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METHODOLOGY FOR MEASURING SUSTAINABLE DEVELOPMENT TARGETS AND INDICATORS RELATED TO FOOD SECURITY:

A REVIEW OF SELECTED METHODOLOGIES TO ASSESS FOOD SECURITY

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ACRONYMS

ADESA	Average Dietary Energy Supply Adequacy
ASTI	Agricultural Science and Technology Indicators
CBD	Convention on Biological Diversity
CFS	World Food Security
CPI	Consumer Price Index
DK	Don't know
EIU	Economist Intelligence Unit
ESCWA	Economic and Social Commission for Western Asia
FAO	United Nation's Food and Agriculture Organization
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
FEPS	Food and Environment Policies Section
FIES	Food Insecurity Experience Scale
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GFSI	Global Food Security Index
GHI	Global Hunger Index
GIEWS	Global Information and Early Warning System
GTAP	Global Trade Analysis Project
IAEG	Inter-Agency and Expert Group
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IFSA	International Food Security Assessment
IMF	International Monetary Fund
Kg	Kilogramme
LDCs	Least Developed Countries
MENA	Middle East & North Africa
OECD	Organisation for Economic Co-operation and Development

PIGLOG	Price-Independent Generalized Logarithmic
SDGs	Sustainable Development Goals
SDPD	Sustainable Development and Policies Division
Sida	Swedish International Development Agency
SOFI	State of Food Insecurity
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UN-DOALOS	United Nations Division for Ocean Affairs and the Law of the Sea
UNEP	United Nations Environment Programme
UNICEF	United Nations Children's Fund
UN-IGME	United Nations Inter-Agency Group for Child Mortality Estimation
UNU	United Nations University
UN-Water	United Nations Water
US	United States
USDA	United States Department of Agriculture
WB	World Bank
WDI	World Development Indicators
WFP	World Food Programme
WFS	World Food Summit
WHO	World Health Organization
WTO	World Trade Organization

I. INTRODUCTION

Food security is related to the supply of and access to food by nations, communities and individuals. Although the concept of food security was not introduced until the mid-1970s, ensuring food availability and access to food have always been key policy objectives throughout history as highlighted in numerous historical writings such as those related to famines and food storage (Winjah, 2014). In the late 1790s, Thomas Malthus said that one day the population would surpass food production, which essentially predicted future food insecurity (Simon, 2012). However, it was not until the United Nations World Food Conference in 1974 that the word "food security" was coined and globalized.

At the World Food Conference, food security was understood as related to the availability of adequate food supply and defined as the "*availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations and prices*." The current definition of food security was not developed until the World Food Summit (WFS) in 1996 when it was agreed that "*food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for active and healthy life*." In 2012, the Committee on World Food Security (CFS) tried to expand and refine the definition by including the notions of nutrition and food safety among others. The new expanded definition proposed was: "*food and nutrition security exists when all people at all times have physical, social and economic access to food, which is safe and consumed in sufficient quantity and quality to meet their dietary needs and food preferences, and is supported by an environment of adequate sanitation, health services and care, allowing for a healthy and active life*" (Moltedo et al., 2014), though it has not gained as much traction as its predecessor.

The food security definitions developed through world conferences and summits are the most used and relied upon, but it is thought that there are more than 200 definitions in published writings, which may lead one to think that the concept of food security is either complex or flexible. The multiplicity of food security definitions highlights the need to ascertain the concept being referred to whenever food security is discussed, especially when it is not based on the commonly agreed upon definition from the WFS. Moreover, this great number of definitions and views on food security tends to hamper the development of a single or few comprehensive indicators that could best describe food security (FAO, 2003; Moltedo et al., 2014).

Based on the WFS definition above, food security has four dimensions, which are availability (sufficient food), access (ability to acquire and reach food), utilization (ability to consume food) and stability (year-round food availability, accessibility and utilization). Each of these dimensions is sometimes used to describe and analyze food security though each is also complex and best described by a range of indicators, some of which might not be directly related to the issue of food, such as roads/rail and other infrastructure, the availability of sanitation facilities or political conflicts to name a few (FAO et al., 2015). On the other hand, the notion of "*food preferences for an active and healthy life*" in the above definition does not seem to be included in the four dimensions of food security (Simon, 2012). Thus, food security is complex and hard to measure or assess and it is no wonder that it is often measured differently using differing methodologies, as will be seen in the remainder of the report.

Given the difficulty of measuring or assessing food security, it is often food insecurity that is described through selected and limited indicators or variables. Food insecurity is described, for example, through a lack of food (i.e., availability dimension), the paucity of means to acquire the food (i.e., access dimension), the inadequacy of nutrition (i.e., utilization dimension) or a disruption in supply (i.e., stability dimension). Many of these analyses rely as well on a limited number of indicators or variables, particularly when attempting to conduct cross-country comparisons (e.g., the State of Food Insecurity [SOFI] 2017 report or the Global Hunger Index) or on an aggregation into a few or a single composite index(es) (e.g., the Global Food Security Index) through the use of arbitrary weights and/or experts' opinions, noting that both have their drawbacks, which include determining the

most appropriate weight or finding a pool of knowledgeable experts. On the other hand, using many indicators might not provide a quick and comprehensive mapping of the status of food security as they become overwhelming to examine, analyze and draw conclusions from. Sifting through 30 or more time-series indicators becomes a daunting challenge while failing to provide a meaningful view on the food security outlook nor allowing an easy cross-country comparison or the rapid identification of those factors having the greatest impact on the prevailing food security situation (e.g., the United Nation's Food and Agriculture Organization's [FAO's] list of food security indicators), often resulting in a discontinuation of efforts or challenges in the consistent and continuous collection of related data (Simon, 2012).

In 2015, the 2030 Agenda for Sustainable Development, which contains the Sustainable Development Goals (SDGs), was adopted by the United Nations General Assembly. The Agenda calls for the achievement of sustainable development in its three dimensions—social, economic and environmental—by the year 2030. The Agenda is divided into 17 SDGs, which are made up of 169 targets and about 230 indicators. To monitor progress towards the achievement of the SDGs, relevant indicators are being identified or defined, and a methodological framework for collecting data is being developed through the United Nations Statistical Commission, including the development of related indicators (UN, 2017). To successfully measure progress towards the achievement of the SDGs, ways will need to be found in terms of how to efficiently collect related data and information at the country level and possibly how to easily analyze these so as to be able to conduct comparisons across countries and regions to better highlight hotspots and bright spots and the likelihood of achieving the SDGs by 2030 and to enhance experience sharing. Food security related indicators are comprised in Goal 2 [SDG2] as will be further discussed below, though a few more indicators are found in other SDGs with potentially other relevant indicators not having been included. The purpose of the present report is to review and assess the potency of a few selected methodological frameworks to assess food security and to evaluate a proposed methodology that could be used in the Arab region.

The report is divided into four main parts. The first part reviews food security as outlined within the SDGs and briefly provides the United Nations Economic and Social Commission for Western Asia's (ESCWA's) suggested SDGs targets and indicators related to food security as well as the indicators that have been assigned to the FAO as the leading agency on food security in addition to those being reported upon in the new SOFI reports. The second part overviews three methodological frameworks providing the ex-post (observed) assessment or measurement of food security, which are relatively well-recognized and used for food security or insecurity assessment: (a) the Food Insecurity Experience Scale (FIES), (b) the Global Hunger Index (GHI) and (c) the Global Food Security Index (GFSI). The third part reviews two other methodologies that provide the ex-ante (predicted) assessment of food security, which build on caloric intake and/or availability to determine the status of food security. The last part of the report reviews an iteration of the last two methodologies, which was used to develop a framework to assess the existing gap in caloric nutritional consumption and production at both the sub-regional and Arab levels.

II. FOOD SECURITY IN THE SDGS

Among others, the 2030 Development Agenda calls for ending hunger, achieving food security and improved nutrition and promoting sustainable agriculture under Goal 2. Related targets and means of implementation were identified, and monitoring indicators were put forward (Table 1).

Table 1. Sustainable Development Goal 2 targets and indicators

Target	Indicators	Tier
Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture		
2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round	2.1.1 Prevalence of undernourishment	I
	2.1.2 Prevalence of moderate or severe food insecurity in the population, based on the Food Insecurity Experience Scale (FIES)	I
2.2 By 2030, end 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	2.2.1 Prevalence of stunting (height for age <-2 standard deviation from the median of the World Health Organization (WHO) Child Growth Standards) among children under 5 years of age	I
	2.2.2 Prevalence of malnutrition (weight for height >+2 or <-2 standard deviation from the median of the WHO Child Growth Standards) among children under 5 years of age, by type (wasting and overweight)	I
2.3 By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment	2.3.1 Volume of production per labour unit by classes of farming/pastoral/forestry enterprise size	III
	2.3.2 Average income of small-scale food producers, by sex and indigenous status	III
2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality	2.4.1 Proportion of agricultural area under productive and sustainable agriculture	III
2.5 By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed	2.5.1 Number of plant and animal genetic resources for food and agriculture secured in either medium or long-term conservation facilities	II
	2.5.2 Proportion of local breeds classified as being at risk, not-at-risk or at unknown level of risk of extinction	II
2.a Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks in order to enhance agricultural productive capacity in developing countries, in particular least developed countries	2.a.1 The agriculture orientation index for government expenditures	II
	2.a.2 Total official flows (official development assistance plus other official flows) to the agriculture sector	I
2.b Correct and prevent trade restrictions and distortions in world agricultural markets, including through the parallel elimination of all forms of agricultural export subsidies and all export measures with equivalent effect, in accordance with the mandate of the Doha Development Round	2.b.1 Agricultural export subsidies	I
2.c Adopt measures to ensure the proper functioning of food commodity markets and their derivatives and facilitate timely access to market information, including on food reserves, in order to help limit extreme food price volatility	2.c.1 Indicator of food price anomalies	II

Source: UN (2017)

Currently, SDGs indicators are classified in three tiers, as follows (UN, 2017):

- Tier I indicators are those that are conceptually clear, that have established methodology and standards and whose data are being produced by countries;

- Tier II indicators are conceptually clear and have an established methodology and standards but whose data are not regularly produced by countries;

- Tier III indicators have no internationally established methodology or standards though these are being (or will be) developed or tested.

