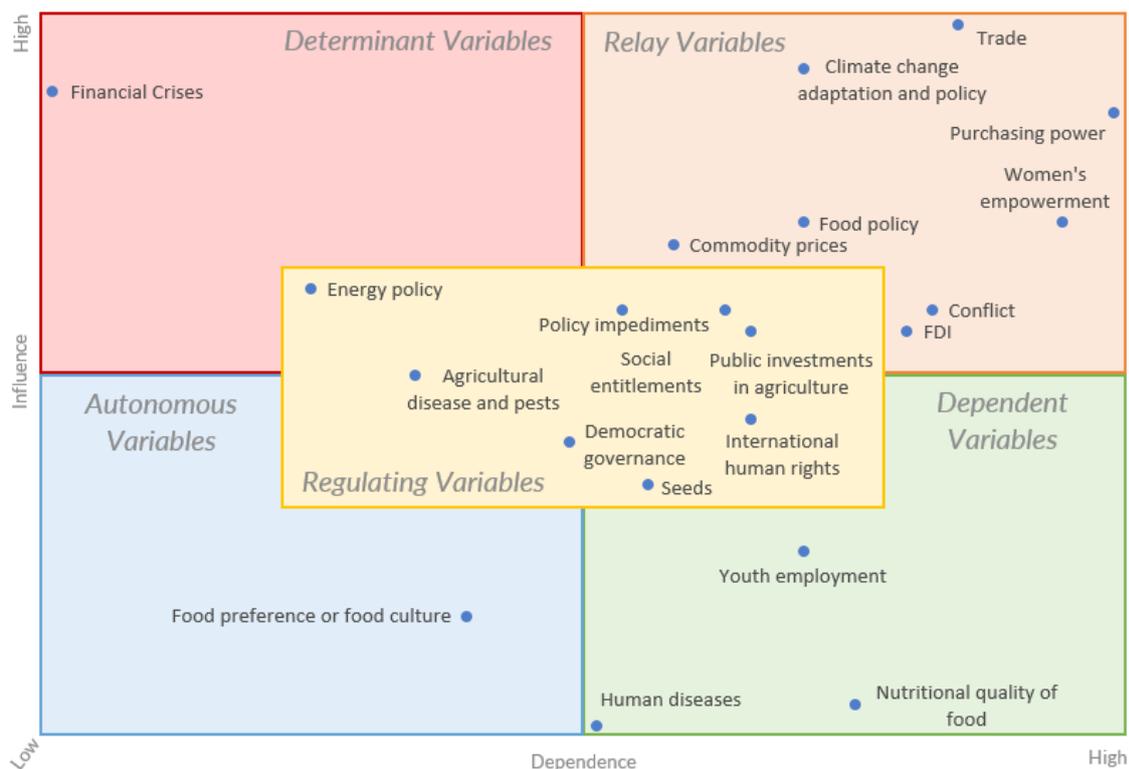
The fifth category is Autonomous Variables which are located in the lower-left. They have a low influence and dependence and so are largely disconnected from the system. Acting on them will not influence the rest of the driver nor will changing the system significantly impact them. There is only one in the model: Food Preferences and Food Culture.

Based on the results of the MICMAC analysis, our working group identified the following nine drivers for further consideration and provided a brief overview. They were selected for having the highest influence values on the analysis. They reflect most of the Determinant and Relay Variables discussed above. While the conflict driver was tied in influence with two others for the final spot, it was selected over the other two because of the critical importance it is known to have on the issue.

To supplement the structured analysis, these drivers were also examined quantitatively to determine their statistical relationship to five measures of hunger: child mortality, wasting, stunting, undernourishment, and the Global Hunger Index. All the drivers had a statistically significant correlation with at least one of these metrics for quantifying hunger. So, while this supports that they are important drivers of hunger, they can impact it differently. For example, women's empowerment was shown to reduce wasting rates and therefore likely helps to build resilience to crises, while consumer prices affected undernourishment rates and thus may be more linked to food accessibility. A full description of this quantitative analysis can be found in the appendix.

Critical uncertainties of note

Conflict, in this report, is a broad category referring to a range of situations from armed conflict to interpersonal violence. Armed conflicts are a major driver of hunger. Countries in protracted conflicts have on average over twice the rate of undernourishment than developing countries[43]. As people flee the violence, they suffer the loss of their livelihood and agricultural production and distribution halts, making food less available and accessible. Then, as part of a vicious cycle, hunger can contribute to conflict in return. Hunger weakens social institutions, displaces families, and deepens social tensions which fuels conflict. Since the end of the Cold War, interstate and societal violence have strongly decreased, though there has been a small increase in the latter since 2011. Yet 3.34 billion people, almost half of the world population "live in proximity to or feel the impact of political violence"[44]. In the past 15 years, at least 53 countries have been impacted by political violence, and roughly a third of this is directed towards civilians[45]. In conflicts currently, the majority of deaths are civilian (mostly women and children) and while the exact percentage is under debate, most agree that it has been rising over the past several decades[46]. Currently, the majority of conflict related deaths are in Afghanistan and Pakistan, Syria and Iraq, and East and Central Africa. In several ongoing crises, humanitarian aid is unable to be delivered because of violence directed towards aid workers. In the beginning of 2017, famine was declared in South Sudan and the crises in Somalia, Yemen, and Northeast Nigeria had almost descended to that level. Conflict is a leading driver of hunger in

these four dire situations. However, the violence that prevents humanitarian aid from being delivered is what risks turning a crisis into a famine.

In parallel with armed conflict, other kinds of violence are of great concern. Even in conflict affected areas, most killing occurs off the battlefield. Interpersonal violence kills about half a million people a year, which is nine times greater than battlefield deaths[47], and is concentrated in Central and Southern Africa, and Central and South America. Growing numbers of people are forced to leave their homes to escape violence putting more pressure on neighboring regions and hosting countries. There are many cause of violence including: political, social, and economic inequalities; poverty and unemployment; state fragility; and the history of conflict in the region. While these variables can increase the likelihood of conflict, it is still difficult to predict the extent, location, or intensity of future conflicts[48].

Women's empowerment means that women "can take control over their lives: set their own agendas, gain skills (or have their own skills and knowledge recognized), increase self-confidence, solve problems, and develop self-reliance"[49]. This entails the amount of social and financial independence women have including decision making power, legislative rights, educational and employment opportunities, and access to resources. Women face unequal treatment around the world, inhibited by social, political, and economic barriers. Women have lower rates of educational attainment, workforce participation, and political representation. Early marriage and childbearing are a significant contributor to this, particularly in least developed regions. Women play a critical role in household food security through their traditional gender role in being domestically active such as gardening and gathering wild foods, post-harvest processing and preservation, cooking, and supplemental income generation[50]. As such, development programs have specifically targeted women to help reduce hunger and malnutrition. Within the agricultural sector, it is estimated that if women had equal access to productive resources they would increase their yields by 20-30%, equating to a 2.5-4% increase in total agricultural production in less developed countries and reducing world hunger by 12-17%[51]. Recommendations for improving women's empowerment include: guaranteeing equal rights and fair market participation, more access to education, financial, and productive resources, and investing in labor saving technologies[52].

> **The violence that prevents humanitarian aid from being delivered is what risks turning a crisis into a famine.**

The advancements made on women's empowerment vary by region and indicator, but globally much progress has been made over the past several years, particularly in primary school enrollment and political representation. Nevertheless, how this trend will progress over the next fifteen years remains highly uncertain. Further developments will be influenced by local and national conditions of political and institutional frameworks, economic conditions, and societal norms.

Food policy refers to a range of policies that impact the food system. These typically take the form of regulations, rules, and guidelines. Governments are the primary sources of food policy, be they at the international, national, and/or subnational scale. These policies are largely intended to promote public nutrition and health and the agricultural industry. Government food policy can include regulation, subsidies, taxes, education, strategic reserves, and social safety nets. Many developing countries have attempted to reduce hunger by importing large quantities of cheap food from countries with highly intensive agricultural systems. While this can keep food prices low, it can also undercut local agriculture and the livelihoods of small scale producers and distributers. Brazil has developed another approach to food policy that has been increasingly adopted by other LDCs[53]. These government initiatives seek to purchase food from struggling farmers and provide it to schools and hospitals. This is an example of how governments can use food policies to support local agricultural production, value chains, and livelihoods while also ensuring the health and food security of their vulnerable groups.

> **Advancements made on women's empowerment vary by region and indicator, but globally much progress has been made over the past several years, particularly in primary school enrollment and political representation.**

Changing policy concepts of food security are adapting to major modifications affecting the food system and the consumers' preferences. Fear that food production will not keep up with growing population has led decisions-makers for the past two decades to focus on food production through large scale, intensive, agribusiness operations[54]. Industrialization and globalization of the food system have been the driving forces behind most of the changes affecting the food system. The food supply chain's revolution has deeply modified the way food is produced, distributed, consumed, and controlled by empowering transnational food companies that growingly control the chain from the supply of agricultural inputs, through food production to food manufacturing and retail. The rapid spread of supermarkets and fast-food restaurants have accelerated the global convergence towards the Western diet. Food safety issues have evolved towards adulteration, bio-safety issues in processed food or pesticides residues in food. The regular food scandals such

as the Chinese meat[55] or the "gutter oil" in Taiwan[56], have revealed the fragility of the agribusiness system and the necessity of new regulations. Given the food price shocks in recent years from, mostly from draught and oil price spikes, strengthening resilience and promoting sustainability have become major themes in the development community.

The Green Revolution brought unparalleled increases in agricultural productivity and is attributed with having saved millions from starvation. It also represented a great symbol of international agricultural research cooperation with the knowledge and benefits being shared around the world with more and less developed nations[57]. The adoption of new technologies such as high-yield varieties, in association with chemical fertilizers and agro-chemicals, a controlled water supply and new methods of cultivation were all ingredients of the "modern" package of practices. However, the emphasis on new industrialized production methods and crops like wheats and rice, left some regions like sub-Saharan Africa behind. The minor crops have still not benefited from intensive breeding programs and the reliance on machinery and artificial inputs prohibits many poor, small-scale producers from exploiting the approach. Additionally, the Green Revolution led to the pervasive use of intensive, industrial agriculture which has profound negative consequences on health, livelihoods, and the environment. While for some the resulting rise in purchasing power allowed for greater dietary diversity and nutrient consumption, for others expansion of cereal monocultures, in place of a range of traditional crops, led to a reduction in the availability and accessibility of micronutrient rich food[58]. Small scale producers with limited resources were often slow or unable to adopt these new technologies and so became even less competitive against large scale operations, creating greater economic and regional inequalities. Increased use of artificial fertilizers and pesticides poisoned farmers and the environment. Increased irrigation has diminished groundwater availability and led to salinization of farmlands. Monoculture crops have led to biodiversity loss and worsened the risk of devastating pest outbreaks[59]. The use of more artificial inputs and mechanization also require more fossil fuel consumption. Because of these concerns, many are now calling for the sustainable intensification of agriculture in order to meet future increases in demand[60,61].

Governments have often intervened heavily in domestic markets to protect and stabilize the prices of agricultural commodities, with the result that domestic producer prices have varied substantially less than international prices. The relationship between diversification and risk is thus crucial in the context of trade and macroeconomic reforms designed to align domestic prices more closely with international prices. Investing in social protection prevents long-term consequences of early childhood malnutrition and more generally protects the assets of the poor. A real improvement has been made in providing social protections for vulnerable groups, especially in Latin America.

Energy policy includes the actions taken by governments, businesses, and other actors regarding energy production, distribution, and consumption. Energy importing nations seek to diversify their energy sources to avoid overdependence on a single source or supplier which leaves them vulnerable. Oil exporting nations face the dilemma of raising prices to increase income or keeping prices low to discourage investments in alternative fuels. Climate change treaties also have been shaping nations' energy policies as they seek to cut emissions from fossil fuels and invest in green energy. A central point of contention surrounding energy policy is decarbonization: with the international agreements largely set for a goal of reducing CO_2 emission, energy policies must adapt both in term of quantity and quality. Each country has its own Intended Nationally Determined Contributions (INDCs), limiting their gas emission, but they also plan a diversification in terms of type of energy. Solar and wind power have been making rapid gains, boosted by investment and improving technology. Hydropower has also been expanding though along with some controversy. Major dam projects have been criticized for their ecological impact and in some cases the forced displacement of people. Nuclear energy is also a source of debate. Some see it as the most viable alternative to fossil fuels. Others though, find that the waste storage and risk of disaster, such as was seen in the Fukushima Daiichi nuclear accident in 2011.

Biofuel is the final area of contention. Higher fuel prices encourage the redistribution of agricultural resources away from food production, resulting in higher food prices. It also risks further intertwining the two markets and making food prices more volatile, particularly through the role of financial speculators. Areas that will influence energy policy over the next fifteen years are: domestic politics, geopolitical tensions, oil price volatility, stability of oil producing nations, developments in green technology, and disasters affecting the energy sector.

Climate change policy and adaptation includes the policies and actions taken by governments, businesses, and other actors to reduce the harm or take advantage of the benefits of climate change. This driver is limited to policy and programing and is distinct from the physical effects of climate change. International agreements on climate change have moved beyond attempting to mitigate it through reductions in emissions to now including actions to adapt to its effects. The effects of climate change are expected to become more pronounced in the global food system by 2030 and so steps must be taken now to deal with the looming threats. Food security is one area that is of great concern. Increasing climate variability and instances of extreme weather pose a danger to food production. Many adaptation-focused projects are agriculture-related aiming at determining the best farming practices to maintain production in a changing environment. Such actions will be necessary to building resilience in the least developed countries particularly by maintaining domestic food production and protecting rural livelihoods against external shocks. Such adaptation programs may be an ideal opportunity to promote agroecology as a means of sustainable agricultural development and building small producer resilience. Doing so will also be crucial in preventing the displacement of large populations of climate refugees. However, the future of climate change policies and adaptive measures remains uncertain. Current initiatives may be insufficient as the level of impact is not entirely known and because an increased probability of extreme events does not foretell the number of instance that will actually occur. Furthermore, the level of commitment by nations, particularly in funding adaptation programs, remains highly uncertain.

Purchasing power is defined as "the quantities of goods and services that can be bought with a given amount of money. It depends on income and prices"[62]. That is to say, it is determined by how much money people have and how much it costs to buy things. Hunger can be ended when everyone has access to affordable and nutritious food, but this access is often an issue of purchasing power. Simply put, reducing hunger can be done by reducing poverty and the cost of food. To complicate matters, increasing rural incomes can potentially be offset by higher food prices, as the market balances supply and demand, and thereby negate any benefit to their purchasing power. Interventions therefore must carefully consider the balance between local financial resources and food stocks, while also bearing in mind the influence of trade. There are many factors that can impact purchasing power. Inflation is an important one as it changes the cost of goods or services for consumers. Other factors also impact income such as income growth and employment rates. Less directly, issues such as trade policy affect employment

and inflation which in turn influence purchasing power. Lastly, natural disasters and conflict can also lead to shortages of goods, increasing prices, and lowering purchasing power. Consequently, purchasing power is determined by many economic factors, each of which is difficult to forecast fifteen years into the future, and so its trend out to 2030 remains uncertain.

Commodity prices in this report refers to the global to local price of raw materials, primary agricultural products and fuel being the two areas most tied to hunger. Over the 20th Century most commodity prices have fallen by almost half in real terms, underpinning the global economic growth. Lower prices were mainly pushed down by non-stop gains in productivity and by an expanded supply growing faster than demand. However, 2000-2014 saw a spike in prices before record lows in 2016. Such fluctuations in global prices have a direct and indirect effect on local prices that varies with the local context. High price volatility has a negative impact on food security especially affecting the most vulnerable groups such as the small-scale agricultural producers and low income populations. Soaring prices directly affect the most vulnerable households reducing their purchasing power and ability to access affordable food. In Africa, an increase in food prices strongly impacts poor populations who devote on average 50% of their income to food purchase[63]. In 2007-2008 when food prices were at record highs, a peak in chronic undernourishment was registered at 927 million people. This period also coincided with widespread social unrest, emphasizing the link between food security and political stability. While price spikes can make food

> **Climate change adaptation programs may be an ideal opportunity to promote agroecology as a means of sustainable agricultural development and building small producer resilience.**

unaffordable to the poor, very low commodity prices can also have a negative effect on small scale producers whose incomes may then suffer. Trade dependence therefore increases vulnerability to price fluctuations. When one is already living on the edge such market fluctuations can be enough to push them over into extreme poverty and hunger. Building resilience can be achieved through greater food sovereignty that can keep local prices more stable.

Many factors can impact prices, making this driver's future course uncertain. Over the short-term, many externalities cause price volatility such as, biofuel production, global cereal stocks, natural disaster, disease, financial speculation, economic crisis, etc. International trade legislation has a strong impact if exports barriers are raised or if import quotas are voted. Over the long-term, technological improvements tend to drive prices down through increased efficiencies. Even as certain products grow scarcer and prices should therefore rise, their increased value funds improved production and/or the development of alternatives, and so in the long run the prices still tend to decrease[64,65]. With regard to food prices, however, there are reoccurring concerns that this trend may eventually break when we reach the limits of our environment's carrying capacity. At which point, prices would rise, fueled in large part by the extra burden from population growth, the demand for more resource intensive foods (meats and dairy), competition from biofuels, and the effects of climate change. The role of speculation on commodity prices has been very controversial over the last decade, some arguing that non-commercial trading on commodity index in agricultural product could destabilize the natural equilibrium of the demand and supply market.

Trade is the buying and selling of goods and services, from the local to global scale. The era of global free trade began following World War Two, in an effort to avoid the economic crises of the 1930s which were blamed in part on protectionist trade policies. This development reached a new high following the formation of the World Trade Organization (WTO) in 1995. Its objectives included the opening of sensitive sectors namely agriculture, textile and steel, the end of quotas, public subsidies, and the harmonization of norms. Initiatives within the WTO, such as the Doha Development Round, have sought to make globalization more inclusive for poor countries by reducing subsidizes on the goods they import, especially agricultural. Aside from the WTO, there trade is also negotiated through a multitude of regional and bilateral agreements, such as the Economic Partnership Agreement between the EU and West Africa. 2015-2016 saw the return of protectionist narratives and policies around the world, from the US and UK[66] to Indonesia[67], often linked to the rise in nationalisms. Such policies would harm trade dependent nations such as in Eastern Europe, South East Asia, the Middle East, and Sub-Saharan Africa. The impact on other nations is less certain with some arguing that it will strengthen domestic markets while others argue that it will slow or reduce economic growth. Though, agricultural exports have been increasingly dominated by the US, Netherlands, Germany, France, and Brazil, countries like China and India are some of the largest producers but consume most of it domestically rather than export surpluses. Furthermore, other nations have become increasingly dependent on importing

cheap food from the West, finding themselves unable to compete against the low prices that result from high mechanization and government subsidies. A sudden breakdown in trade could create a shock to the system, particularly in these import dependent nations, and lead to outbreaks of hunger. However, others argue that increasing protectionist policies could serve to protect these countries from the dumping of cheap food which over the long run would serve to develop their domestic agricultural sector and make them more productive and resilient. Food sovereignty movements, like La Vía Campesina, take this argument further, contending that neoliberalism and the corporatization of the food system have caused great harm to rural peoples and that protectionism is necessary to protecting livelihoods and human rights[68]. The future volume and nature of trade is uncertain as it will be influenced by: domestic policies, international trade agreement, commodity prices, global economic growth, monetary system stability, and resource accessibility.

> **Despite the lessons learned from the 2008-09 crisis, asset bubbles, price shocks, and general financial crises still remain a major threat to leading economies.**

Financial crises are situations where financial assets rapidly lose value, or if the gap between real and market prices is significant. This impacts the real economy, leading to a reduction in trade, lending, economic growth and sometimes to an economic crisis with a recession or depression. Such crises can lead to widespread outbreaks of hunger as purchasing power suddenly drops, and in the worst cases the lack of financial access can inhibit agricultural production and distribution. Financial crises can come in different shapes and sizes, evolve over time into different forms, and can rapidly spread across borders[69]. Despite the lessons learned from the 2008-09 crisis[70], asset bubbles, price shock, and general financial crises still remain a major threat to leading economies. Several areas of concern remain such as a potential debt crisis and another housing bubble. In emerging markets, there also are potential dangers such as their level of debt that could lead to sovereign default and declining liquidity. Similarly, low oil prices could lead emerging market oil exporters to default on their loans. As noted by the OECD, financial crises are difficult to anticipate because of "the identification of imbalances and unsustainability entering the crisis, the timing of their unwinding and the likely impact on real activity"[71]. A number of recommendations were made following the 2008 food crisis including: using current and accurate data on crises to develop effective response; greater coordination of responses; greater humanitarian assistance and national safety nets; limit or reduce production, and subsidies, of biofuels made from food (e.g. maize); avoiding reactive protectionist trade policies; agricultural policies to promote staple crops and small scale producers, particularly women; and improving access to knowledge, technology and finical capital[72]. Key areas of uncertainty for this driver include: energy prices, political decisions, financial regulations, and emerging market capabilities to sustain their debts.

Scenarios

The final structured analysis technique used for this report was the creation of scenarios. The heavy trends were taken as working assumptions that were consistent for all the scenarios. For the eight critical uncertainties noted above, a series of three to five hypotheses was created outlining how they might unfold over the next fifteen years. The results were then used to create a matrix known as a "morphologic box." The combinations were chosen using a form of morphology analysis. Hypothesis pairs were evaluated for "exclusions," logically inconsistent combinations, and "preferences," or congruent matches. These were then aggregated into sets of one hypothesis for each of the eight drivers to represent the basic morphology of each scenario. Two scenarios were based on an optimistic future with a reduction in global hunger, one through more equitable Western-led growth and the other via growth from emerging market economies. Another scenario followed a business as usual path, with a continued slow reduction in hunger. The last two scenarios showed how the global hunger situation could worsen, with one based on deepening global inequality and the other on a major, global economic crisis. The scenarios thereby represent a range of plausible courses in which the future may unfold, based on the possible evolution and interaction of key factors. Each scenario was written in a narrative fashion from the perspective of 2030. The table on the following page represents a simplified version of the hypotheses for each scenario and critical uncertainty pairing. The heavy trends, described earlier in the report, act as assumptions consistent throughout all the scenarios. Though these represent global trends and so there can be some regional variations.

The following five scenarios are intended to provide insight into the future of hunger. Each represents a possible future. They should not be taken as definitive predictions, rather as archetypes to help illustrate how the system of drivers that shape hunger may transform. By better understanding the range of possible futures, organizations like Action Against Hunger can better develop strategic plans to fight hunger in an uncertain future.

Summary table of the role of critical uncertainties in each scenario

Drivers	Scenarios				
	Strong and equitable growth	Rise of the Rest	Slow and fragile growth	Deepening divide	System shock
Conflict	Reduction	Reduction	Neutral	Increase	Increase
Women's Empowerment	Rapid increase	Culture clash	Gradual increase	Neutral	Reduction
Climate Change Adaptation	Strong action	Limited action	Limited action	Strong in MDCs, weak in LDCs	No meaningful action taken
Food Policy	MDC-LDC transfer for the better	Grassroots movements in LDCs	Strong in MDCs, weak in LDCs	MDC-LDC transfer for the worse	Strong in MDCs, weak in LDCs
Energy Policy	Energy diversification	Energy diversification	Fossil fuel dependence	Biofuels	Fossil fuel dependence
Purchasing Power	Increases	Increases in rural, decreases in urban	Increases in urban, decreases in rural	Inequalities in urban	Decreases
Commodity Prices	Food prices decline	Food prices decline	Food prices incline	Food prices incline	Food prices spike
Trade	Fair trade	Protectionism leads to LDC growth	Free trade	Protectionism in MDCs, none in LDCs	Protectionism leads to trade wars
Financial Crises	None	None	Regional, Southeast Asia	Regional, Southeast Asia	Global

Scenario 1

Strong and equitable growth (optimistic)

By 2030 much of the world has reached hunger levels below 5% as a result of strong and equitable growth around the world. THe lack of financial crises or other systemic shocks has led to years of rapid economic expansion While the era of globalization continues, it is no longer dominated by neoliberal trade policies. Fair trade has slowly replaced free trade as its guiding doctrine. More developed countries (MDCs) are still interconnected with emerging markets but the nature of those linkages has growth more mutually beneficial through governmental and corporate policy reforms. International trade now leads to economic development in less developed countries (LDCs) and is a major contributor to the decline in extreme poverty. While LDCs remains heavily commodity dependent, they receive high prices for their goods and have begun diversifying their economies.

The international community is implementing climate change adaptation programs around the world. The commitments of years past have been honored with nations providing the necessary funding to implement the programs both in MDCs and LDCs. Policy prescriptions have become more specific, guided by the latest scientific research. Governments coordinate with civil society and the private sector in implementing adaptive measures. This cooperation leads to improvements in other humanitarian and development efforts, which also helps to bring an infusion of money and skills transfers to less developed countries. While the effects of climate change are becoming more pronounced, the resulting improvements in resilience have prevented the worst storms and droughts from turning into humanitarian catastrophes. Farmers are receiving extension support to learn new practices to adapt to the changing climate. While many have had to adjust to new crops and technologies, it has prevented wide scale crop failures.

The world has made significant progress towards energy diversification. Technological innovation has greatly reduced the cost of renewable energy to the point where it is a viable competitor with traditional fossil fuels. Subsidies from more industrialized nations seeking to meet their climate obligations provide a boost to the emerging green energy industry. However, China and other emerging markets also played a leading role in the research and development as they sought to be leaders in the growth industry. Emerging economies were early adopters as they sought decentralized energy systems that did not require as great of an infrastructure investment. While petrochemical fuels are still in use, they no longer dominate the market. Consequently, when a minor disruption to oil production occurred, the new elasticity in the market prevented a major price spike and a subsequent ripple effect throughout the global economy.