SDG2 is comprised of five targets and three means of implementation and has 13 indicators. Out of the 13 indicators, six are Tier I and four are Tier II while the remaining three are Tier III. Thus, less than half of the indicators are currently being collected by countries. This is expected to hamper progress in assessing the status and achievement of SDG2, let alone food security, as current SDG2 indicators do not cover all facets of food security in its four dimensions—availability, accessibility, utilization and stability. Nevertheless, SDG2 attempts to integrate hunger, food security and nutrition while also linking them to the need to ensure sustainability, resilience to climate change and recognition of the importance of small producers. Viewed as such, it is multi-dimensional along the three pillars of sustainable development in that it endeavors to ensure the following:

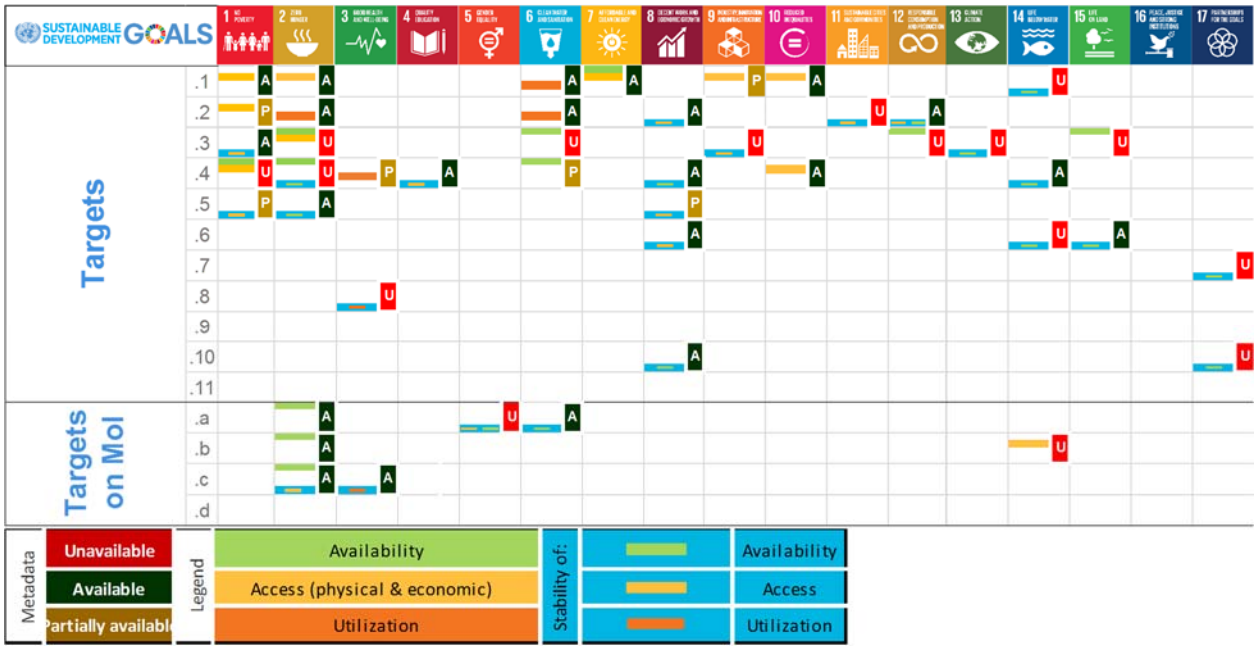
- Social acceptability, referring to ending hunger, achieving food security and improved nutrition and ensuring equal access to resources through targets 2.1, 2.2 and 2.3;

- Economic viability, meaning improving productivity and enhancing income through targets 2.3, 2.a, 2.b and 2.c; and

- Environmental soundness, which is ensuring sustainable food production, implementing resilient agricultural practices and maintaining genetic diversity through targets 2.4 and 2.5.

In a forthcoming publication on food security ESCWA notes that, given its cross-cutting nature, food security cannot be isolated in a single SDG but rather assesd through an array of targets and indicators spanning several SDGs. In addition to SDG2, ESCWA identifies elements that support food security in almost all SDGs (Table 2).

Table 2. Mapping food security dimensions in the SDGs



Source: UN (Forthcoming)

However, additional work is being conducted to assess the validity of the above mapping exercise and to explore ways to collect and use the data so as to be able to provide a comprehensive view on the status of food security at national and regional levels in a simple and meaningful manner. This is being done through a project on food security being implemented by ESCWA in collaboration with various national and regional partners with financing from the Swedish International Development Agency (Sida). As listed above, the ESCWA-proposed indicators total about 50, with several being Tier II and Tier III indicators for which currently no data are being collected. The task of translating the above indicators into action-oriented policy recommendations that could be acted upon by member states will remain a challenge for the foreseeable future.

Within the SDGs, the FAO has been assigned 21 indicators (see Annex Table A1) and is contributing to an additional six (FAO, 2017a). It should be noted that these indicators are not in line with the previous list of food security indicators that the FAO used to monitor and report upon in previous editions of the SOFI report (FAO et al., 2015). The FAO is in the process of discontinuing reporting on all the 31 food security indicators (see Annex Table A2) of previous SOFI reports. In the latest SOFI report and as part of the process of monitoring progress, the FAO is now partnering with other agencies to report on eight indicators (Table 3): undernourished people; food insecure people (FIES, see below for more information); wasting; stunting and overweight among children under five years; obesity in the population; women affected by anemia and infants breastfed (FAO et al., 2017). Given the heavy focus on nutrition and children, SOFI has become a joint effort between the FAO and the International Fund for Agricultural Development (IFAD), the United Nations Children's Fund (UNICEF), the World Food Programme (WFP) and WHO.

The SDGs and the previous FAO list of indicators for food security are ambitious, far reaching and inclusive and as such could provide a good mapping toward the achievement of intended objectives. However, both raise concerns because of those very characteristics as they are cumbersome to collect, analyze and use to monitor progress effectively, especially in countries that do not have the necessary capacity to collect and analyze data on

a wide-ranging list of indicators. It remains to be seen whether the data to be collected will provide accurate and meaningful information to allow the monitoring of progress and the identification of hotspots or problem areas, that might need special focus and bright spot areas that could be relied upon for replication and experience sharing.

An overwhelming amount of data and indicators could easily lead to a situation referred to as "*paralysis by analysis,*" whereby no or delayed action is taken due to the great amount of data and information to sift through and analyze beforehand. Needless to highlight as well is that the above indicators are related to agriculture, food and nutrition, while there are many other indicators that will need to be collected and analyzed in assessing achievement toward the 2030 sustainable development agenda.

III. EX-POST (OBSERVED) ASSESSMENT OF FOOD SECURITY: SELECTED METHODOLOGIES

A. The Food Insecurity Experience Scale and the State of Food Insecurity

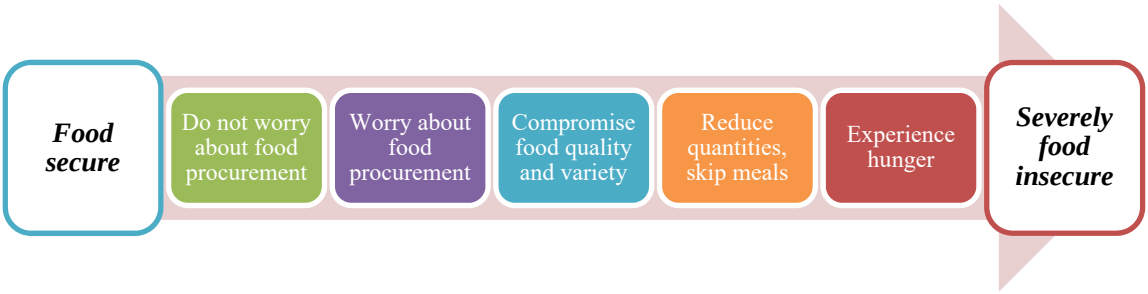
1. Overview

The FIES is an experience-based survey to assess the severity of food insecurity based on actual responses of directly affected or targeted populations to a series of eight questions meant to assess access to sufficient food. It is being advocated by the FAO though it was first put into practice in North and Latin America.[1] The FIES is anticipated to become an important complementary tool to existing food security and nutrition measurements and indicators as it helps document the access dimension of food insecurity at individual and household levels, which could better highlight its impact on women and children who are usually the most vulnerable (Ballard et al., 2013; Cafiero, 2017; ESCWA, 2017).

The principle of the experience-based scale of food insecurity is to ask people directly about their access to food and whether they are confronted with the difficult choice of choosing between food quality and quantity due to reduced means of living. Each series of questions tries to examine a different situation to assess levels of food insecurity severity (see Annex Table A3). During the analysis of the results, the respondents are distributed into various food insecurity classes based on severity. It starts with those who feel they are food secure as they have provided a negative answer to all questions and ends with the most food insecure who have responded in the affirmative to all questions, resulting in a continuum of food insecurity severity (Figure 1).

[1] In the early 2000s, several countries in the Latin American region, notably Brazil and Colombia, began to use an experience-based indicator to assess the status of food security at household and individual levels. The early versions of these food insecurity scales built themselves from the United States Household Food Security Survey Module which was initiated in the mid-1990s. The disparate national initiatives were combined into one for the entire region in a bid to allow for the harmonization of efforts and to improve comparability (Ballard et al., 2013).

Figure 1. Food insecurity severity continuum scale



Source: Adapted from Ballard et al (2013)

The FIES results provide an estimate of the proportion of individuals or households facing difficulty in acquiring sufficient food but do not provide a measurement on the actual quantity or quality of the food consumed. Individuals and/or households are grouped into food insecurity classes from moderate to severe over a 12-month period. Those at the severe level are likely experiencing hunger as they are unable to access sufficient food and suffer from undernourishment. The FIES was used to evaluate food insecurity in 145 countries during 2014/2015 (see Annex Table A4). About 7.5% of the world population aged 15 years and above, or about 400 million people, experienced food insecurity. In Northern Africa and Western Asia, food insecure people represent about 9–10 percent of the population (FAO, 2017b; FAO et al., 2017).

2. Advantages and disadvantages

The FIES could allow the assessment of food insecurity over large areas through simple polls at a low cost though population-wide assessments could also be conducted at much larger costs through censuses or household surveys. The FAO is planning to leverage the Gallup World Poll which is conducted annually in more than 140 countries, to monitor food security on a regular basis (Ballard et al., 2013). The FIES could help inform policy-makers on the prevailing food security situation with limited time lag compared to existing assessments, such as through malnutrition and other indicators for which the time-lag could be as long as two to three years. Its results could positively complement other food security measurements and indicators by acting as an early warning system.

However, as with all polls and surveys, it is intrinsically inherent to distortions when, for example, the respondents are not fully truthful, such as due to a perceived threat, or the sampling is not done carefully, notably if the survey/poll is not part of a nation-wide census or household survey. For example, the recent elections in the United Kingdom during "Brexit" and the United States during the presidential election of 2016 are often cited to highlight polls and/or surveys that have been inaccurate throughout. This happens notably when the response rate of the sampled population is low or if the poll/survey is not conducted in good faith (Silverstein, 2016).

B. The Global Hunger Index (GHI)

1. Overview

The GHI was developed by the International Food Policy Research Institute (IFPRI) and is calculated on a yearly basis though with a time-lag (von Grebmer et al, 2016). It aims to measure and track hunger at both the country

level and regional and global levels. It allows the tracking of progress or lack thereof in combating hunger over time and geographical areas. The GHI is a good tool to monitor part of SDG2 on ending hunger, achieving food security and improved nutrition.