Food prices have general declined from their peak in 2008 and 2011. Exceptional cereal harvests lead to ample stocks that help maintain low prices. Demand in meat has not boomed as expected and the production has increased putting pressure on prices. China and Brazil have become two major producers for meat absorbing most of the growth in meat consumption. Record levels of oilseed production are reached, especially from soybean. Oilseed prices have dropped due to a saturated demand especially for biofuel whereas soya has become very attractive as a protein meal substitutable to meat. Fish prices have also declined sharply as a large increase in production in the developing world and major investments in aquaculture lead to it surpassing fisheries.

Purchasing power increases for the poor around the world, led by income growth and slow declines in basic commodity prices such as food and energy. Small scale producers have begun to specialize in labor intensive or non-temperate crops that can compete on the international market against economies of scale for large producers in more industrialized nations. As economic growth in the emerging and less developed economies has grown more equitable, wages have risen. The largest impact was seen in the sharp decline in extreme poverty. A growing segment of society can now afford the basic necessities of life along with having a disposable income remaining. This provides a feedback mechanism that supports further growth in the least developed countries as money starts to circulate more extensively within their communities. Growing wealth has also led to an increase in the global dietary convergence as people start to consume more dairy, fats, and processed foods. Obesity and related non-communicable diseases have become more prevalent.

The world has witnessed a period of rapid empowerment of women, driven in large part by their inclusion in economic growth. After decades of investing in girls' education and promoting the principles of gender equality, the changing financial landscape provided the catalyst for substantive change. Women have entered the workforce in record number in middle income countries to help fill all the new jobs. Slower, but still noticeable progress is being made in LDCs. The increasing prosperity has set a positive mood and men do not feel threatened by women entering the workforce. As people see more women in positions of power it hastens the change in societal gender norms. Women, similarly, have gained more political representation and instituted more legal and institutional reforms to promote gender equality. As women are now further their education and pursuing employment, the age of marriage and childbirth has been pushed back by many years. The West is leading efforts to promote more robust food policies in the LDCs. The global food system is increasingly interconnected. They help promote effective food policies in LDCs to protect the health of their own consumers, prevent against the spread of agricultural diseases, and as part of comprehensive development assistance programs. These efforts have led to the implementation of more food safety standards, nutritional education and assistance, and investments in their domestic agricultural sector.

Scenario 2

Rise of the rest (optimistic)

By 2030 much of the world has reached hunger levels below 5% as a result of strong growth in the emerging economies and LDCs. The world has avoided any significant economic crises since 2008. While economic expansions have been witnessed around the globe, the largest gains have been made in less developed countries. These nations have been diversifying their economies and few remain heavily commodity dependent. Textiles and other light manufacturing industries have begun to emerge in Sub-Saharan Africa. Some nations have also sought to leapfrog from primary to tertiary industries by skipping manufacturing in favor of information technology development.

There is progress being made to adapt to the ever increasing effects of climate change. The international community has agreed on the course of action that must be taken. However, some nations are failing to meet their National Development Contributions. While the implementation of adaptive programs is occurring slower than was planned, it is occurring, though there are concerns that many people remain vulnerable.

The world has made better progress in energy diversification. Advancements in renewable energy technology have made these energy sources competitive. Emerging economies in Asia have proved a driving force in scaling up their production to the point where they have become accessible to a wide audience. Many of the least developed countries have utilized the technology to create decentralized energy systems and rural areas have widely gained reliable electricity. This has served to help boost rural industries and promote wider rural development. Biofuel production is no longer being produced from food fuel stocks as other alternatives are more economical. The increasing use of hydropower, particularly in the Amazon and Congo basins have raised environmental and indigenous rights concerns, with some arguing that these nations are putting economic growth above these other principles.

Decades of neoliberal trade policies give way to the resurgence of protectionist trade policies. The rise of nationalist parties in the West fifteen years ago sparked the resurgence in protectionism which quickly spread around the world. Trade networks have reshaped themselves and have begun to strengthen local and national markets. LDCs have seen some of the greatest advancements. In retaliation to the West, they blocked the flood of cheap, often subsidized, goods into their countries. However, this led to rapid development in their domestic industries which now had room to grow and compete, particularly through regional and South-South trade. Value chains are now keeping more wealth within countries, spurring further economic expansion.

The developing world has seen the development of pro-poor food policies. Led at first by farmers' movements, these grassroots citizen movements have pressured their governments to invest in domestic agricultural and nutritional programs while reducing the influence of international agribusiness. The success of these programs has been striking in bringing about a successful agroecological transition. Coming from within, they have proved far more effective than past development and aid programs coming from the West. Prevalence rates of undernourishment and particularly stunting have fallen rapidly following the implementation of these programs. Rural development has also swiftly grown as agricultural investments have greatly increased productivity and raised the majority of rural populations out of poverty.

Food prices have been gradually declining. Increased investment in LDCs has boosted production. Most of this has also gone to into local food systems that also save on reduced transportation costs and less processing. By keeping production local, along with the resurgence in traditional cultural pride, there has been less of a convergence towards the Western diet than was anticipated. The increase in demand for food has then comfortably been met by the increased agricultural output allowing for this decline in prices.

Purchasing power has increased for the rural poor, though fallen in urban settings. While economic growth has occurred in both areas, poverty and inequality remain high in cities where higher prices lead to lower purchasing power. Rural development though has led to increased incomes and local production, particularly of food, while the cost of living declines along with dependence on imported goods.

Social tensions in the developing world grow as economic development spurs social transformations. Women are more economically independent and are pushing for greater social and political empowerment. However, this is leading to clashes with reactive social and political forces that are attempting to preserve traditional gender norms. However, women remain more educated than in generations past and economic growth has provided them with new opportunities for financial independence. Indigenous feminist movements are on the rise and many nations have witnessed their own tumultuous social revolutions.

Scenario 3

Slow and fragile growth (business as usual)

By 2030 progress has continued slowly in the fight against hunger. Free trade remains dominant. Neoliberal trade policies continue to push for economic globalization. Market access and integration continue to grow and the LDCs remain dependent on commodity exports from upper and middle income countries. The global economy has seen average sluggish growth on average for the past two decades, slowed by periodic economic crises.

Recently, a regional banking crisis has struck Singapore and spread throughout South East Asia. The economies in the region have begun to contract, with the manufacturing sector suffering the most. Middle-class, urban workers will see the largest comparative decline in their standard of living, as their recent economic gains disappear nearly overnight and many fall back into poverty. Poverty and inequality have worsened in the region. Rapid inflation has led to increased imports and a growing trade deficit. Governments have enacted austerity programs, cutting social protections at a time when people are most in need of assistance.

Elsewhere in the world, though, purchasing power has increased for the urban poor while declining for rural populations. Economic growth is continually concentrated in megacities while poverty deepens in rural areas. The disparity in purchasing power has intensified as goods and serves grow cheaper in urban centers while costing more in rural areas to access away from them.

Food prices have gradually increased. A growing global population with an increasing Western diet has increased demand. Agricultural production has been increasing as well but is only barely keeping pace. Limited investment and no great agricultural research breakthrough have kept production from increasing as much as many had hoped. Bad harvests have also become more common as a result of climate change, which leads to periodic spikes in food prices.

The international community has been working to implement climate change adaption programs. Their rollout has been slow and occasionally problematic. While there is a general consensus among nations on what must be done, political disputes and failure to live up to financial contributions have proved a major setback. Some public-private partnerships have proved somewhat promising, though none have been scaled up to the levels necessary to reach all those in need. As the political debates continue to bog down implementation programs, the effects of climate change have already hit the most vulnerable regions and food security has begun to worsen in Sub-Saharan Africa. Migrations and conflict become more common in this region.

Despite similar pledges to diversify the energy sector, the world is still dependent on fossil fuels. The expansion of renewables continues to grow but has not reached the point where they can economically compete on a largest enough scale to replace petrochemicals. Peak oil has turned into plateau oil with prices high but level, on average. The issue with oil is the lack of elasticity in the market. Price volatility has worsened and it is very vulnerable to shock. Economists are worried that a major disruption to production could result in price spikes across the market setting back recent economic growth.

Food policies remain deficient across much of the developing world. Upper and, to a lesser extent, middle income countries continue to invest in consumer protections, public health, and their domestic agricultural industry. While in lower income countries, inadequate funding and less prioritization keep food policies from doing the same. As a result, agricultural industries remain underdeveloped and a large share of the population remains vulnerable to both hunger and increasingly the double burden of malnutrition.

Women's empowerment continues, but the improvements are slow and gradual. Limited legislative and institutional reforms are made in advancing gender equality, though they often lack enforcement. Girls' education rates slowly improve but most of the benefits are seen at primary and early secondary school, while many still do not complete upper secondary school. Limited employment opportunities from slow global economic growth and the persistence of early marriage and childbearing continue to keep many young women from furthering their education and entering the labor force. The formation of women's groups does provide some social capital and empowerment, but their influence is limited to the community level. Women continue to have limited representation in government but do not represent a political bloc.

Scenario 4

Deepening divide (pessimistic)

By 2030 progress towards reducing global hunger has halted. Growing inequality, between regions and economic classes, is expanding poverty and food insecurity rates. The global economy, as a whole, has continued to grow but the increase in wealth is increasing concentrated. A regional financial crisis has struck the emerging economies of South East Asia, mostly driven by sovereign default. This has set back the economic development of the region and other parts of the Global South. The crisis and its aftermath has brought about years of deepening poverty, loss of social investments, and austerity as the norm. Economists expect it will take more than a decade to recover from the setbacks.

The international community has taken proactive measures to mitigate climate change, however adaptation programs are only being implemented in wealthier nations. MDCs have been willing to adopt more sustainable technologies as they become cost effective to capitalize on the new industry, however they remain less inclined to financially contribute to adaptation programs in foreign countries.

Demand for biofuels has noticeably cut into staple crop production. At a time when the world needed to feed a billion more people, a large share of which are consuming more than ever before, a segment of the agricultural industry is being diverted to producing fuel instead of food. The competition results in rising food prices making more people food insecure. Additionally, the increased profitability of agriculture results in the sector becoming even more dominated by agribusinesses which displace traditional smallholders. Less agricultural labor is required in LDCs as the sector become increasing mechanized resulting in worsening income inequality rural exodus and rapid urbanization. Agriculturealproduction increases but not fast enough to keep up with demand for food from the growing global population and as a result food prices are rising. The double burden of malnutrition increases as more people adopt the Western diet.

Additionally, Western food policies are reshaping the agricultural sector of LDCs. As food systems have become ever more international in their reach, the policies of one country have even stronger impacts on others. Regulations from importing countries, that are intended to ensure food safety and labor and environmental certifications, need to be enforced by producing nations. The added costs of compliance result in LDCs producing more high-value, export-oriented crops. Additionally, agribusinesses who have more financial resources are favored, pushing out smallholders unless they are able to form cooperatives. As the agricultural sector in less developed countries becomes more export focused, it also becomes more dependent on imports of staple foods and vulnerable to price shocks.

The MDCs have also seen a rise in economic nationalism. They have implemented protectionist trade policies, arguing that the flood of cheap products from the LDCs are harming their domestic industries and workers. However, these only go one way. While preventing cheap products from entering their markets, they are still willing to flood other markets with cheap goods. As the import-dependent LDCs do not have the same economic leverage to retaliate. They are unable to protect their markets which are flooded with goods from MDCs and the emerging economies, such as subsidized agricultural goods. This influx of cheap imports continues to prevent the LDCs from making any development in their domestic industries.

Inequalities in purchasing power have deepened within urban populations. The convergence of urbanization and inequality has led to the formation of massive slums surrounding the new megacities of the emerging economies. Large swathes of the population are now living with inadequate access to basic services like electricity, clean water, sanitation, and education. Many are not expected to see their economic situation improve, leading to a two-tiered system of socio-economic exclusion. Resentment leads to an increase in crime in urban areas and the prevalence of armed conflict has grown.

In LDCs, women have also seen their situation worsen. The economic turmoil has been exploited to promote traditional gender roles. Women are increasing excluded from the workforce to provide the limited remaining opportunities for their male counterparts. Women are encouraged to support their families through domestic labor. As a result, fewer girls are completing secondary school as education is no longer seen as a priority and early marriage and childbirth begin to rise.

Scenario 5

System shock (pessimistic)

By 2030 a series of systemic shocks has led to rising rates of hunger around the world. The world is hit by another global financial crisis. Another speculative bubble bursts in the United States. The effects are felt throughout the interconnected world. In the emerging markets, economic growth slows considerably and the recent growth in the middle-class reverses course as many are forced back into poverty and the inequality gap grows.