The index builds on the definition of hunger as it measures the distress caused by a lack of food, which is manifested in its two basic components: undernutrition and malnutrition. Undernutrition accounts for deficiencies including those related to energy, protein and essential micronutrients, while malnutrition encompasses problems related to nutrition deficiencies (undernutrition) as well as those related to excesses (overnutrition). Undernutrition concerns the entire population, while malnutrition is measured among children. Building on the above, hunger is split into four sub-elements, which are the undernourishment of the population and then its three impacts on children five years and below—wasting, stunting and mortality (von Grebmer, 2015).

These four sub-components of hunger are then combined using weights to estimate the GHI, which makes it a multidimensional descriptive tool for hunger. Each sub-component is described as follows (see Annex Table A5):

- Undernourishment: proportion of people with inadequate intake of calories;
- Child wasting: proportion of children under five years who have low weight for their heights;
- Child stunting: proportion of children under five years who have inadequate height for their age and
- Child mortality: rate of mortality among children under five years.

The coefficients of each of the four sub-components of the GHI were derived from a standardization exercise which led to scores of 80 percent for undernourishment, 30 percent for wasting, 70 percent for stunting and 35 percent for under-five mortality. Additional expert-generated weights were applied as well before the aggregation of the four sub-components into a single final score expressed in percentage terms though the resulting final GHI score is on a 100-point scale with 0 reflecting a situation of no hunger and 100 one with complete hunger (Wiesmann et al, 2015). In reality, these two extremes are never reached, and, as such different levels of hunger are identified as follows:

- below 5, hunger is minimal,
- between 5 and 9.9, hunger is low,
- between 10 and 19.9, hunger is moderate,
- between 20 and 34.9, hunger is serious,
- between 35 and 49.9, hunger is alarming, and
- beyond 50, hunger is extremely alarming.

This new methodology was introduced in 2015 as until then stunting and wasting were subsumed by child underweight and the data were not standardized (von Grebmer et al, 2016). The GHI is calculated for developing countries whenever data for the four sub-components are available. Below is the corresponding data for Arab countries for which the GHI was estimated in the latest edition (von Grebmer et al., 2016)

Table 3. GHI score and its sub-components for Arab countries

Country	Undernourished		Wasting		Stunting		<5 mortality		**GHI**	
	2008	2016	2008	2016	2008	2016	2008	2016	**2008**	**2016**
Algeria	6.1	2.9	4.2	4.1	13.2	11.7	2.9	2.6	**10.8**	**8.7**
Bahrain	--	--	5.3	5.2	9.2	9.0	0.9	0.6	**--**	**--**
Comoros	--	--	9.2	11.1	39.8	32.1	9.1	7.4	**--**	**--**
Djibouti	26.2	15.9	17.0	21.5	33.0	33.5	8.1	6.5	**35.9**	**32.7**
Egypt	3.5	1.9	7.9	9.5	30.7	22.3	3.1	2.4	**16.1**	**13.7**
Iraq	26.6	22.8	5.8	7.4	27.5	22.6	3.8	3.2	**24.5**	**22.0**
Jordan	2.2	1.8	1.6	2.4	8.3	7.8	2.2	1.8	**5.9**	**5.7**
Kuwait	1.7	3.1	2.2	2.4	5.1	5.8	1.1	0.9	**<5**	**<5**
Lebanon	3.7	3.0	4.3	4.0	13.8	12.0	1.1	0.8	**8.3**	**7.1**
Libya	--	--	6.5	6.4	21.0	23.3	1.9	1.3	**--**	**--**
Mauritania	9.2	5.6	8.1	11.6	23.0	22.0	10.3	8.5	**23.6**	**22.1**
Morocco	5.4	4.4	3.5	2.3	18.3	14.9	3.6	2.8	**12.0**	**9.3**
Oman	7.9	4.1	7.1	7.5	9.8	14.1	1.2	1.2	**10.7**	**10.4**
Palestine										
Qatar	--	--	2.0	2.0	1.1	1.0	1.0	0.8	**--**	**--**
Saudi Arabia	2.9	1.2	6.1	3.6	11.9	3.4	1.8	1.5	**9.1**	**<5**
Somalia	--	--	14.9	--	25.9	--	16.9	13.7	**--**	**--**
Sudan	--	--	--	16.3	--	38.2	--	7.0	**--**	**--**
Syria	--	--	11.5	--	27.5	--	1.7	1.3	**--**	**--**
Tunisia	0.9	0.4	3.4	2.8	9.0	10.1	1.9	1.4	**6.2**	**5.5**
United A. Emirates										
Yemen	27.7	26.1	14.4	16.2	47.0	46.8	6.1	4.2	**36.5**	**35.0**

Source: Extracted from von Grebmer et al. (2016)

The GHI index shows that most countries in the region have made progress in eliminating hunger between 2008 and 2016 though at differing paces, with Saudi Arabia recording the strongest improvement. About half the countries could be classified as experiencing no to moderate hunger and four countries being classified in the serious and above hunger category though the number of countries in this category could be higher given that six countries have no GHI score as they are either poor or experiencing protracted crises.

2. Advantages and disadvantages

The GHI is a good measure of food security as it builds on undernourishment in the general population and nutrition issues among children, which are strongly determined by food availability, accessibility, utilization and stability. Moreover, the measurement of hunger through a combination of factors is threefold: (i) it allows an integrated assessment of the nutrition situation of the population while putting an emphasis on children who are the most vulnerable; (ii) it allows the reduction of the impact of outliers or extreme measurements, which could distort the incidence of malnutrition due to a good or bad year, for example and (iii) the inclusion of both stunting and wasting allows the reflection of acute and chronic hunger, which takes into account longer-term nutritional and food security issues. Finally, a single indicator to describe a situation seems, in general, appealing to both policy-makers and the public as it transmits the message succinctly while allowing global comparability.

A drawback of the GHI is that some of its components might be complex to compute and rely on national capacity to produce reliable data on a yearly or other basis. This could constitute a challenge in those countries with insufficiently developed data collection capability or those experiencing protracted crises. As currently produced, the GHI also does not allow the assessment of food security at individual, household or country subdivisions (i.e., provincial or county) levels, which might hamper the adoption of focused and targeted policies and strategies. Moreover, as with most ex-post indicators, there is always a time delay between the collection of data and the

computation and dissemination of the index, which might not allow for the fast identification of arising problems for swift action (Ballard et al., 2013).

C. The Global Food Security Index (GFSI)

1. Overview

The GFSI was developed by the Economist Intelligence Unit (EIU). The GFSI aims to assess food security through three dimensions, which are affordability, availability and quality and safety. These differ slightly from the usual food security dimensions based on the WFS definition, which are availability, accessibility, stability and utilization. However, they both overlap once the "nitty-gritty" of indicators is considered. Contrary to the GHI, on the other hand, it goes beyond hunger and thus nutrition as the main metric for food security to include other factors, such as the fluctuation of global food prices, which determine the risk faced by countries in terms of food affordability, to name but one (EIU, 2016).

The GFSI index is made up of 28 quantitative and qualitative indicators that are combined through a benchmarking model to describe the status of food security across a wide range of countries around the world (see Annex Table A6). The EIU relies on expert analyses to categorize and select the indicators to be used, including their prioritization. The experts designed the framework, selected the indicators and determined their weights as relevant and constructed the index. Slight adjustments were made in subsequent iterations of the index though most of these changes concerned the type of data to collect or use. The three categories—affordability, availability and quality and safety—each have their own scores, which are derived from weighted means of the underlying factors. These are then scaled from 0 to 100, with 100 being the most favorable. The overall score of the GFSI is computed as a weighted average of the above three category scores (EIU, 2016).[2]

The GFSI allows some flexibility as users can adjust some weights based on their own experience and assumptions with regards to the importance of each indicator. However, two options of fixed weights are also provided. The first option is a neutral weight, which assumes that all indicators are similarly important and are given an equal weight, while the second option, which is the default option for the model, builds on the weights selected by an expert panel. The GFSI data are compiled from national and international sources with adjustments introduced by the EIU whenever required. When data points are missing, the EIU uses its own estimates building on the information available from numerous relevant sources. The GFSI is computed for 113 countries in Asia and the Pacific, Central and South America, North America, Europe, the Middle East and North Africa and Sub-Saharan Africa.

The latest iteration of the GFSI shows that though food security has improved globally over the last five years, food insecurity still persists (EIU, 2016). The GFSI scores for Arab countries for which the index is computed is provided below (Table 4), and the scores are compared to those of selected sub-regions (GCC, MENA, Sub-Sahara Africa, Low Income, High Income and the World). In the Arab region, Bahrain, Syria and Yemen have witnessed a slight decline of their overall score, most probably due to their prevailing socio-political situations. Other countries recorded positive changes, with a neutral score for Jordan.

[2] The indicators are normalized before aggregation within the three categories to ease comparisons across countries. The normalization process consists in bringing all indicators to a common unit by selecting from the country list the lowest data (when a high value is a positive outcome, e.g., GDP) or highest data (when a high value is a negative outcome, e.g. food loss) and subtracting it from the data of the concerned country and dividing the result by the difference between the highest and lowest data. The normalized value, which is between 0-1, is multiplied by 100.

Table 4. 2016 GFSI score for Arab countries and selected world regions (100 = most favorable)

Country	Affordability	Availability	Quality & Safety	GFSI score	1-year change
Qatar	93.6	63.2	76.7	77.5	+1.0
Oman	74.2	73.2	73.0	73.6	+0.9
Kuwait	82.8	64.9	73.7	73.5	+0.7
United Arab Emirates	85.7	60.3	68.6	71.8	+0.1
Saudi Arabia	76.5	67.4	68.0	71.1	+0.3
Bahrain	78.9	65.0	61.9	70.1	-0.5
Tunisia	56.7	57.4	62.2	57.9	+0.6
Egypt	46.3	66.9	56.8	57.1	+1.0
Jordan	57.3	58.4	52.1	56.9	0
Morocco	52.2	58.3	56.4	55.5	+0.8
Algeria	52.4	57.3	50.6	54.3	+1.1
Syria	32.3	40.8	34.2	36.3	-1.4
Sudan	29.2	36.1	44.5	34.7	+0.6
Yemen	37.7	35.0	22.2	34.0	-4.2
Gulf Cooperation Council countries	82.0	65.7	70.3	72.9	+0.4
Middle East & North Africa countries	64.3	60.7	60.8	62.1	+0.1
Sub-Saharan Africa	29.5	44.6	37.3	37.4	+0.3
Low Income	26.6	41.3	33.3	34.1	+0.3
High Income	78.3	73.2	79.3	76.2	+0.8
World	55.6	58.4	58.5	57.3	+0.6

Source: Extracted from EIU (2016)

2. Advantages and disadvantages

The GFSI is a composite indicator, which allows for an immediate visualization of the food security status of each country examined and a quick comparison across countries and regions. This is in line with its overall aim as a standardized metric, which is to provide a common denominator for assessing food security worldwide and to enhance the understanding of related food security issues for policies, economics and innovation (EIU, 2016). As with the GHI, the fact that the GFSI provides a single indicator to describe food security, it is slowly gaining increasingly more acceptance worldwide and particularly in the media.