Buoyed by economic turmoil, protectionism has led to the outbreak of trade wars. Nationalism has swept the West leading to withdrawal from multilateral trade agreements and the implementation of policies intended to shield domestic employment and wages. To discourage outsourcing, states impose tariffs on imported goods. Other nations retaliate by imposing their own tariffs. Trade volumes decline and the price of goods increases.

Economic shocks are also felt in the commodity market. Especially worrying is the recent spike in food prices. A series of extreme weather events, many believe to be linked to climate change, has limited agriculture production for the past three years and reduced the elasticity in the market. Yet demand has grown along with the population and consumption patterns. Further worsening matters, the new Middle Eastern oil embargo, reminiscent of the crisis in 1979, has caused fuel prices to skyrocket. The lack of diversification over the past decade has left the market vulnerable to just such an incident. Food prices have similarly spiked because of increased costs of transportation, artificial inputs, and the expansion of biofuels. As prices have risen and incomes fallen, purchasing power has also significantly dropped. The progress in eradicating extreme poverty then comes to a halt and begins reversing course. Around the world, food riots have occurred, some leading to wider conflicts.

The international community made numerous climate change agreements years ago, but their implementation was never realized. Economic constraints and populist politics have led to the US and China pulling out of the conventions, several other states remain committed on paper but fail to meet their financial obligations. The remaining countries are unable to implement substantive international change on their own. As the effects of climate change are beginning to be felt more broadly, a number of wealthier nations have begun to implement their own domestic adaptive programs, however they remain less inclined to financially contribute to adaptation programs in foreign countries. The LDCs, particularly in sub-Saharan Africa, who face the direst impact are unable to fund similar efforts on their own and remains increasing vulnerable. Millions of climate refugees have been forced to flee. More developed countries have implemented stronger border protects to keep them out. Refugee camps and resettlement programs are overwhelmed and riots frequently break out. Political tensions are growing over the crisis.

Following a similar pattern, food policy remains limited in LDCs. The economic crisis has even further constrained their budgets and international aid has been declining. Increasing protectionist trade policies, have left Western nations less concerned about the agricultural practices of the rest of the world from a commercial and humanitarian perspective. They rely on agricultural and food quality inspections at their own borders rather than trying to protect the entire food system. Nutritional programs in LDCs disappear as governments struggle to provide basic sustenance to growing shares of their populations.

The trend of women's empowerment has largely reversed as a result of the worsening economic situation. Limited employment and financing opportunities available are directed to men while women are pressured to resume more traditional gender roles and contribute to their household by performing unpaid domestic labor. The lack of alternatives leads to increased rates of early marriage and childbearing.

Conclusion

The international community has committed to the principle of ending hunger around the world. However, despite several goals, some success, and a few setbacks, hunger still persists for far too many. There are many challenges we still face, some as fundamental as agreeing upon what we mean by "hunger" and finding an accurate way of determining how many people actually are hungry. This report is intended to help clarify some of these basic matters and the system of factors that drive hunger.

There are many heavy trends that will continue to have a strong and predictable effect on hunger through 2030, the most notable of which are: natural disasters, population density, economic inequality, agricultural systems, and agricultural productivity[73]. However, many drivers of hunger are less clear in their future trajectory. The analysis of these critical uncertainties shows their network of interactions with each other. Additionally, we were then able to identify key drivers that shape this system. These represent potential entry points to the system. Leveraging them can have a cascading effect on all the other drivers that directly or indirectly are influenced by them. **Therefore, these key drivers make for good targets for programming to maximize its impact. These include: conflict, women's empowerment, food policy, energy policy, climate change policy and adaptation, purchasing power, commodity prices, and trade.**

The quantitative analysis, presented in the appendix, provides further insight into these nine key drivers of hunger. It shows the significance and level of influence each have on five separate metrics that are used to quantify hunger: child mortality, wasting, stunting, undernourishment, and the Global Hunger Index. All the drivers had a statistically significant correlation with at least one of these metrics for quantifying hunger. So, while this supports their importance as drivers of hunger, they can be impacted differently. The results can be used to better link programming areas with objectives. **The table below shows which drivers can be targeted to affect specific aspects of hunger.**

Hunger indicator	Key drivers to target (weight of influence)
Global Hunger Index	Purchasing power (0.87), climate change adaptation (0.56), conflict (0.18), financial crises (0.12)
Undernourishment	Commodity prices (1.21), climate change adaptation (0.85), financial crises (0.24), conflict (0.23), food policy (0.16)
Stunting	Climate change adaptation (0.50), conflict (0.22), financial crises (0.18)
Wasting	Women's empowerment (0.45), conflict (0.41)
Child mortality	Purchasing power (0.82), climate change adaptation (0.33), trade (0.09)

Based on these critical uncertainties the report lays out five scenarios that represent archetypal futures based on how these drivers may unfold over the coming years. These are not predictions and the future will not neatly match any one of them. Instead, these scenarios are a structured way to help us think about the future. In so doing, we can make more informed decisions today as we plan for the years to come. The scenarios cover a range of possible trajectories, from rosy to bleak. "Strong and Equitable Growth" and "Rise of the Rest"[74] represent two possible courses to a more optimistic future. The former is based on a more equitable form of Western-led development. The latter is based on growth coming from the strong, and at times tumultuous, development of the non-Western world. "Slow and Fragile Growth" follows more along the lines of business as usual, whereby no major changes in trajectory occur. It also warns that without major changes, hunger will be a pressing issue for hundreds of millions of people for decades to come. "Deepening Divide" shows what would occur if the negative trends we witness today become more dominant, threatening to halt the progress made in ending hunger. The final scenario, "System Shock", illustrates how the world is still very vulnerable to shocks and how if a series of these were to occur it could cause hunger to become even worse of a crisis.

None of the scenarios indicate that the Sustainable Development Goal of ending hunger by 2030 will be met. The business as usual scenario ("Slow and Fragile Growth") shows only small progress being made, echoing the FAO's projections that over 650 million people are likely to be undernourished by then[75]. While the two optimistic scenarios ("Strong and Equitable Growth" and "Rise of the Rest") in this report have the world getting close to this target, it was found that several heavy trends would prevent it from being reached in full. **Persistent issues such as growing populations, economic inequality, social exclusion, climate change, and natural disasters cannot be resolved within that timeframe.** Committed, long-term programming will be necessary to affect these heavy trends. By combining these long-term efforts with the immediate gains that can be made by targeting the key drivers of hunger, we can achieve substantive results by 2030 and ultimately bring about a world free from hunger.

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Annex: Heavy Trend Summaries

Heavy trends refer to those factors that are influential in shaping global hunger, for better or worse, and whose impact through 2030 can be well predicted from our current perspective in 2017.

Urbanization

Trends

Urban population, as a share of total population, has consistently been increasing for decades and is expected to continue to do so through 2030[76].

Growth of urban population:
The urban population is projected to represent 60% of the global population by 2030[77]. Sixteen countries have urbanization levels of below 20%[78]. These states will see there urban population proportion more than double by 2050[79]. Nearly 90% of the global increase of urban population will come from Asia and Africa.

Rise of megacities:
The world will contain more than 600 cities of over one million inhabitants by 2030[80], including 40 megacities with 10 million inhabitants or more, representing 730 million people or 9% of world population. The increase in number and size of cities will be greatest in the emerging economies of Asia and Africa.

Difficulties of management and "slumification":
The management of urban development is a challenge for many emerging countries that already have difficulty in providing basic services to their urban dwellers (accommodation, sanitary, sanitation...). In the developing world, the share of of the urban population living in slums has been steadily decreasing (30% in 2014), however the total number of slum dwellers has still been increasing (880 million in 2014) given the overall growth in urban populations[81]. The challenge remains in providing services and employment opportunities to a rapidly growing population.

Impact on hunger

Cheaper food in cities at the expense of the rural farming communities[82]:
Historically, developing states have had the tendency to implement food policies that favor urban populations that means food policies that promote low price staple food importations. Consequently, domestic agricultural production often suffers as it is not able to compete against the economies of scale of industrialized agriculture. Increasing imports instead of promoting local agriculture causes an increase in poverty and hunger in rural areas.

Changes in dietary patterns and malnutrition.
Urbanization brings with it new dietary patterns: a reduction in staple foods filled by an increase in animal products, sugar, and processed food. This is contributed to by the type of food retailers both traditional (e.g. street vendors and small merchants) and modern (e.g. supermarkets) that increase access to these types of foods. Urban environments are much more likely to manifest the double burden of malnutrition, undernutrition and overnutrition, where individuals can simultaneously experience the adverse health effects of inadequate nutrition along with that of being overweight. Food deserts also demonstrate this link between the accessibility of nutritious food and the double burden of malnutrition[83].

Lack of investment in infrastructure.
Insufficient infrastructure development to meet the needs of an increasing urban food demand heightens the risk of hunger. Investment is needed in infrastructure across the food chain to ensure nutritious food is consistently available and accessible to all.

Climate Change

Trends

CO_2, and other greenhouse gases, concentrations in the atmosphere have been exponentially increasing since the start of the Industrial Revolution and will alter the climate for centuries to come, even if strong mitigation actions are taken today. According to the scientific findings of the IPPC, written down in the Synthesis Report of 2014, it is now 95% certain that humans are the main cause of current global warming. With the commitment of thousands of experts and scientists from around the world, the Synthesis Report has projected surface temperature to rise over the 21st century and mentions that "it is very likely that heat waves will occur more often and last longer, and that extreme precipitation events will become more intense and frequent in many regions. The ocean will continue to warm and acidify, and global mean sea level to rise"[84]. The International Community set an important international legal framework to address climate change issues – i.e. The Paris Agreement adopted in 2015 and each country has its own goals (INDCs). The failure of climate change mitigation and adaptation has been considered a leading risk for the past three years and is currently considered to have the most severe impact on the future[85]. Countries are likely to have to increase their actions on climate change, especially on the development of green technologies and the inclusion of adaptation-policies in all the sectors[86]. **The impact of climate change will continue to increase through 2030, though extent of the effect will vary according to nations' locations and ability to adapt[87].**

Impact on hunger

Climate change is a critical challenge impacting both food production and food consumption around the world[88]. Agriculture and fisheries are sectors of particular risk from the impacts of a changing climate. For example, crop yields can be significantly impacted by changes in temperature, atmospheric carbon dioxin, and the frequency and intensity of extreme weather. The effects of climate change on agricultural production will vary by location. Low latitude countries will be negatively affected, while higher latitudes may benefit initially. Arid regions and those depended on glacial runoff will be the most negatively impacted. This will exaggerate existing global inequalities and worsen food insecurity and dependence for much of the Global South. While global yields will not likely see a net impact before 2030, some low latitude countries will be impacted before then. Food security and climate change adaptation are likely to become increasingly linked for development and humanitarian projects. In this sense, the International Fund for Agricultural Development established a dedicated fund in 2012 called Adaptation for Smallholder Agriculture Programme (ASAP) to help farmers to build resilience to climate change, and yet lack of funding and political will have prevented much progress from being made[89].

Natural disasters

Disasters can take many different forms, we define natural disasters as being distinct from those of a man-made or technological origin. Hurricanes, earthquakes, drought, and agricultural pests and diseases are examples of natural disasters.

Trends[90]

Natural disasters are an enivitable issue that humanity will have to continue to face, however they are becoming more frequent and intense due to climate change[91]. Despite this increase, the number of affected people have slightly decline to an average of 165 million people impacted each year. Even though natural disasters happen globally, inequalities facing these disasters are growing. Asia is by far the most impacted area with highest number of affected people and death toll. South and South-east Asia is particularly hit by significant storms and floods events, while Africa is increasingly impacted by drought. By 2030, natural disasters will impact a growing number of people, as populations grow and are concentrated in fragile coastal areas.

Impact on hunger

Unequal distribution of occurrences:
Some populations experience far more frequent and/or severe natural disasters because of their specific location's climate, geology, or environmental degradation. They are regularly affected by drought, floods or storms which can lead to hunger. Haiti, Somalia, or Ethiopia are good examples of countries who have suffered from high rates of hunger and difficulty in developing because of repeated natural disasters.

Human ecosystem brittleness:
Natural disasters weaken affected areas by damaging essential infrastructures (roads, hospitals, schools...) delaying assistance arrival. In the direct aftermath, populations have difficulty accessing basic necessities like food, fuel, and clean drinking-water. Longer term effects include damage to agricultural and food distribution systems.

Vulnerable displaced population:
The impact of displacement on food security depends on the complexity and duration of the displacement period. Whereas displacement resulting from natural disasters can create immediate food needs that could worsen to the extent of malnutrition and in some cases, starvation, protracted displacement caused by conflict can create more systemic issues requiring nuanced, multifaceted interventions.

Population growth, structure, and density

Trends[92]

Projected growth:
The world population is projected to increase by more than one billion people within the next 15 years reaching 8.5 billion in 2030. The increase is expecting to slow down with a lower fertility rate. However, even under the most optimistic projection, populations will continue to grow for half a century[93]. Population growth will continue to occur unequally around the world. Half of the growth is expected to occur in Africa and Asia and by 2050. Many less developed countries are projected to see their populations double in size by 2050.