The GFSI builds solely on indicators, which means that it is also ex-post and that there is usually a two- to three-year time lag between the collection of data and the computation of the index. Another drawback is that it relies quite a bit on expert opinions, while some of these experts might not be fully cognizant of the food sector specifics of all countries. Finally, compared to the GHI and the recent move by the FAO and its partners to give more weights to nutrition issues in food security, the nutrition aspect in the GFSI is more descriptive than quantitative in that rather than taking into account the number of undernourished people and children affected by undernutrition it emphasizes the availability or presence of nutrition strategies, policies and guidelines.

IV. EX-ANTE (PREDICTED) ASSESSMENT OF FOOD SECURITY: SELECTED METHODOLOGIES

A. THE INTERNATIONAL FOOD SECURITY ASSESSMENT (IFSA)

1. Overview

The International Food Security Assessment (IFSA) was developed by the United States Department of Agriculture (USDA), as reported in Beghin et al. (2015) and Rosen et al. (2016). The IFSA estimates food

insecurity for 76 low- and middle-income countries by assessing the impact of international food price shocks on the food security status of vulnerable populations. As such, it puts great emphasis on price and costing issues, including tariffs, and uses food prices and the responsiveness of consumers to these prices (elasticities) and income to assess the impact on caloric food consumption by income groups. The results are then projected, under certain assumptions, into the next decade while comparing them to the nutritional target of 2,100 calories per person per day considered necessary to meet basic food security.

Recent enhancements to the model consider income continuity rather than income groups, which is reported to improve accuracy in the estimation of the number of food insecure people along all income deciles. This improved approach is demand-oriented as it tries to assess the unfulfilled food demand in the entire population, in opposition to the previous supply-oriented approach, which assumes food security to concern the lowest income decile groups due to low or inaccessible food supplies. However, the new approach is more data intensive and requires data series on local food prices and local consumption data, which in some cases are difficult to obtain or might lack in quality (Rosen et al., 2016).

The IFSA basic modeling builds on the price-independent generalized logarithmic (PIGLOG) demand approach, which is often used in food demand analyses. It is based on the principle that expenditure on or demand for food is a function of price and income, with expenditure on or demand for food decreasing as income increases. The PIGLOG demand approach was preferred to other alternative approaches as it allows for aggregations across food types and population deciles. The model is made up of a series of functions that allow for the projection of food supply or demand using variables such as food production, cropped area, yields, labor, fertilizer or capital use, among others.[3] The data to run these functions is derived from various international sources (Beghin et al., 2015; Rosen et al., 2016).[4]

The food is aggregated into four major categories, which are grains (cereals), other grains (legumes), roots and tubers and all other foods. The contribution of each food group to food availability is assessed through its caloric contribution to the full meal. This method allows for the introduction of a notion of quality by linking income to the consumption of expensive foods through the introduction of income elasticity, which is usually higher for non-staple food items. Once total food demand is obtained, it is decomposed into its grain equivalent and compared to actual demand based on population and income growth and fluctuations in commodity prices. This allows the estimation of the food gap and consequently that of the population that might be affected (Beghin et al., 2015; Rosen et al., 2016).

The IFSA results are dependent on the type of assumptions made though these are based on available evidence. For example, in the latest run of the model it was assumed that food prices would continue to fall as they had been over the past few years while income would keep rising, which led to lower levels of food insecurity for the upcoming decade (Table 5). However, the IFSA report notes that a recent World Bank outlook points toward slightly higher food prices and a rise in income less optimistic than originally anticipated, which might affect the number of food insecure people over the next decade.

[3] Projected variables: food demand & consumption, domestic prices, crop production, area harvested, yields and import/export
Determined variables: Average consumption per capita, grain shares, elasticities of price and income, domestic prices, tariffs, exchange rates and consumer price index (CPIs), population, world prices, stocks, seed use, food exports, inputs, agricultural labor, net foreign credit, value of export, export deflator in terms of trade, per capita income, income distribution, coefficient of variation of food consumption (Rosen et al., 2016)

[4] Data sources: FAO/SOFI, FAOSTAT, FAO/GIEWS, WFP, IMF, World Bank, UN Population, USDA, US Census (Rosen et al., 2016)

Table 5. IFSA's projected food insecure population in selected countries (millions)

	2016	2026
Arab Countries		
Algeria	1.0	0.4
Egypt	1.4	0.4
Mauritania	0.3	0.0
Morocco	1.2	0.4
Somalia	7.0	7.7
Sudan	13.3	16.1
Tunisia	0.1	0.0
Yemen	11.1	8.0
Sampled other countries in the world		
Afghanistan	12.7	5.4
Pakistan	41.6	12.6
Bolivia	3.1	
Chad	4.9	5.5
Congo, DR	70.6	50.5
Zimbabwe	5.7	2.1

Source: Rosen et al (2016)

2. Advantages and disadvantages

An interesting characteristic of the IFSA compared to most other methodologies is that it allows for the estimation of the potential number of people who might become affected by the fluctuating food gap over a given period. This could help countries adjust their policies, strategies and programmes, including their social safety nets programmes to respond to an increase or decrease in the number of food insecure people over the said period (decade).

A drawback of the IFSA is that it requires extensive and detailed data on many variables that might influence food security, including production data, elasticities, commodities prices and tariffs and many other macro-economic forms of data. As such, it requires the maintenance of an extensive database and detailed econometric functions and, so far, it runs on a dedicated software. The USDA relies on its strong economic modeling ability, which is complemented by the Global Trade Analysis Project (GTAP)[5], which describes bilateral trade using computable general equilibrium modeling.

B. DEMAND AND SUPPLY STRUCTURE FOR FOOD IN ASIA

1. Overview

The model was developed by Kanichiro Matsumura (2011) to forecast food demand and supply in Asia as the region houses almost half of humanity. Modeling food demand and supply could help inform food policies in the short to medium term in the region. The model uses the System Dynamics Method approach, which is used to describe non-linear complex systems over time using inputs, outputs and other determinants to forecast behaviors by running multiple interlinked simulations (Kirkwood, 1998).

Matsumura (2011) runs a series of multiple regression analyses using simple functions. These allow for small adjustments to be made based on specific assumptions. For example, for population, rather than using the available

[5] The GTAP is described as a global network of researchers and research institutions based at Purdue University, which runs the GTAP software and database to analyze economic policies.

annual population forecasts, smaller regression analyses are run, which allows the forecasting of small population changes between time-periods under specific assumptions such as higher income per capita, which could lead to lower population growth rates. However, the main hypothesis is that food demand will increase as countries develop due to growth in income as the affluent population will demand not only more food but also higher-quality and higher-value foods. Food supply on the other hand would be dependent on environmental constraints, which would be reflected in a growing scarcity of natural resources, notably land and water (see Annex Figure A1).

The model runs regressions based on one to three variables on population, capital stock, value of production, work force, birth rates, mortality rates, food consumption per capita and by country, food supply, agricultural area, land productivity, fertilizer consumption, crop supply/production and income, to name a few (see Annex Table A7). The structure of the food supply function follows a Cobb-Douglas production function, for which a general equation is provided below with gross production Y being determined by two independent variables, capital stock K and labor input L, and a coefficient A:

$$\mathbf{Y = A \times K^{\alpha} \times L^{\beta}}$$

Regression analyses are applied on variants of such functions noting that some were expressed in logarithmic terms. For countries, such as Myanmar or the Philippines, emphasis was put on labor, while for others such as China, Korea or Japan, emphasis was put on capital stock. Similarly, food demand was described using a series of functions integrating population variables, such as birth and mortality rates and income levels proxied by income (GDP) per capita. The data used are from open international sources such as the United Nations Population Division, the International Monetary Fund (IMF), the World Bank or the FAO, which are complemented by national data from the Asian countries under consideration, which are Japan, Bangladesh, China, Indonesia, India, Korea, Malaysia, Pakistan, Philippines and Thailand.

Having the basic functions for both food supply and demand in caloric terms, Matsumura conducted projections over a 15-year period for major variables. The projections for Japan show that demand was higher than supply throughout the considered period, while in India demand was below supply but expected to overtake it in the years 2005–08 (see Annex Figure A2 and A3). As such, Matsumura's model allows for the estimation of food supply and demand to provide policy makers with the overall directions of the existing food gap between food production and food consumption, whether positive or negative, so they can design policies, strategies and programmes in an informed manner.

2. Advantages and disadvantages

The model provides a general short- to medium-term view on the existing gap between production and consumption. This could help countries adjust their macroeconomic policies to respond to anticipated shortfalls or excesses and to design and implement related and relevant strategies and programmes. Another important aspect of the model is that it is solely run on Microsoft Excel software, which is available and accessible to those interested who have access to and minimum knowledge of windows-running hardware.

The Matsumura model relies on multiple simple functions, which could be overwhelming at times, while their added value to the end result might be relatively minimal. On the other hand, the data requirement is quite high while some of these might not be readily available both from national and international sources.

V. A SUGGESTED APPROACH: ESTIMATING THE CALORIC FOOD GAP IN THE ARAB REGION

The estimation of the food gap as the difference between caloric food production and consumption for the Arab region builds on both the USDA and Matsumura methodologies described above, with more emphasis given to the latter methodological framework. This approach was chosen as it is simpler to develop and run and relies

largely on available international data sources, such as FAOSTAT, UN Population Division, World Bank or IMF, while still providing a relatively good estimation of the existing gap between production and consumption and its projection into the near future. The Matsumura methodology is also emphasized as it uses simple functions with few variables and runs on Microsoft Excel software while the USDA model is based on relatively more complex functions and requires both specialized software and databases such as the USDA owned and estimated dataset and the GTAP database and analyses.

To further simplify the model compared to the Matsumura methodology, fewer functions and variables are used, and therefore fewer regression analyses are run compared to the higher number of functions and regressions used by Matsumura, which results in fewer required variables and related data. It should be highlighted, though, that using fewer functions seems to lead to a slight loss in stability as the resulting analyses are slightly less smooth in the short-term, particularly at country level. Some of the swings observed during the projections seem to result from the original data used, which could be a reflection of data quality, volatility in production due to droughts in the Maghreb or drastic changes in agricultural strategies, notably for the Gulf Cooperation Council (GCC) countries.

The underlying structures of both the production and consumption functions[6] are provided below.

Production = f(time, land, yields)

Consumption = f(time, population, income)

Production is assumed to be a function of time, land capital and technology proxied by yields. It is hoped that in subsequent runs of the model additional functions can be added to account for labor together with other variables such as capital stocks, machinery or fertilizers if accurate and complete data are available. For now, these are assumed to be reflected in both land and yields. Domestic production data in caloric terms were computed using food production data obtained through FAOSTAT. Production data available in weight were transformed into caloric terms, as will be explained below noting that items such as seeds, feeds, food waste and losses and so on were excluded to account only for the food that is available for human consumption.

Consumption is assumed to be a function of time, population and income proxied by GDP per capita. Here again, for more accuracy elasticities could have been used since not all population deciles consume in the same manner. These and other potentially useful variables might be used in subsequent runs of the model if reliable and accurate data are obtained and for as long as the model does not become too complex and cumbersome to run. Consumption data were extracted as well from the FAOSTAT database and more precisely from the food balance sheet database. However, for a few countries no data were available and in those cases a rough estimation of the food balance sheet was conducted by adding domestic food production to food imports and subtracting food exports, resulting in a rough estimation of the food consumed domestically. Whenever possible food loss and waste and other non-food uses were excluded though the data for these items were not readily available for all countries and all years. The food balance sheets as published by the FAO, comprise only products and/or commodities used for human consumption (FAOSTAT, 2017).

[6] In this methodological framework, the terms “production” and “consumption” functions and projections were preferred compared to “supply” and “demand” to avoid confusions that might arise with the supply and demand projections used in the yearly FAO/OECD Outlook reports, which are based on the AGLINK/COSIMO methodological framework.

A. Data compilation, computation and aggregation

The food balance sheet in the FAO database consists of a country-level accounting of food available for consumption. It provides the calories and nutrients consumed on a yearly basis and represents a balance of food production, trade and stock data. Food balance sheets are computed for most countries in the world though data might not be comprehensive at times, notably with regards to food loss and waste by commodity. It is also worth mentioning that the food balance sheets are used by the FAO to estimate the prevalence of undernourishment at the country level, which in turn are used in the GHI, GFSI, IFSA and Matsumuro methodologies examined above (Moteldo et al., 2014).

ESCWA compiled data by country on area harvested, number of animals, yields, production and import and export for both crops and livestock from FAOSTAT. The population data were extracted from the UN Population Division database while the income data were obtained from the World Bank's World Development Indicators. The quantities in metric tons for crops/livestock were converted into calories using the food nutrient and caloric composition table for international comparison, available in the FAO food balance sheet handbook (FAO, 2001). For illustrative purposes, the caloric content for 100 grams of the retail produce for selected commodities is provided below (Table 6).

Table 6. Food composition for a sample of commodities (100 grams)

Item	Caloric (kcal)
Wheat	324
Potatoes	67
Watermelons	17
Cow meat	150
Cow milk	61
Chicken eggs	139
Honey	298
Pelagic fish	86

Source: FAO (2001)

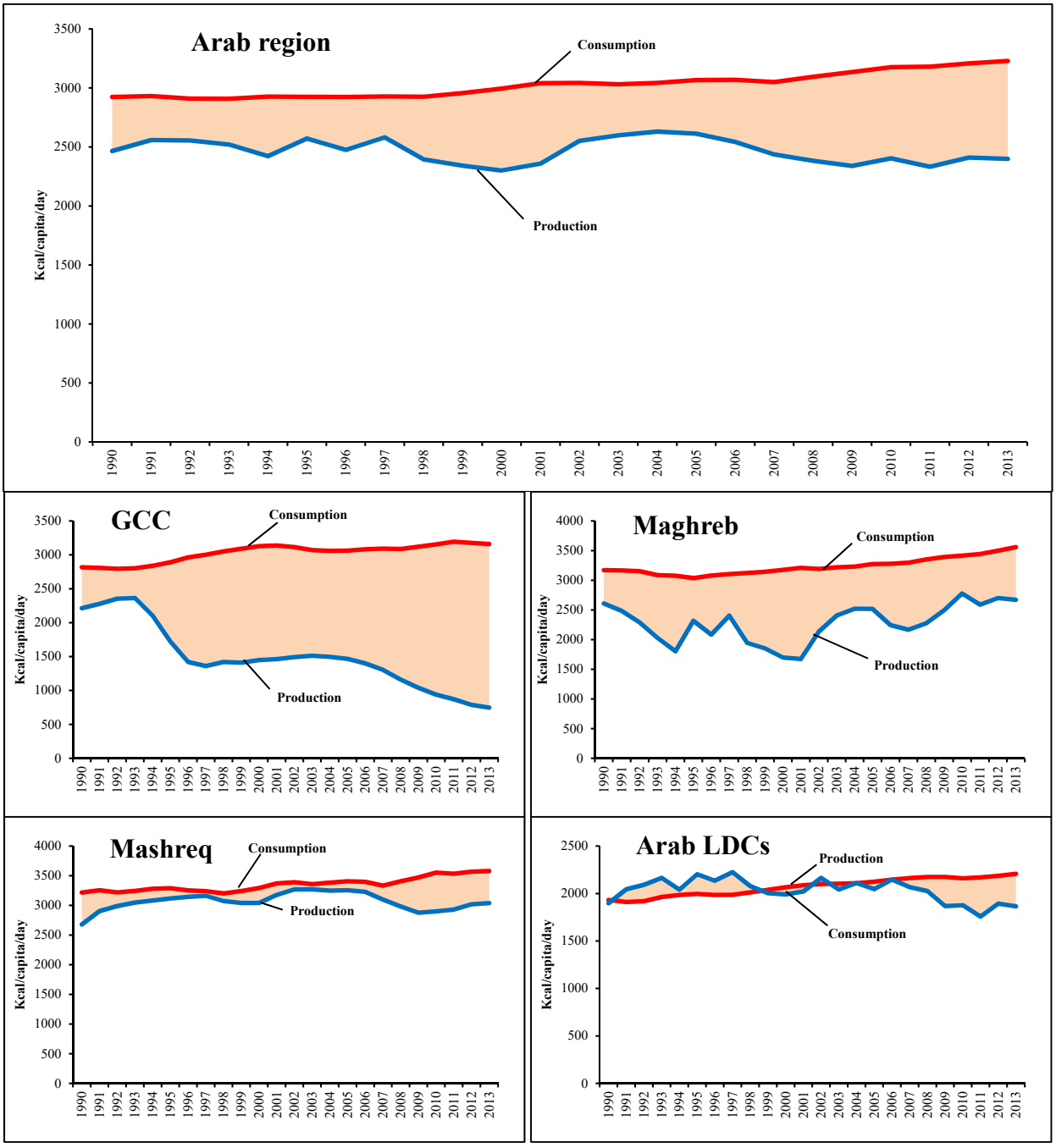
Upon conversion into calories, food quantities were aggregated at the country and sub-regional levels and then further converted into calories per person per day for food production or supply as well as for food consumption or demand whenever they were not already available through the FAO food balance sheets. The data consist of time series running from 1990 to 2013. For each country and sub-region and at the Arab level, data on production, consumption, harvested area, yields, population and income were compiled into a single Windows Excel sheet, from which related regression analyses were run at the sub-region and Arab levels.

B. Observed food gap between production and consumption

The graphs below were generated from the observed or historical data on food production and consumption (Figure 2). They depict the observed gap between food production and consumption in caloric terms. For most sub-regions and the Arab region, the food gap is negative, meaning that food consumption (red) is usually higher than food production (blue). The gap is notably consequential for the GCC countries, which is predictable given

that the sub-region has low food production potential. It is worth noting that the gap used to be smaller in the early 1990s as Saudi Arabia used to be a major producer of wheat before it reversed policies given the negative impact on its non-renewable groundwater resources. In the Maghreb countries, production seems volatile, which follows a pattern similar to that for Tunisia. From the literature, there seems to be no valid reason to explain the observed volatility in production in Tunisia, and, as such, it could be due to inconsistencies in data collections or climate impact, such as drought, since most food production is rainfed. In the Mashreq countries, the food gap is smallest as the sub-region is home to countries with consequent agricultural sectors, including Egypt, Lebanon, Syria and Iraq. In the Arab Least Developed Countries (LDCs), food production was higher than food consumption in some years as the group comprises at least one major food producer, Sudan, while the levels of food consumption are lower than for other sub-regions.

Figure 2. Pattern of food production and consumption in the Arab region



Source: ESCWA

C. FOOD PRODUCTION AND CONSUMPTION GAP FORECAST

Projections were carried out based on functions obtained following the run of a few regression analyses. As is usually the case, the projections assume that all other non-mentioned factors and conditions remain the same or

constant ("*ceteris paribus*") during the considered timeframe, 2013–2030. The evolution of three of the variables, namely area harvested, yields and GDP, was projected to 2030 using simple regressions analyses on their three-year moving averages. In most cases, the significance levels based on both the F-value and P-value were significant at both the 1 percent and 5 percent levels, and the correlations (R-squares) were high enough (higher than 0.70), meaning that the variables used were relevant and justified for our analyses (Table 7).

Table 7. Excel regression analysis output: Food production in GCC

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.9778
R Square	0.9562
Adjusted R Square	0.9496
Standard Error	106.76
Observations	24

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	4973239.3	1657746.4	145.4373	9.48573E-14
Residual	20	227967.2	11398.4		
Total	23	5201206.5			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	146713.8	17260.8	8.4998	4.513E-08	110708.5	182719.2	110708.5	182719.2
Year	-74.0304	8.7455	-8.4650	4.817E-08	-92.2731	-55.7876	-92.2731	-55.7876
Area Harvested	1.4741	0.2025	7.2797	4.850E-07	1.0517	1.8965	1.0517	1.8965
Yields	6.2705	1.6543	3.7905	1.148E-03	2.8197	9.7212	2.8197	9.7212

Source: ESCWA

The production regression equation, which builds on time, land and yields to predict outputs, is provided below for the Arab region and the four sub-regions (Table 8). As noted above, the correlations and significance levels are high enough to explain the equation exclusion for the Mashreq region where the correlation is just above 40 percent with a significance level of 5 percent. However, since the same variables are used for all sub-regions and the Arab region, it could be assumed that the same holds true for the Mashreq region, as will be seen in the projection graphs below (Figure 3).

Table 8. Predicted coefficients and correlation for the production function

Country	Intercept	Year	Land	Yields	Correlation	Significance level (**<0.01, *<0.05)
Arab region	-0.00001	69.13	0.0134	-12.53	0.71	**
GCC	146714	-71.03	-1.4741	6.2705	0.96	**
Maghreb	68728	-36.10	0.2527	5.8357	0.89	**
Mashreq	-32069	16.76	0.1910	-1.7381	0.42	*
LDCs	76285	-38.16	0.0503	-6.6060	0.79	**

Source: ESCWA

The consumption regression equation is determined by time, population and income (GDP/capita) as explanatory variables for food demand, and the corresponding results are provided below (Table 9). The correlation and significance levels are strong enough for all the sub-regions and the Arab region to explain the resulting equations.