Structure:
Population is expected to age by 2050. Life expectancy at birth is projected to rise by 7 years. The ratio of people over 60 will meet the ratio of under 15 by 2050, despite countries with high fertility rates remaining with a young population.

Impact on hunger
The fast growth of the population does not lead directly to the scarcity of food. Larger populations do require more food, but this is also compounded by increasing wealth and the demand for more resource intensive foods. Global agricultural production is projected to meet the needs of a growing population. However, even today when the world produces a surplus of food, a large share still goes hungry. The challenge is in creating a more equitable food system that provides for the needs of all. The alternative is far larger populations affected by hunger

Economic inequality

Trends

Poverty rates are likely to decline in the next decade while economic inequality will remain high. Disparities are rising as the share of income going to the top 1% has increased since the 1980s in many developed countries[94]. In these countries, the income of the poorest 10% of the population has risen by 3 dollars per year between 1998 and 2011 while it has risen 182 times more for the wealthiest 1%[95]. Even the rapid growth of the middle class in emerging countries will not eliminate the gap between the richest and the poorest. Based on historic assessments, long-term trends in economic inequality change gradually, especially when aggregated to regional or global levels. As such, even major and immediate economic changes will not likely alter current trends before 2030.

Impact on hunger

Inequality has a high influence on the ability of economic growth to reduce poverty[96]. For example, it has been estimated that a 1% increase in income levels could result in a 4.3% decline in poverty in countries with very low inequality or as little as a 0.6% decline in poverty in highly unequal countries[97]. As such, inequality is a major barrier to reducing poverty, and by extension hunger.

Market integration

Market integration is following a strong trend over many decades, it is therefore highly likely that it will continue through 2030, even if countervailing forces were to attempt to reverse it.

Trends

There is an increasing trend in the integration of markets and the link between commodity prices. **For the past several decades market integration has kept increasing along with economic liberalization and supranational agreements such as in the EU, the ASEAN etc. This trend is expected to continue through 2030 given its past trajectory and the level of economic interdependence that currently exists.** Market integration is increasingly making the global local. With a high level of integration, international prices and domestic markets' prices are heavily tied[98] with international prices impacting domestic ones and often increasing their volatility. A complete integration of markets is not foreseeable by 2030 or anytime in the near future. Governments and economic actors can still adjust the levels of integration through positive or negative means. For example, increasing the cost of importing/exporting a commodity would decrease the degree to which a market is integrated[99]. Despite international efforts to promote free trade, most countries still have some domestic sectors they seek to protect.

Impact on hunger

Market integration has a high impact on agricultural trade and commodity prices. More developed countries strongly limit the negative integration of this sector with policies designed to protect their farmers while less developed countries are unable or unwilling to do the same[100], though there are high levels of variation by region and by commodity[101]. Such inequalities in trade, along with those of agricultural production, lead to the latter becoming increasingly dependent on cheap imports instead of promoting their domestic production. This is particularly problematic when market volatility leads to local price spikes that put basic necessities out of reach for lower income individuals.

Financial capital

Trends

Financial capital is increasing around the world. Yet, it is still out of reach for most of those living in poverty. This trend is expected to continue through 2030, following a decades-long trend in economic globalization[102]. Major changes in trajectory would be slow in coming or the result of a high impact / low probability system shock. Incomes have been rising for some in less developed countries, which allows them to invest more of their earnings back into their livelihoods. Additionally, financial lending has expanded particularly in emerging markets. Access to capital allows for the emergence of entrepreneurship that can promote productivity. However, lending to the poorest segments of society is still limited as they are considered too high risk. Unfortunately, these are the people most in need of access to financial capital to break out of the cycle of poverty.

Impact on hunger

Access to food: Access to financial capital allows for greater returns on investments, increasing household wealth which in turn increases access to food.

Availability of food: For small scale producers, agricultural investments can also increase yields and therefore the availability of food. But financial capital remains rarely accessible to small producers and is generally oriented to larger farms. Added to that, massive investments usually lead to the adoption of new technologies often still based on the model of the Green Revolution "package of practices", which means the association of chemical fertilizers, agro-chemicals, irrigation, and new methods of cultivation, including mechanization. Such investments may support the destruction of peasant farming systems.
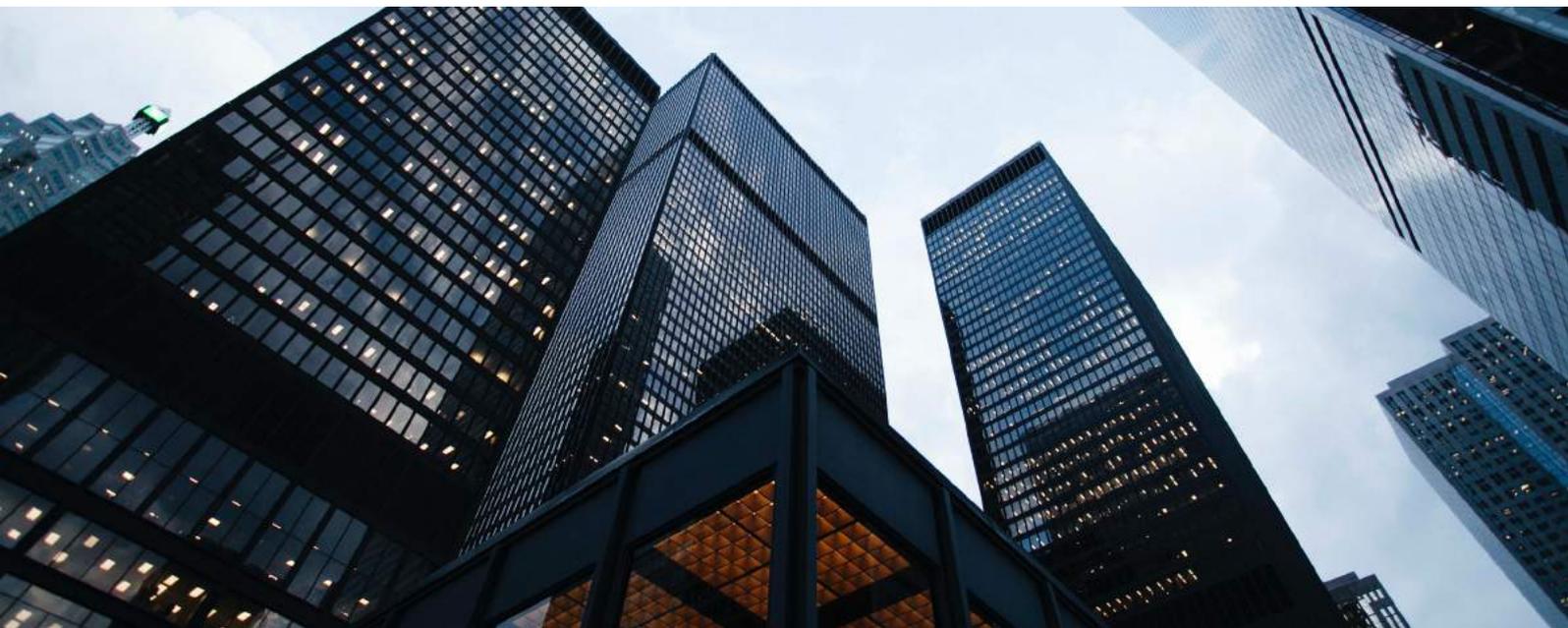
Access to markets

Trends

A decline of tariffs and trade barriers for least developed countries. WTO members have increased their quota-free or duty-free market access to less developed countries for a preferential access to markets[103].

Impediments for small scale producers:
Competing in the international marketplace requires abiding by an increasing number of international standards and practices. Small scale producers face greater challenges in meeting these requirements. Gaining access to the basic information of what they are and how they can be met is an initial challenge. Furthermore, some of these require additional financial investments which may be beyond their ability to access. Meanwhile, larger and/or wealthier enterprises do, and are far less encumbered by these obstacles.

Transportation and distribution impediments:
Lack of infrastructure in poor countries increases the prices of goods, such as in East Africa where transport costs are among the highest. The added finical burden makes competing on, or even accessing, the world market far more challenging for national and local actors from such countries[104].

Impact on hunger

Access to markets for agricultural producers is key to increase income, production, growth and reduce hunger and poverty. Small-scale producers, for knowledge and logistics reason, often favor local markets. International markets could allow producers to sell more at higher prices[105] but can also bring less added value, less bargaining power and less income to small scale producers, as well as spreading less employment benefits at the local level in developing countries[106]. Poor countries' farmers have difficulties in meeting international standards and keeping up with market prices and information[107]. Technologies and the internet are increasing the connection between producers and consumers. Small initiatives are growing such as ePing, giving access to market information, advising on how to avoid waste or surplus, and empowering women through access to the market[108]. However, such actions still have had very limited impact on hunger to date.

Agricultural dependence (as share of GDP)

Trends

Globally, agriculture as a share of GDP has exponentially fallen and begun to level out in the mid-2000s[109], driven by trends in Asia as other sectors became more economically dominant[110]. For most upper and middle income countries, this value is only a couple percent, while Asia as a region has decline from 23.8% in 1970 down to 7.7% in 2013 and is expected to fall even further. **Sub-Saharan Africa is the noticeable exception** where the average rate has held near 15% for decades. The situation remains highly unequal between regional zones with a huge gap between Africa and the rest of the world: in the Sahelian strip, agriculture still contributes to almost one third of GDP. There is a strong correlation between low-income countries, and more precisely high indebted countries, and a high dependency rate. Among the most dependent countries, we can observe a very slow decline in the dependency ratio since 2000, which means that no significant efforts have been made to reduce the dependency on this sector. On the contrary European Union has a 1.59% dependency rate to agriculture because the value of agriculture sector compared to other activities is very low.

Impact on hunger

The problem is the volatility and the unpredictability of the agricultural revenues especially in countries with traditional farming methods and weak non-agricultural exports. However, if diversification of economies can help mitigate the risk associated with variable productions and agricultural competitive markets, investing in small scale agriculture raises incomes more than in any other sector.

Humanitarian and development assistance

Trends

The past half century has shown an increasing amount of international humanitarian aid, with only one period of interruption coinciding with the major geopolitical shifts between the end of the Cold War and the September 11th attacks. As such, it is expected to continue increasing through 2030.

Insufficient funding to respond to emergencies. Following a decade-long trend, the funding gap - difference between funding received and funding required - has been significantly widening since 2014, reaching almost 10,000 million USD in December 2016[111]. UN-led humanitarian funding data suggest that the need for international emergency aid is outpacing donor governments' willingness to increase contributions. In 2016, for example, donors gave $11.4 billion towards UN-coordinated appeals – a record amount, but still barely more than half of the $20.1 billion requested. Ten years ago, when the annual appeal was a mere $5 billion, it was almost 70% funded[112]. Regarding the importance of food assistance in emergency situations, the widening funding gap is quite alarming regarding the progress of hunger and even famines.

Decentralization of NGOs. NGOs will increasingly work with national staff for a variety of advantageous reasons, including access to vulnerable populations[113], especially through alliances and partnerships with local structures. This process will lead to the adoption of federation style organizational structures: global funds for localized actions through huge networks[114].

Multipolarity of donors. With the rise of a multipolar system, many non-traditional and non-DAC donors have increased their funding, leading to a de-westernization of the humanitarian sector and a regionalization of the aid. A cultural conflict might occur between traditional humanitarian principles and new donors' values. The private sector will also play a key role in humanitarian and development funding especially through private-public partnerships and self-funding mechanisms (e.g.: START): innovative financing will increase.

Impact on hunger

Hunger is a concern for the humanitarian sector. The Sustainable Development Goals (Goal 2)[115] and previous Millennium Development Goals (Target 1.C)[116] embody the importance of the issue and the need for decisive international action to resolve it. Reducing hunger and immediate risks of malnutrition and undernourishment are a key element of humanitarian response. It is one of the highest funded humanitarian sectors, accounting for 23.4% of total funding in 2016 which equals 5.2 billion US dollars[117].

Lack of dedicated resources and volatility of food aid: Food aid trends are volatile and closely linked to short-term shocks and availability (emergency remained by far the most predominant category for food aid)[118]. However, even in emergency contexts, donor countries fail to provide enough food for many hunger emergencies – often chronic hunger crises with little or no political or media attention. Food aid often arrives too late, even in cases where a crisis could be predicted. And, if poorly targeted, food aid can distort local production and markets and thereby threaten long-term food security.