Table 9. Predicted coefficients and correlation for the consumption function

Country	Intercept	Year	Population	GDP	Correlation	Significance level (**<0.01, *<0.05)
Arab region	70385	-34.77	0.0077	-0.0081	0.95	**
GCC	-66886	35.14	-0.0079	-0.0088	0.88	**
Maghreb	-43680	23.95	-0.0161	0.0735	0.90	**
Mashreq	-322939	163.96	0.0702	-0.1046	0.91	**
LDCs	-123860	63.84	-0.0309	0.0091	0.98	**

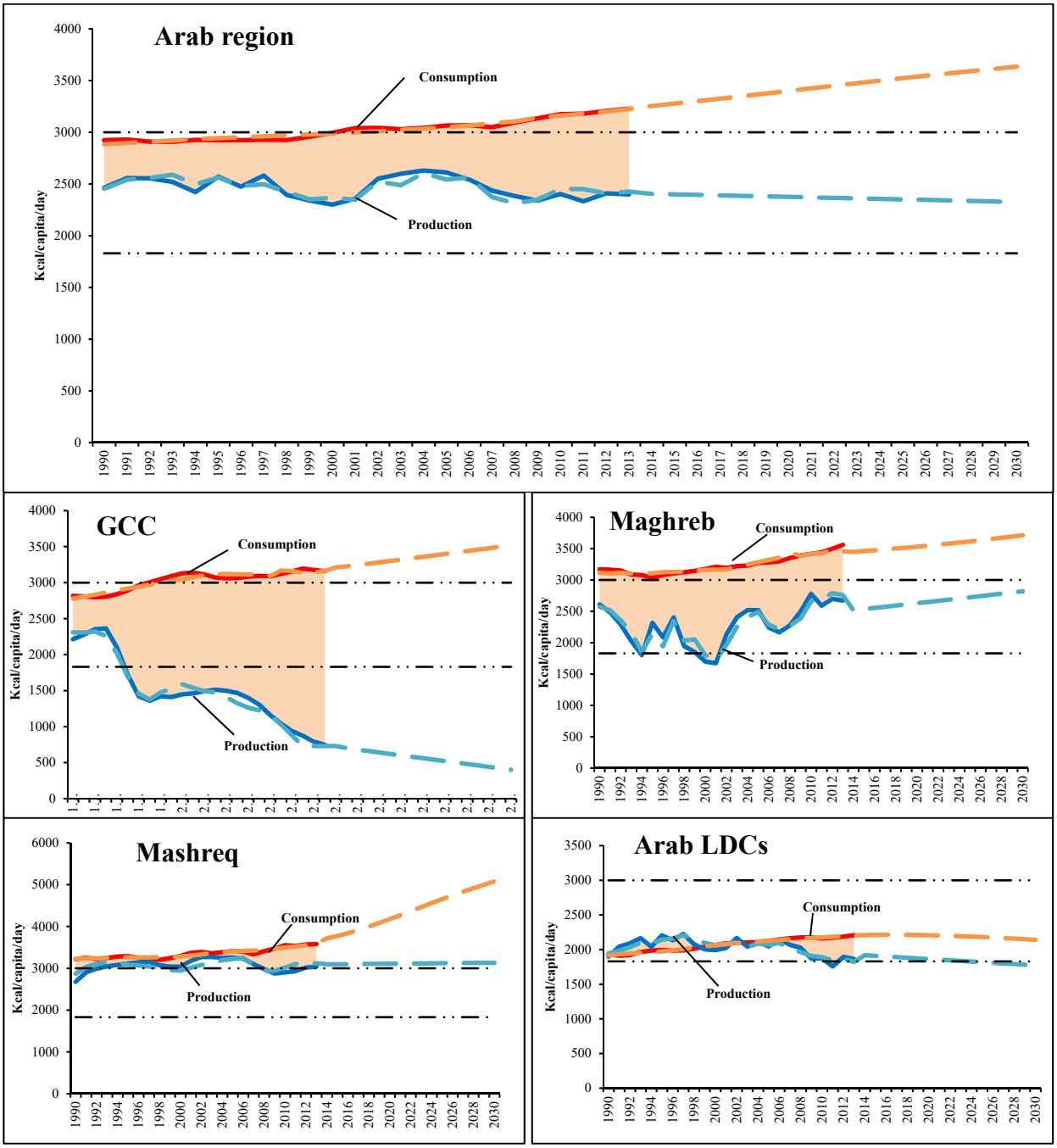
Source: ESCWA

Using the above equations, projections for food production and consumption were computed and the results plotted in the series of graphs below (Figure 3). The equations predict relatively well the historical food production and consumption. As it was assumed that there would be a linear regression, the food consumption continues to grow, albeit slowly, until the horizon at 2030. This would lead to a lower Average Dietary Energy Supply Adequacy (ADESA), which is defined as the ratio of the dietary energy supply to the average dietary energy requirement. The higher the food security of a country, the higher the ADESA should be. Future iterations of the model will assume that the caloric food consumption will be capped at about 3,000 kcal/capita/day, which would allow the ADESA to be determined solely by the food production.

In the graphs below, caloric production and consumption are compared to, respectively (the two dotted lines in the graphs below), to the levels of 1850 kcal/capita/day, which ensures enough dietary energy for survival or basic food security and 3000 kcal/capita/day that is the required intake of dietary energy for a normal moderately active adult male (FAO/WHO/UNU, 2001). In most cases, caloric production tends to be higher than the 1,850 kcal/capita/day threshold while in several instances it is lower than the 3,000 kcal/capita/day threshold. This points to low levels of ADESA and as such low food security, which is concerning in low-income countries and the poorest groups of the population.

It is worth noting that for all sub-regions except for the LDCs, caloric consumption is located towards the upper bound of good nutrition and in many cases beyond those levels, which indicates that most Arab countries either consume a great quantity of food or, more likely, that they consume foods with high caloric content, such as cereals, sugar and oil crops.

Figure 3. Pattern of food production and consumption projections in the Arab region



Source: ESCWA

VI. CONCLUSION

The following review revisits the concept of food security starting from its origins to highlight its complexity and the difficulty encountered in measuring or describing it, particularly through the use of a single index or limited number of indicators. With the recent adoption of theSDGs, it is anticipated that the large number of indicators being proposed will not ease the problem even though those specifically assigned to food security under its dedicated goal (SDG2) are fewer compared, for example, to those that used to be reported upon by the FAO through its SOFI report. However, the targets and indicators under SDG2 are not comprehensive enough to fully describe the status of food security. Moreover, the SDGs tend to have multiple reinforcing linkages among them, which add to the challenge. Other SDGs not reflected under the specifically dedicated goal also contribute to the achievement of food security. The FAO, which leads most effort on the issue of food security, has been assigned 21 indicators from the SDGs with an additional six indicators on which they support other agencies. These indicators are spread over seven goals though the bulk are in SDG2 (food security), followed by SDG14 (life below water) and SDG15 (life on land). The FAO already had its own list of 31 food security indicators split among the four dimensions of food security (availability, accessibility, stability and utilization) though these are being scaled back. A drawback of both the SDGs and FAO food security list of indicators in assessing the status of food security is that there is a large number of indicators, which fails to provide a comprehensive view on the prevailing situation. In most cases, they are both overwhelming and difficult to interpret and the collection of their related data cumbersome when these are available. In the case of the SDGs, several of the proposed indicators are still Tiers II and Tier III, which do not yet have supporting and comprehensive metadata.

The next three food security assessment methodological frameworks, the FIES, the GHI and the GFSI, are easier to interpret though they are fraught with data collection issues of their own as well. The FIES is basically a survey, which can be used for a fast appraisal on the prevailing situation. However, polls tend to be difficult and expensive to conduct in a comprehensive manner, and the results might be subject to prevailing or existing biases based on multiple factors. The GHI puts more emphasis on data on malnutrition and undernourishment together with those on wasting and stunting, which are collected by different agencies with differing methodologies. Weights are then applied though these might be somewhat suggestive. The GFSI builds on a wide-ranging number of indicators, some of which are descriptive rather than quantitative, and on expert opinions, some of whom might not be well-informed on the prevailing situation at the country level since it is a worldwide initiative. Both the GHI and the GFSI provide an easily understandable metric of food security though they do not allow for the development of specific actions as they are composite indicators and are usually time-lagged. Despite the shortcomings, it could be argued that the above three indicators are more likely to provide data that are easier to interpret and for conducting cross-country comparisons and analyses.

The last two methodological assessments of food security examined in this report are not as widely known and relied upon compared to the previous three, and they are still being refined. They rely on dietary energy consumption to assess the status of food security. The IFSA developed by the USDA, evaluates the distribution of dietary energy across income levels to estimate the number of food insecure people in a given country. The last methodological assessment reviewed was developed by Matsumura and consists of an evaluation of the existing gap between caloric production and consumption to evaluate the food security of selected countries in South- and East Asia. The interest in both of these is that they could guide macro-economic policies as they put more emphasis on projections to anticipate future food security outcomes.

Building on these last two methodologies, the food security situation in the Arab region was assessed through a comparison of the existing gap between caloric production and consumption. A negative gap indicates that countries are unable to procure the food they need in caloric terms using internal resources, let alone achieving food security, and vice versa for positive gaps. Deficiencies could be filled through global markets to ensure that sufficient food is available locally, while excesses could be traded internationally to procure other food items for

an equilibrated diet. More work will be needed to further validate and refine this methodology for the Arab region, notably through the consideration of additional factors that could be used to refine and smooth the projections. Nevertheless, it is already possible to identify that the Arab region and most of its sub-regions are currently experiencing a substantial food deficit, as estimated through the difference between caloric consumption and production. This is nothing new for this region given the scarcity of natural resources, which precludes intensive food production. It is anticipated that the food gap is and will continue to be filled through global markets, which should not be a concern for high-income and most middle-income countries. For low-income countries and those experiencing civil strife, war or occupation, dedicated food security policies, strategies and programmes will be needed to ensure that they continue to have access to enough food within the four dimensions of food security—availability, accessibility, stability and utilization. These could include enhancing production and yields when feasible sustainably, improving the food supply chain, supporting intra-regional and global trade, ending conflicts and civil strife wherever applicable, enhancing livelihood particularly in rural areas and putting in place appropriate safety nets for the most vulnerable.

The present review of several methodological approaches to assessing food security point to the fact that though much has been achieved in attempts to assess food security, no globally agreed-upon method to estimate it exists as of yet. Listing a great number of indicators, such as those in the SDGs or the FAO list of indicators, will not help the public and policymakers much as they do not allow for a sound understanding in a timely manner of how food security is evolving for immediate remedial action. The situation could be improved by aggregating these indicators into a few or even a single composite one, such as was done for the GFSI or the GHI, but these have their own shortcomings, starting from the weights used to the expert opinions relied upon, which introduce biases or fail to fully depict the prevailing conditions on the ground. It is hoped, however, that from these experiences new and more meaningful approaches will be developed that can be used globally. With the advent of the SDGs and the greater attention being devoted to the development of global indicators, better and more relevant indicators should be developed for the assessment of the prevailing situation at the country and regional levels in terms of overall development and regarding food security in particular.

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ANNEX

Table A1. FAO's 21 indicators (shaded) + 6 (taned)

	GOAL		TARGET		INDICATOR	CUSTODIAN	PARTNERS	TIER
1.	Poverty	4	Access resources	2	Adult with tenure rights	UN-Habitat	FAO, others	III
		5	Enhance resilience	2	Disaster loss to GDP	UNISDR	FAO, UNEP	II
2.	Hunger	1	End hunger	1	Undernourishment	FAO		I
				2	Food Insecurity (FIES)	FAO		I
		3	Productivity	1	Volume production	FAO	World Bank	III
				2	Average income	FAO	World Bank	III
		4	Sustainable production	1	Area under production	FAO	UNEP	III
		5	Genetic diversity	1	Number genetic resources	FAO	UNEP	II
				2	Risks on local breeds	FAO	UNEP	II
		a	Investments	1	Government expenditures	FAO	IMF	II
				2	ODA to agriculture	OECD	FAO, WTO	I
		c	Markets & information	1	Food price anomalies	FAO		III
3.	Health							
4.	Education							
5.	Gender	a	Rights to resources	1	Women ownership rights	FAO	Others	III
				2	Countries with land rights	FAO		III
6.	Water	4	Water use efficiency	1	Change WUE over time	FAO/UN-Water		III
				2	Level water stress	FAO/UN-Water		II
7.	Energy							
8.	Growth							
9.	Infrastructure							
10.	Inequalities							
11.	Cities							
12.	SCP	3	Food loss & waste	1	Global food loss index	FAO	UNEP	III
13.	Climate							
14.	Marine	4	End overfishing	1	Proportion fish stocks	FAO		I
		6	Fishery subsidies	1	Ending unregulated fishing	FAO		III
		7	Benefits SIs & LDCs	1	Fishery as % GDP	FAO (interim)		III
		b	Artisanal fishers	1	Protecting small fisheries	FAO		III
		c	Law of the sea	1	Ratification & implementation	UN-DOALOS	FAO, others	III
15.	Land	1	Manage land & water	1	Forests as % of land	FAO	UNEP	I
		2	Manage forests	1	Sust. forest management	FAO		II
		3	Desertification & LD	1	Degraded over total land	UNCCD	FAO, UNEP	III
		4	Conserve mountains	2	Mountain green cover index	FAO	UNEP	II
		6	Genetic resources	1	Equal sharing of benefits	CBD	FAO, UNEP	III
16.	Peace							
17.	Partnerships							

Source: Adapted from FAO (2017a)

Table A2. FAO food security indicators by dimension (FAO's SDGs indicator shaded)

FOOD SECURITY INDICATORS	RELATED SDGs INDICATORS	DIMENSION
Average dietary energy supply adequacy		AVAILABILITY
Average value of food production	2.3.2	
Share of dietary energy supply derived from cereals, roots and tubers		
Average protein supply		
Average supply of protein of animal origin		
Percentage of paved roads over total roads	9.1.1	ACCESS
Road density	9.1.2	
Rail lines density	9.1.2	
Gross domestic product (in purchasing power parity)	8.1.1	
Domestic food price index	2.c.1	
Prevalence of undernourishment	2.1.1	
Share of food expenditure of the poor		
Depth of the food deficit	2.1.2	
Prevalence of food inadequacy	2.1.2	
Cereal import dependency ratio	17.11.1	STABILITY
Percent of arable land equipped for irrigation	2.4.1	
Value of food imports over total merchandise exports	17.11.1	
Political stability and absence of violence/terrorism	16.1.2	
Domestic food price volatility	2.c.1	
Per capita food production variability	2.3.1	
Per capita food supply variability		
Access to improved water sources	6.1.1	UTILIZATION
Access to improved sanitation facilities	1.4.1/6.2.1	
Percentage of children under 5 years of age affected by wasting	2.2.2	
Percentage of children under 5 years of age who are stunted	2.2.1	
Percentage of children under 5 years of age who are underweight	2.2.2	
Percentage of adults who are underweight	2.1.1	
Prevalence of anemia among pregnant women		
Prevalence of anemia among children under 5 years of age		
Prevalence of vitamin A deficiency in the population		
Prevalence of iodine deficiency in the population		

Source: Adapted from SOFI (FAO et al., 2015)

Table A3. Food Insecurity Experience Scale questions

Now, I would like to ask you some questions about your food consumption in the last 12 months. During the last 12 MONTHS, was there a time when:				
Q1. You were worried you would run out of food because of a lack of money or other resources? Tries to assess the worry, anxiety, apprehensiveness, fright or concern for not having enough food as a result for example of unemployment or lack of income. It does not imply that the respondent has run out of food	0 1	No Yes	98 99	DK[7] Refused[8]
Q2. You were unable to eat healthy and nutritious food because of a lack of money or other resources? The question is related to food quality and relies on the opinion of the respondent on whether they had to forgo healthy or nutrient balanced food due to lack of means (money)	0 1	No Yes	98 99	DK Refused
Q3. You ate only a few kinds of foods because of a lack of money or other resources? The question refers as well to food quality (diet) and not quantity due to lack of money. It inquires whether the concerned had to limit food variety, eat the same food or relatively limited kinds of food every day due to lack of money	0 1	No Yes	98 99	DK Refused
Q4. You had to skip a meal because there was not enough money or other resources to get food? The question enquires about food insufficiency as it relates to the experience of having to miss or skip a meal due to lack of money or resources	0 1	No Yes	98 99	DK Refused
Q5. You ate less than you thought you should because of a lack of money or other resources? The question is related to food quantity and builds on the respondents' opinion as it assesses whether they had to eat less food than usual as there was not enough resources (money) to acquire sufficient food	0 1	No Yes	98 99	DK Refused
Q6. Your household ran out of food because of a lack of money or other resources? The question asks about the experience of not having food in the household due to a lack of money or other resources	0 1	No Yes	98 99	DK Refused
Q7. You were hungry but did not eat because there was not enough money or other resources for food? The question is related to the experience of feeling hungry and not being able to buy the food needed because of a lack of means (money)	0 1	No Yes	98 99	DK Refused
Q8. You went without eating for a whole day because of a lack of money or other resources? The question is about a behavior, i.e. not eating all day because of lack of money or resources (not in relation to dieting or fasting)	0 1	No Yes	98 99	DK Refused

Source: Ballard et al. (2013)

Table A4. Prevalence of food insecurity based on FIES in 2014/15

Regions/sub-regions	Prevalence of severe food insecurity		Estimated food insecure people 15 years and older		Estimated food insecure people old ages	
	%	Error	000s	Error	000s	Error
Northern Africa	9.23	0.73	14,029	1,112	22,644	1,639
Western Asia	9.74	0.55	15,565	874	24,780	1,265
Sub-Saharan Africa	25.74	0.64	153,217	3,789	280,133	6,629
Latin America	4.88	0.22	21,423	969	33,210	1,305
Eastern Asia	0.51	0.17	6,187	2,023	8,279	2,442
Southern Asia	12.44	1.26	159,736	16,108	246,576	22,865
South-East Asia	5.12	0.73	23,808	3,405	35,531	4,636
Least developing countries	20.55	0.55	116,128	3,107	209,173	5,184
Developing regions	8.98	0.39	390,079	17,088	643,626	23,802
Developed regions	1.47	0.10	15,491	1,081	21,103	1,294
World	7.51	0.32	405,570	17,122	664,729	24,511

Source: Adapted from FAO (2017b)

Table A5. Major characteristics of the GHI

SUB-COMPONENT	WEIGHT	DESCRIPTION	SOURCE DATA
Undernourishment	1/3	• Reflects insufficient food supply • Concerns the entire population • Used globally to reflect hunger	FAO (inadequate food supply)
Child wasting	1/6	• Considers diet quality and utilization • Concerns children as more vulnerable • Wasting and stunting are used in the SDGs	UNICEF, WHO, World Bank (child undernutrition)
Child stunting	1/6		
Child mortality	1/3	• Reflects children vulnerability to hunger • Introduces micronutrients deficiencies • Previously did not fully reflect mortality risk	UN-IGME (child mortality)
GHI = 1/3*(0.8*undernourished) + 1/6*(0.3*wasting) + 1/6*(0.7*stunting) + 1/3*(0.35*child mortality)			

Source: Adapted from von Grebmer et al. (2015) and Wiesmann et al. (2015)

[7] DK = Don't know
[8] Refused to answer

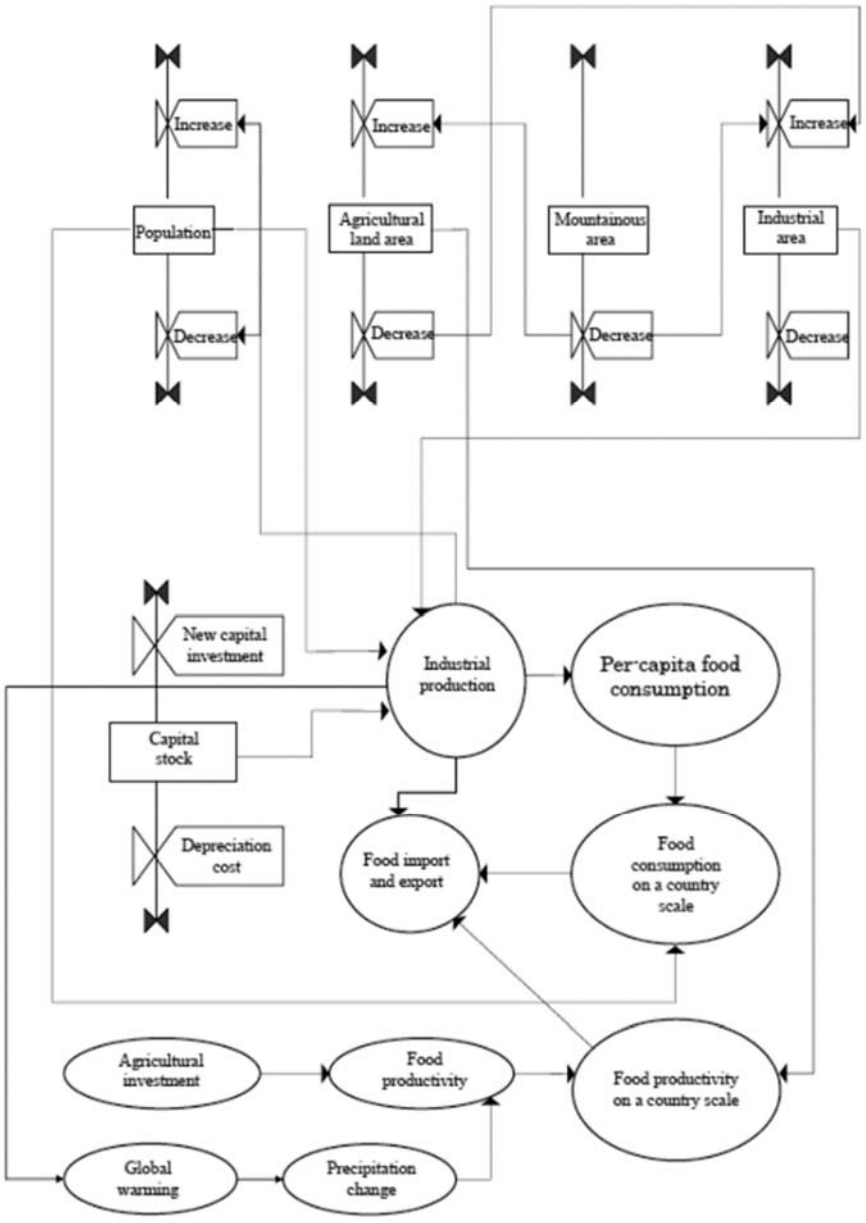
Table A6. GFSI categories and indicators description