Land tenure systems/rights

Trends

Land tenure systems define how access is granted to right holders to use, control, and transfer land. Land tenure does not only apply to farmed land. Land tenure and rights is essential for forest communities and pastoralists, and people largely depending on rangelands for grazing areas (transhumance livestock breeders in Central Asia, the Sahel, Horn of Africa). There is a trend towards more formalized land tenure systems. Low levels of land tenure security have been linked with the rush for large-scale land acquisitions in developing countries in the past decade[119]. **The legal and social constraints on it, result in any changes being slow in coming and so no major trend changes are expected before 2030.** Securing land tenure can then have many positive impacts towards hunger reduction:

Agricultural productivity. Secure access to land enables farmers to invest in long-term improvements to their farms in the expectation that they will reap the benefits of those investments without fear that their land be confiscated arbitrarily. With out secure property rights and land tenancy, farmers are less likely to commit to improving agricultural production systems and their sustainability, opting instead for solutions that maximise profit in the short term, but could cause land degradation in the longer term.

Access to credit and income. Insecure land tenure or the lack of land ownership also restricts the farmers' access to credit. Property ownership also increases farmers' income and financial security. For example, the growing dispossession of small peasant producers from their land in Bangladesh turned farmers into seasonal laborers.

Land reform has varied widely by geographic regions:

- **Latin America:** land reform implied changes in the scale of land holdings through redistribution of land resources among the rural population and breaking up of big estates.

- **East Asia:** land reform meant "land to the tiller" or breaking up of landlord/tenant relations.

- **Africa:** a lot of farming—up to 90%—is done on land held under customary tenure regimes, where land rights are not certified formally[120]. Many barriers remain in Africa to create a sustainable land tenure system: disempowered and weakened local institutions and customary tenure arrangements reducing the demand of formalization among landholders. Especially in Africa, land tenure needs to account for pastoralists to ensure that they are not excluded from traditional grazing lands and as a result, create land-use conflicts with settled agriculturalists.

Impact on hunger

The global level of wealth in Africa has reduced the capabilities for farmers to invest in farms inputs or infrastructures. Land reforms can have social consequences, especially regarding the ability of the poor to gain access to land. If not properly managed, land reform can be prone to corruption, benefiting only individuals or groups favored by the ruling government. Conversion of usufruct systems to private property has rarely occurred historically without considerable social and economic displacement.

Agricultural productivity

Trends

Agricultural productivity is measured as the ratio of agricultural outputs to agricultural inputs. **It has been steadily increasing around the world, though with a slowdown in productivity growth in the US and Europe. The trend has increased since the late 20th Century as more intensive agricultural systems began to spread from the upper to lower income countries. While several factors could eventually change this trajectory, such as new agricultural technologies or the effects of climate change, these are not expected to do so before 2030.** Many sources can improve agricultural productivity such as mechanization, fertilization, irrigation, soil and organic matter management or seed selection. Total Factor Productivity (TFP) is a measure of the efficiency of agricultural productivity, this is the residual growth in output that is unaccounted for by growth in inputs over the same period. The inputs that tend to be included are land, water for irrigation, fuel, fertilizer, seed, pesticides, capital and labor. Growth in TFP is generally driven by technological change, scale economies and switching to more productive agricultural activities. By 2050, the projected rate of TFP growth (1.72%) would almost meet the required rate of TFP growth (1.75%) that means that TFP is expected to grow sufficiently in the coming years so global production would keep up the pace with global demand. However, regional disparities exist, such as in Sub-Saharan Africa where only 14% of total regional demand can be met by maintaining the current TFP growth rate[121].

However, the agricultural output gap is tremendous between intensive agriculture and subsistence farmers. The extreme efficiency of US agriculture creates a hard competition with African countries. Low food prices from the US can not only be explained by a high productivity but also because of low production costs due to government subsidies, a dumping to reduce the stocks, the free costs of research that are not reflected in the price of the goods and different geographic conditions.

There are alternative visions for how agricultural productivity can best be achieved. The industrial vision of productivity, from wealthier industrialized nations, is based on producing more with less land and labor. However, to do so requires mechanization and more artificial inputs. This approach has been questioned for its negative social and environmental impacts from depleting fresh water reserves and hastening climate change to driving rural exoduses and deepening inequalities. Consequently, many now call for an agroecology vision of productivity that is based on sustainable natural resources management. Under such a model, human capital can replace artificial inputs in the production system. As such, it promotes the preservation and improvement of natural resources and biodiversity, empower the role of smallholder farmers, boosts rural development and supports the adaptation and mitigation of climate change (as it provides ecosystem services). The International Assessment of Agricultural Science and Technology for Development (IAASTD)[122] and the International Panel of Experts on Sustainable Food Systems (IPES-Food)[123] both state that agroecology is a viable alternative for increasing productivity. As the world moves towards 2030, the need for agricultural productivity and sustainability will lead to a greater role for agroecology.

Agricultural imports and exports

Trends

Long-term growth in agricultural trade is expected to continue through 2030, though at a slower pace than the 2000-2015 period[124]. The trend is driven by increased demand from developing countries, particularly from changing consumption patterns, and more exports coming from industrialized nations[125]. As a result, there will be a growing divide between net exporting and importing nations. With a global value of 1.486 billion US$, food exports value represents 8% of total merchandise exports[126]. Food products account for 84% of total agricultural products (the rest being mainly biofuel production). However, about a third of arable land goes to producing food for animals rather than for direct human consumption. Global supply does not perfectly match the global production because a significant part of commodities is traditionally stocked. Out of the 2.6 billion metric ton of cereals available on the global market in 2014, 26% was stocked from previous years[127].

Top exporters countries are not necessarily the same than top producer countries because most of the production is consumed domestically. For example, only 5 out of the 10 top producers of cereals in the world in 2014 are also part of the top 10 exporters (Argentina, Brazil, France, Russia, and India). The number of net exporters is decreasing whereas the number of net importers is increasing because agriculture requires massive investments. **Top exporters have steadily increased their production since 1960 (China and US).** The top 15 exporters lead 81% of the agricultural products' export in 2014 (including intra and extra UE exports that account for 43% of global food trade). Africa represent only 3.6% of world exports in 2014.

Impact on hunger

Agricultural trade does not directly impact hunger but global trade balance and GDP. Revenues driven by agricultural trade are highly dependent of international markets' prices. One of the main stated objectives of the Doha Development Round (WTO) – negotiations have stalled since 2008 – is to lower international trade barriers to strengthen production capacities of farmers in developing countries, rendering them less vulnerable to volatile market conditions. However, many experts refute such effects and believe liberal agreements would have the opposite effects than expected. Opening wide up barriers could then have a negative impact on developing economies. Vulnerability of exporting countries also depends on the number of commodities they export. Some countries trade an impressive list of food whereas others are dependent on one or two agricultural export commodities (See for example Guinea Bissau with Brazil nuts, coconut, and cashews).

Global low prices on food markets do not encourage investments in agriculture. For example, China is considering importing food to its coastal cities because it may be cheaper than domestic production coming from the inner land of China.

Agricultural System/Land Use

Changes in agricultural system and land use trends is a slow process that is not likely to vary much before 2030. Agricultural land makes up 37.6% of all land types. This part is divided into: arable land (28% of the global agricultural area)/ permanent crops (3%)/ permanent meadows and pastures (69%) which account for the largest share of the world's agricultural area. **A slight decline of global farmland should happen by 2030[128].** Since 1990, agricultural production has steadily increased, despite the area of land used remaining the same. This is a clear indicator of how land productivity levels have improved.

Future importance of Latin America.
Expansion of arable land comes at expense or other land uses. By 2030, 98% of potential arable land in South Asia will be in use. Whereas, Latin America and Sub-Saharan Africa will be the only regions where this rate remains under 30%[129]. However, a moratorium on the further deforestation of the Amazon in the context of environmental conservation and climate change negotiations would prevent Latin America from being targeted by agribusiness for the expansion of cultivation in the coming years.

Climate change and water stress exacerbate the challenge associated with land use. Improving land management -such as reduced tillage, crop rotations and mulching – can protect the soil and the environment, and also increase long-term yield and reduce GHG emissions.

International agribusinesses

Trends

Multinational leaders: There is an increasing presence of multinationals in all phases of agri-food systems. Following this decades-long trend, and because of their power within the sector, they will continue to be major actors through 2030. Many mega-mergers are increasingly prompting some farm groups to sound the alarm about increased consolidation in the business of food production. The multinational chemical and pharmaceutical giant Bayer AG has recently purchased the agricultural biotech company Monsanto (2016). The two companies currently control most canola seed sales. More generally, 90% of the seeds are controlled by only five enterprises in the world. If monopolies usually diminish the incentives for innovation, they mostly reduce the autonomy of local farmers that become dependent of a couple of mega-corporations for all their supply. Such concentration also has direct impact on nutritional diets: the FAO estimates that the diversity of cultivated crops declined by 75% during the 20th century and that a third of today's diversity could disappear by 2050. Only 30 crops constitute 90% of the calories in the human diet, and only three species (rice, wheat, maize) account for more than half of the human calorie supply[130]. Top agribusiness firms have become so powerful that it is very difficult to compete, especially for local agribusiness firms, especially for the so-called non-traditional exports (seafood, fruits, vegetables, and flowers), very often under the direct control of large-scale retailers. As much as a third of agricultural trade overall can be accounted for by purchases between the subsidiaries of the same firm, where prices are determined by fiscal (including tax) considerations. Small scale farmers become highly dependent on agribusiness prices and supply, which create large internal vulnerabilities.

Impact on hunger

The increasing concentration of a dozen corporations dominating the sector can represent a major oligopolistic risk (i.e. if they hold enough power to influence prices and can deter competitors from entering the market, or even worse, destroy any existing initiative of domestic agribusiness). Additionally, they can decide what norms they promote and influence political decisions and policies in their favor.

While investments in Africa and Central Europe may change the equation in the coming decades, Brazil is emerging as the global supply source for a range of strategic agri-food. China is now reviewing its policy on foreign direct investment: Chinese investments in vast agricultural projects in Asia, Africa, and Latin America, aimed at exporting to its domestic market.

Appendix: Quantitative Analysis

To supplement the structured analysis, the report also includes a statistical analysis of relationship between the scenario drivers and hunger, consisting of linear regression[131] modelling. It is intended to provide additional support to the qualitative analysis by examining the statistical relation between the drivers and hunger. For each of the nine drivers, a quantitative indicator was assigned to be used as independent variables[132] in the model. For example, the driver of Women's Empowerment used UNDP's Gender Inequality Index score. The full list of indicators is presented in below.

Methods

Five indicators of hunger were included as dependent variables: child mortality rate, prevalence of wasting, stunting, undernourishment, and the Global Hunger Index (GHI)[133]. The analysis then examined their relationship to nine independent variables representing the drivers. Observations are based on the mean values from 2004 to 2014, although for a couple of the indicators only a single point of more recent data was available. In particular, for the hunger drivers, average over this eleven year period were considered for the first four, although most of the countries had many missing observation years for prevalence of wasting and stunting, and for the Global Hunger Index, only data for 2006 and 2014 was available, so the average of the two years was used. Observations were of national level data, though not all countries were included. By removing some like more developed countries, those with very small populations, and those with many missing data points, the model was better able to target the nuances of what is contributing to hunger.

Five separate linear regression models were run each with the drivers as independent variables and with one of the hunger indicators as the dependent variable. The models were run against 65 mostly low and low-middle income countries that had data available for all dependent and independent variables, the results of which are presented. Additionally, in order to incorporate all possible data, each model was run separately against all low and low-middle income countries for which data for that particular model were available,[134] the results of which are not presented but were similar enough to provide further validation for the initial results. The results are presented in the following table. Statistically significant independent variables[135] are represented by their degree of significance[136].

The following table shows the standardized coefficients for each driver in each of the hunger indicator models. The value in the box represents the average increment or reduction of the corresponding hunger variable (as a factor of its standard deviation) for one standard deviation increment in the independent variable. Thus, it can be interpreted as a comparative weight of influence that each independent variable has. The shading shows the statistical significance of the driver, those without shading were not significant. It can be used to determine what drivers are likely to have a meaningful impact on the various indicators of hunger and the comparative weight of their influence.

Standardized coefficients estimate (the number in the box) and significance levels (the color of the box) for linear regressions of drivers of hunger as a function of five hunger indicators.

Driver	Independent Variables	Hunger models	Model 1: Child Mortality	Model 2: Wasting	Model 3: Stunting	Model 4: Under-nourishment	Model 5: GHI
Purchasing Power	GNI per capita		-0.82	-0.28	-0.53	-0.89	-0.87
Trade	Merchandise trade		-0.09	-0.07	-0.06	0.13	-0.01
Women's Empowerment	Gender Inequality Index		0.35	0.45	0.13	-0.41	0.15
Energy Policy	Renewable energy consumption		0.27	0.00	0.09	0.23	0.12
Food Policy	Agricultural expenditure		0.02	0.29	0.13	-0.16	0.01
Commodity Prices	Consumer prices		-0.40	-0.51	-0.19	1.21	0.29
Financial Crises	Percent of years with negative GDP growth		0.24	-0.03	-0.18	-0.24	-0.12
Climate Change Adaptation	ND-gain index		-0.33	0.06	-0.50	-0.85	-0.56
Conflict	Political stability and absence of violence		0.14	-0.41	-0.22	-0.23	-0.18
P- value significance codes:	Adjusted R2		0.86	0.35	0.60	0.65	0.83
<0.1 <0.05 <0.01 <0.001	F-statistic		$F_{(9, 38)}$ =32.03	$F_{(9, 38)}$ =3.862	$F_{(9, 38)}$ =8.919	$F_{(9, 32)}$ = 9.595	$F_{(9, 32)}$ = 23.61

Results by driver of hunger

Purchasing power, as represented by GNI per capita, was found to have a statistically significant and strong negative correlation to child mortality rates and the Global Hunger Index. It was not significantly correlated to wasting, stunting, or undernourishment.

Trade was only a statistically significant to child mortality rates and this negative correlation was the weakest of the drivers. However, this may be the result of the model use of total merchandize trade volumes that did not capture the nuances of food trade balances. It was not significantly correlated wasting, stunting, undernourishment, or the Global Hunger Index.

Women's empowerment, as represented by the Gender Inequality Index, was statistically significant and of moderate influence to wasting and undernourishment. Interestingly the direction of influence differed between the two. Better conditions for women was tied to lower rates of wasting, possibly as the result of greater family and community resilience. However, this was also linked to lower rates of undernourishment. This was possibly the result of sampling bias with the countries included in the model. It was not significantly correlated child mortality, stunting, or the Global Hunger Index.

Energy policy, as represented by the share of energy coming from renewable sources, was statistically significant and of moderately-weak influence to child mortality rates and undernourishment. The positive correlation was possibly the result of lower levels of industrialization and associated levels of economic development. It was not significantly correlated wasting, stunting, or the Global Hunger Index.

Food policy, as represented by the share of governments' expenditures in the agriculture, was statistically significant to wasting and undernourishment. Higher expenditures had a moderately-weak correlation to rates of wasting and a weak negative correlation to rates of undernourishment. The results may imply that greater investment in the agricultural sector is making calories more accessible but reducing resilience to food crises. It was not significantly correlated child mortality, stunting, or the Global Hunger Index.

Commodity prices, as represented by FAO consumer price indices, are only statistically significant to undernourishment. Though, this was a very strong positive correlation, suggesting that accessibility may be the driver factor behind undernourishment rates. It was not significantly correlated to child mortality, wasting, stunting, or the Global Hunger Index.

Financial crises, represented by percentage of years with negative GDP per capita growth, was statistically significant to child mortality, stunting, undernourishment, or the Global Hunger Index. It was only not significantly correlated to wasting. It had a moderately weak positive correlation with child mortality and weak to moderately weak negative correlations with stunting, undernourishment, or the Global

Hunger Index. Why longer periods of economic retraction were linked to lower rates of these latter indicators of hunger is unclear. If it resulted in international humanitarian interventions, then child mortality would likely be low too. Possibly, there is a disconnect between the condition of the national economy, based on export commodities, and domestic food systems that are linked heavily with subsistence agriculture. The same anomaly is found with the conflict driver.

Climate change adaptation, represented by ND-GAIN Index of countries ability to adapt to climate change, was statistically significant negative correlation to child mortality, stunting, undernourishment, or the Global Hunger Index. It was only not significantly correlated to wasting. Mortality rates was of moderate influence, stunting and the GHI were moderately strong, and undernourishment the strongest. The results suggest that countries that are less vulnerable and more willing to implement adaptation policies already have lower rates of these hunger indicators. This divide should only widen over the coming decades.

Conflict, as represented by a measure of political stability and the absence of violence, was correlated to all five of the hunger indicators. It had a weak positive correlation to child mortality, a moderate negative correlation to wasting, and a moderately weak negative one to stunting, undernourishment, and the Global Hunger Index. The link between conflict and hunger has been long established. Though the result here of lower child mortality rates is unusual and perhaps a statistical aberration or the result of humanitarian interventions such as maternal healthcare at IDP and refugee camps.

Results by hunger indicator

The first model, for **child mortality rate (under five),** had purchasing power as by far the most influential driver with trade, energy policy, financial crises, climate change adaptation, and conflict less so. The model had a very high adjusted R^2 of 0.86, which corresponds to how well the model fits the data or how well these drivers explain the rate. Two counter intuitive trends were present. Child mortality was found to be lower when conflict was greater or economic contraction was longer, both of which contradict the establish literature and may therefore be biased by the data used in the model.

The second model for **wasting** had three statistically significantly variables: women's empowerment, food policy, and conflict. Food policy was of slightly less influence then the other two. The model had a somewhat low adjusted R^2 of 0.35 implying that these three drivers do not explain a great extent of what determines wasting rates. There was one unexpected finding, in that greater government expenditures on agriculture, reflecting food policy, was expected to reduce the wasting rates not increase it. This may indicate that current agricultural development programs have not promoted resilience to food crises. There is extensive literature on the link between conflict and food crises. Wasting, in particular, is the result of sudden and

severe food shortage that can result from natural or man-made disasters. There is also a body of work discussing how greater empowerment of women can build resilience, which would then reduce the likelihood of wasting in a crisis.

In the third model for **stunting,** there was similarly only three significant drivers: financial crises, climate change adaptation, and conflict. Climate change adaptation was of far greater influence than the other two. All three had a negative correlation as would be expected. The effects of economic and security crises on stunting are well documented. The results also warn of the future risk of stunting in countries that are particularly vulnerable and unable to adapt to the effect of climate change. The model had a reasonable high adjusted R2 of 0.60.

The fourth model indicates that prevalence of **undernourishment (PoU)** is correlated to women's empowerment, energy policy, food policy, commodity prices, financial crises, climate change adaptation, and conflict. All but purchasing power and trade. This model also had a reasonable high adjusted R2 of 0.65. Commodity prices had a very strong influence followed by climate change adaptation. The former suggesting the strong role of food accessibility in influencing undernourishment rates. The latter is potentially of concern because this will only become an issue of greater concern as the effects of climate change grow. One unanticipated result was that greater gender inequality was linked to lower rates of undernourishment. This runs counter to the main body of existing research of the topic and could be the result of sampling anomaly.

The fifth model is the one for the **Global Hunger Index (GHI)** which is based on the previous four indicators of hunger, though it only had four significant drivers: purchasing power, financial crises, climate change adaptation, and conflict. The model also has a very good fit, with an adjusted R2 is 0.83, implying that these variables do a good job at explaining the GHI. Purchasing power had the strongest influence, followed by climate change adaptation, while the remaining two were far weaker. As with the findings for PoU, purchasing power is likely also an indicator of the role of accessibility as a determinant of hunger, while climate change adaption may imply that many of the most vulnerable countries will only get more so without drastic changes.

Indicators Used in the Statistical Model

Climate Change Adaptation

- **Indicator:** ND-GAIN Country Index

- **Definition:** An index score of a county's ability to adapt to climate change composed of both its climate change vulnerability and its readiness to adapt. "A country's ND-GAIN score is composed of a vulnerability score and a readiness score. Vulnerability and readiness are based on compiled indicators. 36 indicators contribute to the measure of vulnerability. 9 indicators contribute to the measure of readiness. Each indicator comes from a public data source."

- **Source:** IFPRI (http://index.gain.org/about)

Commodity prices

- **Indicator:** Consumer Prices, General Indices (2010 = 100)

- **Definition:** "Consumer price indices (CPIs) measure changes over time in the general level of prices of consumer goods and services that households acquire, use or pay for consumption. This is done by measuring the cost of purchasing a fixed basket of consumer goods and services of constant quality and similar characteristics, with the products in the basket being selected to be representative of households' expenditure during a year or other specified period."

- **Source:** FAO (http://www.fao.org/faostat/en/#data/CP)

Conflict

- **Indicator:** Political Stability and Absence of Violence/ Terrorism

- **Definition:** Political Stability and Absence of Violence/ Terrorism measures perceptions of the likelihood of political instability and/or politically motivated violence, including terrorism.

- **Source:** World Bank (http://info.worldbank.org/ governance/wgi/index.aspx#home)

Energy Policy

- **Indicator:** Renewable energy consumption as a share of total final energy consumption

- **Definition:** "Renewable energy consumption is the share of renewables energy in total final energy consumption."

- **Source:** World Bank (http://data.worldbank.org/ indicator/EG.FEC.RNEW.ZS)

Financial Crises

- **Indicator:** Percent of years with negative GDP per capita growth

- **Definition:** "Annual percentage growth rate of GDP per capita based on constant local currency. Aggregates are based on constant 2010 U.S. dollars. GDP per capita is gross domestic product divided by midyear population. GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural

resources."

- **Source:** World Bank (http://data.worldbank.org/indicator/NY.GDP.PCAP.KD.ZG)

Food Policy

- **Indicator:** Percentage of agriculture expenditure in total GDP

- **Definition:** Public expenditure, as a share of total GDP, on the agricultural sector. While food policy covers a range of issues, investment in agriculture is the only dataset that currently exists for a range of years and countries around the world. An international database on nutritional spending is being compiled but is not yet available.

- **Source:** Harvard (https://dataverse.harvard.edu/file.xhtml?fileId=2711562&version=2.0)

Purchasing Power

- **Indicator:** GNI per capita, PPP (current international $)

- **Definition:** "Consumer price indices (CPIs) measure changes over time in the general level of prices of consumer goods and services that households acquire, use or pay for consumption. This is done by measuring the cost of purchasing a fixed basket of consumer goods and services of constant quality and similar characteristics, with the products in the basket being selected to be representative of households' expenditure during a year or other specified period."

- **Source:** World Bank (http://data.worldbank.org/indicator/NY.GNP.PCAP.PP.CD)

Trade

- **Indicator:** Merchandise trade

- **Definition**: "It covers all types of inward and outward movement of goods through a country or territory including movements through customs warehouses and free zones."

- **Source:** WTO (https://www.wto.org/english/res_e/statis_e/statis_e.htm)

Women's Empowerment

- **Indicator:** Gender Inequality Index

- **Definition:** "The GII is an inequality index. It measures gender inequalities in three important aspects of human development—reproductive health, measured by maternal mortality ratio and adolescent birth rates; empowerment, measured by proportion of parliamentary seats occupied by females and proportion of adult females and males aged 25 years and older with at least some secondary education; and economic status, expressed as labor market participation and measured by labor force participation rate of female and male populations aged 15 years and older. The GII is built on the same framework as the IHDI — to better expose differences in the distribution of achievements between women and men. It measures the human development costs of gender inequality, thus the higher the GII value the more disparities between females and males and the more loss to human development."

- **Source:** UNDP (http://hdr.undp.org/en/content/gender-inequality-index-gii)

Maps of Hunger Indicator Values

Child Mortality Rates, under five
(average 2004-2014)

Legend

Mortality rate, under-5 (per 1,000 live births)
- Developed country or no data
- Low (0 - 25)
- Marginal (25 - 50)
- Moderate (50 - 75)
- High (75 - 100)
- Very high (>100)
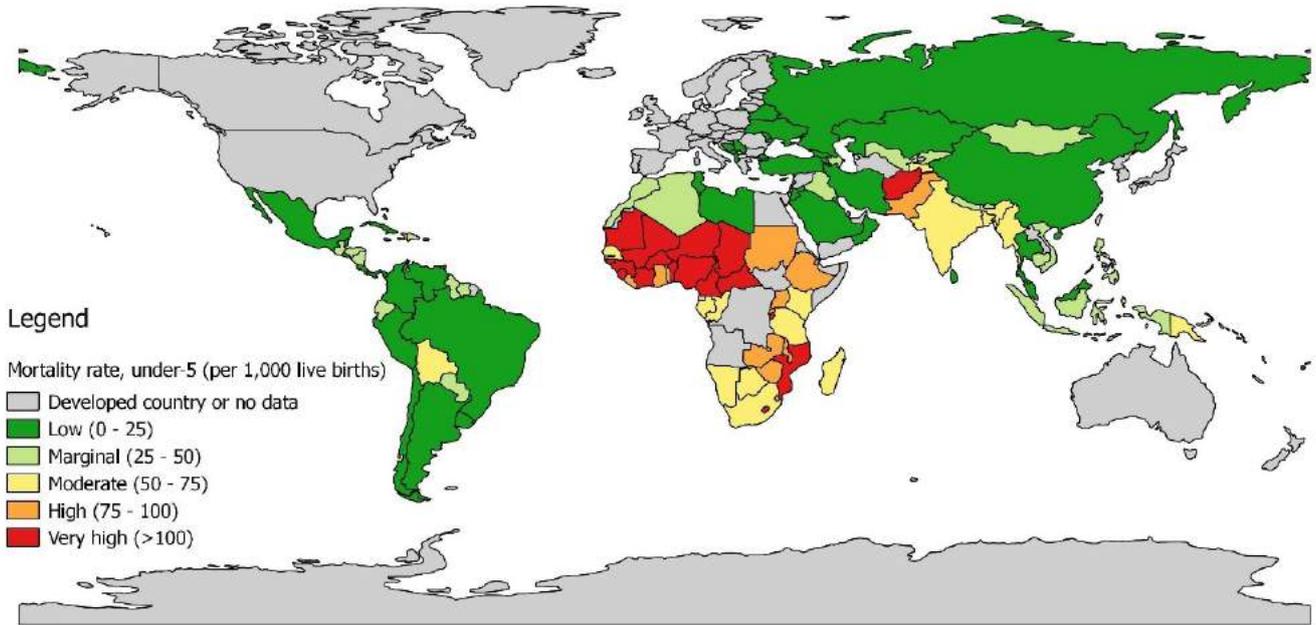
Prevalence of Wasting
(average 2004-2014)