	Category/Indicator	Description	Source data
1.	**Affordability**		
1.1	Food consumption as a share of household expenditure	Average percentage of household expenditure spent on food	National accounts; UN
1.2	Population under global poverty line	% population living on less than US$3.10/day	World Bank (WDI)
1.3	Gross domestic product per capita	Individual income and thus affordability of food in US$ at PPP	EIU
1.4	Agricultural import tariffs	Average applied most-favored nation (MFN) tariff on agricultural imports	WTO
1.5	Food safety net programmes	Safety nets: food distribution, cash, etc. (0-4): 0 = none; 4 = good	EIU (expert scoring)
1.6	Access to financing for farmers	Financing for farmers (0-4): 0 = no access; 4 = wide access	EIU (expert scoring)
2.	**Availability**		
2.1	Sufficiency of supply	Food availability based on average food supply (kcal/capita/day) and dependency on food aid	EIU (expert scoring)
2.1.1	Average food supply	Food available (kcal/capita/day)	FAO
2.1.2	Dependency on chronic food aid	Non-emergency food aid in past 5 years on a scale 0-2: 0 = increasing aid; 1 = decreasing aid; 2 = no or little food aid	WFP
2.2	Expenditure on agricultural R&D	Agricultural R&D as % GDP (1-9): 1 = <0.5% to 9 = >4%	EIU based on OECD & ASTI
2.3	Agricultural infrastructure	Storing & transporting (storage facilities, road infrastructure, port infrastructure)	EIU (expert scoring)
2.3.1	Existence of adequate crop storage facilities	Adequate storage facilities compared to size of agricultural sector and population on scale 0-1: 0 = No; 1 = Yeas	EIU (expert scoring)
2.3.2	Road infrastructure	Quality of road infrastructure on a scale 0-4, where 4 is best	EIU (risk briefing)
2.3.3	Port infrastructure	Quality of port infrastructure on a scale 0-4 where 4 is best	EIU (risk briefing)
2.4	Volatility of agricultural production	Standard deviation of agricultural production growth over last 20-years	FAO
2.5	Political stability risk	General political instability	EIU (risk briefing)
2.6	Corruption	Pervasiveness of corruption on scale 0-4, where 4 is highest risk	EIU (risk briefing)
2.7	Urban absorption capacity	Annual average percentage change in GDP minus urban population growth rate	World Bank (WDI), EIU
2.8	Food loss	Post-harvest & pre-consumer food loss as a ratio of the domestic supply (production, net imports & stock change)	FAO
3.	**Quality & Safety**		
3.1	Diet diversification	Share of non-starchy foods (all foods other than cereal, roots & tubers) in total dietary energy consumption	FAO
3.2	Nutrition standards	Presence of nutritional standards (dietary guidelines, nutrition plan or strategy and nutrition monitoring and surveillance)	EIU (expert scoring)
3.2.1	National dietary guidelines	Presence of published guidelines for a balanced and nutritious diet: 0 = No; 1 = Yes	EIU (expert scoring)
3.2.2	National nutrition plan or strategy	Presence of published national strategy to improve nutrition: 0 = No; 1 = Yes	EIU (expert scoring)
3.2.3	Nutrition monitoring and surveillance	Evidence of monitoring of nutritional status (data on undernourishment, deficiencies, etc.): 0 = No; 1 = Yes	EIU (expert scoring)
3.3	Micronutrient availability	Availability of micronutrients in food supply (vitamin A, animal iron and vegetal iron)	EIU
3.3.1	Dietary availability of vitamin A	Food supply in Vitamin A equivalent (0-2): 0 = < 300mcg; 1-300-600; 2 = > 600 mcg RAE/cap/day (retinal activity equivalent)	FAO
3.3.2	Dietary availability of animal iron	Food supply in iron equivalent (mg/cap/day)	FAO

3.3.3	Dietary availability of vegetal iron	Food supply in iron equivalent (mg/cap/day)	FAO
3.4	Protein quality	Amount of high-quality protein in the diet (from AO & USDA)	EIU
3.5	Food safety	Enabling environment for food safety (food safety agency, % population with access to potable water, formal grocery sector)	EIU (expert scoring)
3.5.1	Agency to ensure the safety and health of food	Regulatory or administrative agency: 0 = No; 1 = Yeas	EIU (expert scoring)
3.5.2	Percentage of population with access to potable water	Percentage of people using improved drinking water sources	World Bank
3.5.3	Presence of formal grocery sector	Prevalence of grocery sector on 0-2 scale: 0 = minimal; 1 = moderate; 2 = widespread	EIU (expert scoring)

Source: Adapted from EIU (2016)

Figure A1. Basic model structure in Matsumura



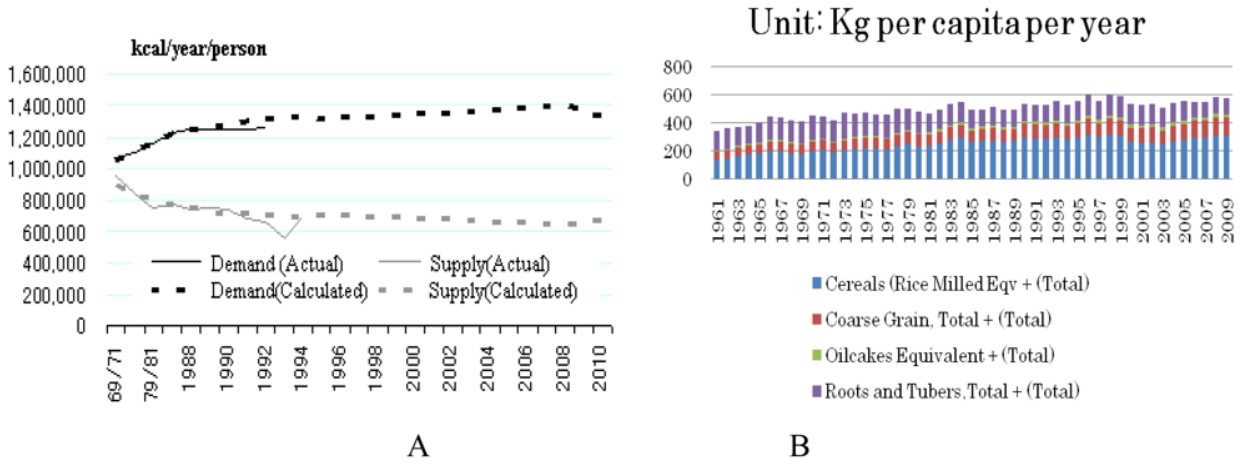
Source: Matsumura (2011)

Table A7. Results of crop supply functions for Japan

	Constant	Agricultural Area	Fertilizer Consumption	Correlation Coefficient
Crops	−11,125	0.3159	45,730	0.723
t–value	0.776	3.562	0.123	
Root	−1,461	0.0739	55,561.11	0.474
t–value	0.276	2.256	0.403	
Pulse	−62.5179	0.0047	−6,207.00	0.689
t-value	0.220	2.654	0.840	
Oil Crops	−320.6917	0.0025	7,528.85	0.593
t–value	2.482	3.153	2.240	

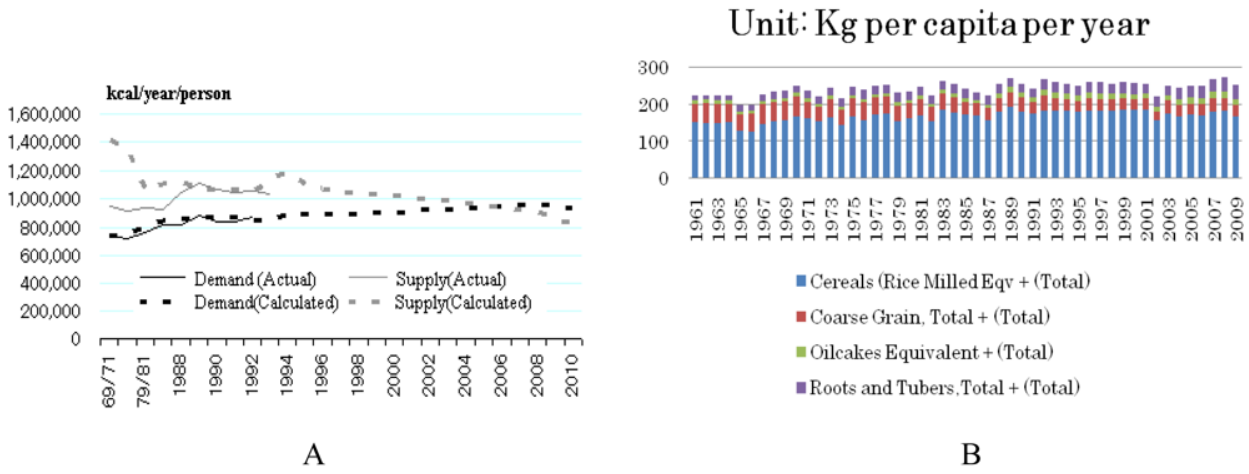
Source: Matsumura (2011)

Figure A2. Food demand and supply in Japan



Source: Matsumura (2011)

Figure A3. Food demand and supply in India



Source: Matsumura (2011)