Legend

Prevalence of Wasting
- Developed country or no data
- Acceptable (0 - 5%)
- Poor (5 - 10%)
- Serious (10 - 15%)
- Critical (>15%)
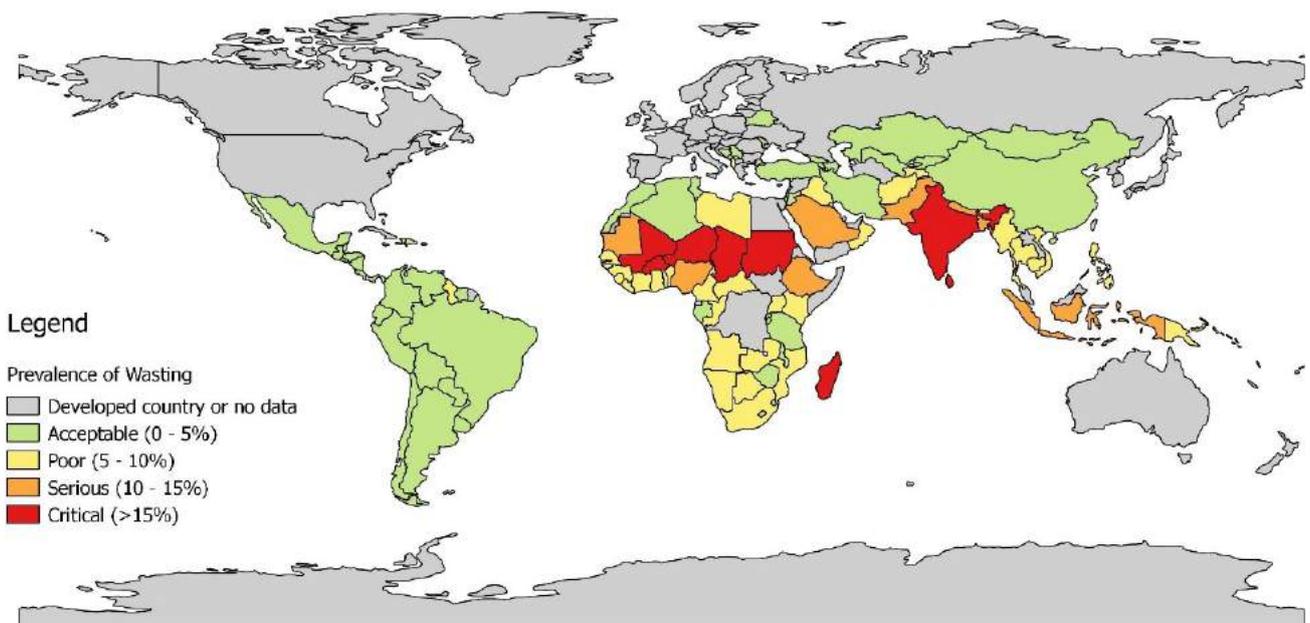
Prevalence of Stunting
（average 2004-2014）

Legend

Prevalence of Stunting
- Developed country or no data
- Very low (0 - 5%)
- Low (5 - 20%)
- Moderate (20 - 30%)
- High (30 - 40%)
- Very high (>40%)
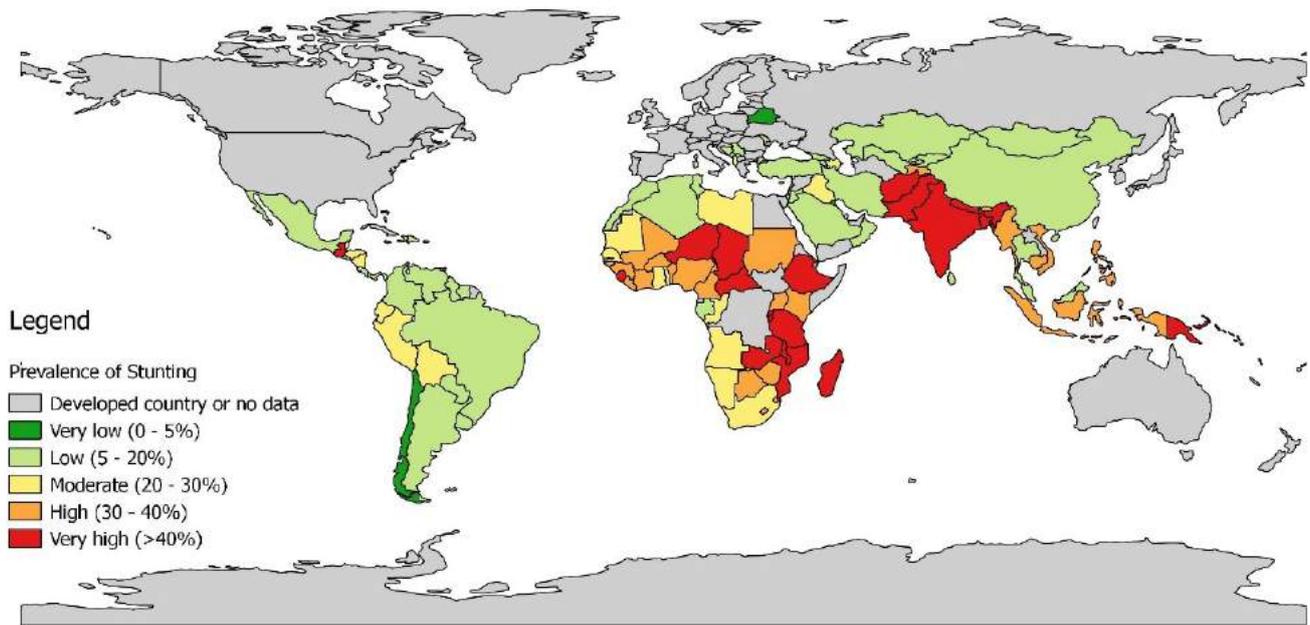
Prevalence of Undernourishment
（average 2004-2014）

Legend

Prevalence of Undernourishment
- Developed country or no data
- Very low (0 - 5%)
- Marginal (5 - 15%)
- Moderate (25 - 35%)
- High (25 - 35%)
- Very high (>35%)
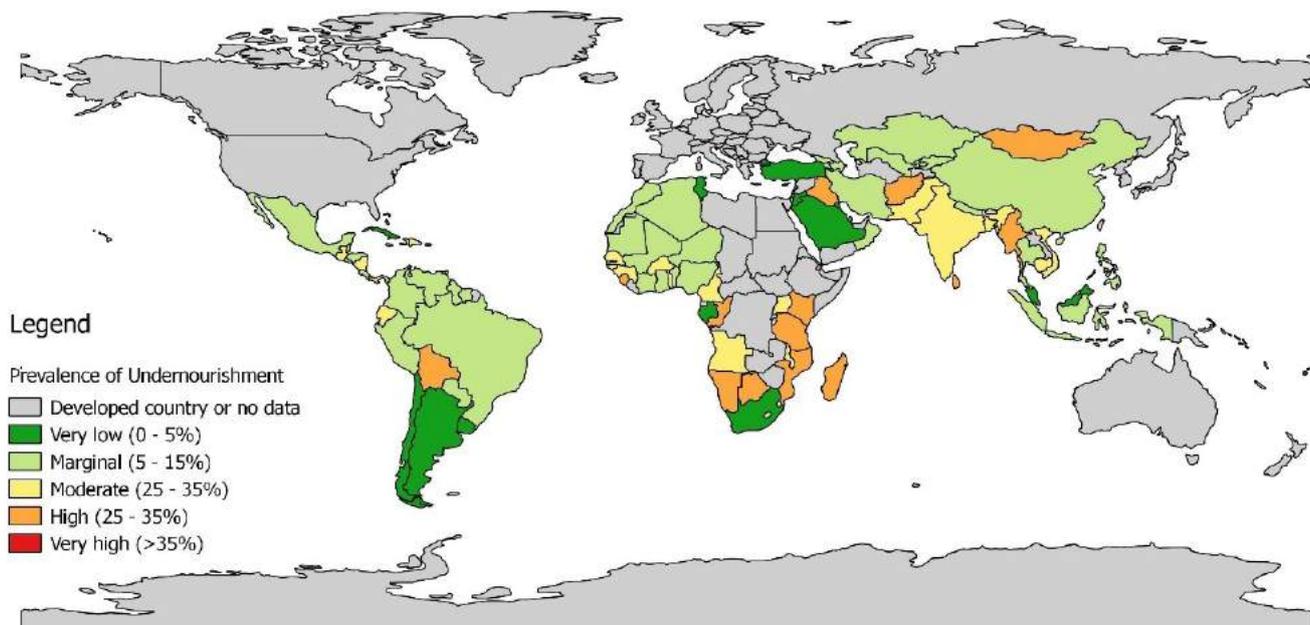
Global Hunger Index scores
(average 2006-2014)

Legend

Global Hunger Index
- Developed country or no data
- Low (0 - 10)
- Moderate (10 - 20)
- Serious (20 - 35)
- Alarming (35 - 50)
- Extremely alarming (>50)
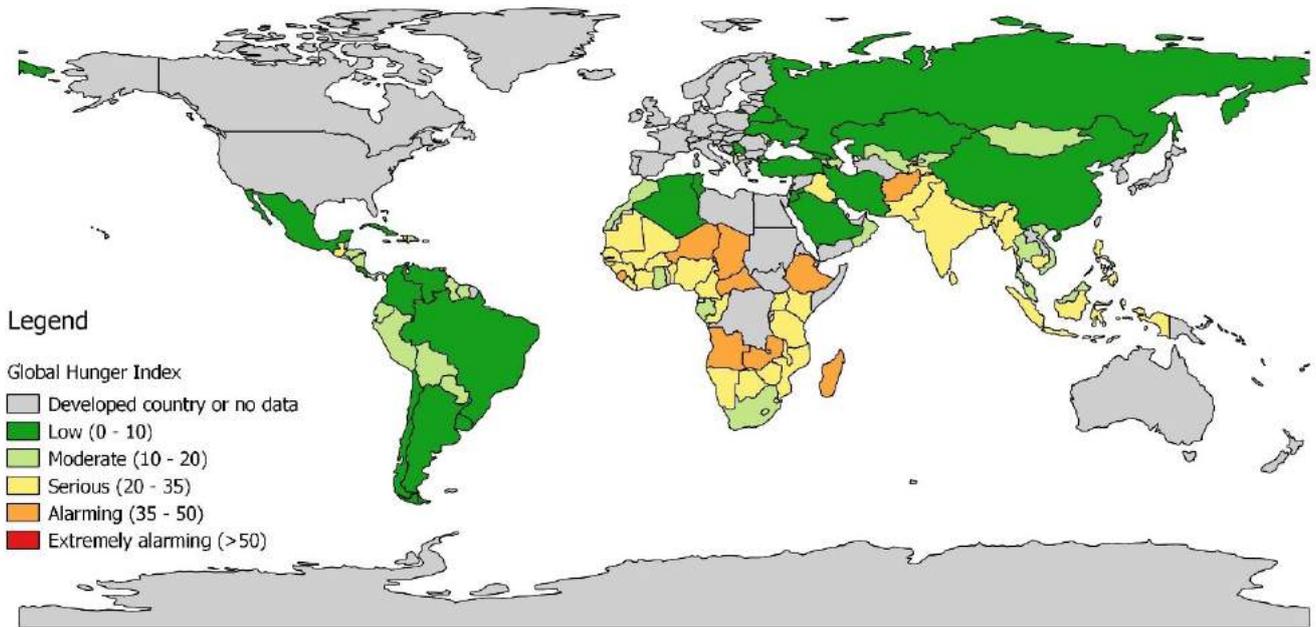
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133.   These five indicators were chosen because there exists data for most countries over the couple of decades and each can be used as a metric for hunger, though they all have their limitations. Indicators that better match AAH definition of hunger do not have the spatial or temporal coverage this analysis.

134.   Data on all independent variables but only on the dependent variable defining each model.

135.   Variables (drivers) whose observed relation with the corresponding hunger variable is shown to be strong enough to be real (and not only due to random or sampling effects).

136.   The smaller the degree of significance (p-value), the stronger the statistical evidence about the relation. As the models represent complex, human systems a larger p-value of 0.1 was used to determine significance. Though the table below highlights the p-values by four separate classes to provide further detail.